Medals of Creation



Gideon Algernon Mantell

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THE MEDALS OF CREATION, VOLUMES 1 AND 2
***

THE

Medals of Creation;

OR,

FIRST LESSONS IN GEOLOGY,

AND

THE STUDY OF ORGANIC REMAINS.

VOL. I.

"If we look with wonder upon the great remains of human works, such as the columns of Palmyra, broken in the midst of the desert; the temples of Pæstum, beautiful in the decay of twenty centuries; or the mutilated fragments of Greek sculpture in the Acropolis of Athens, or in our own museums, as proofs of the genius of artists, and power and riches of nations now past away; with how much deeper feeling of admiration must we consider those grand monuments of nature which mark the revolutions of the Globe; continents broken into islands; one land produced, another destroyed; the bottom of the ocean become a fertile soil; whole races of animals

extinct, and the bones and exuviæ of one class covered with the remains of another; and upon the graves of past generations—the marble or rocky tombs, as it were, of a former animated world—new generations rising, and order and harmony established, and a system of life and beauty produced out of chaos and death; proving the infinite power, wisdom, and goodness of the GREAT CAUSE of all things!"—SIR H. DAVY.

Pl. 1



J. Dinkel del. G. Scharf lithog. *Printed by Hullmandel & Walton*

MEDALS OF CREATION

THE

Medals of Creation;

OR,

FIRST LESSONS IN GEOLOGY,

AND

THE STUDY OF ORGANIC REMAINS.

BY

GIDEON ALGERNON MANTELL,
LL.D. F.R.S. V.P.G.S.

PRESIDENT OF THE WEST LONDON MEDICAL SOCIETY, ETC.
AUTHOR OF THE WONDERS OF GEOLOGY, ETC.



"Voilà! une nouvelle espèce de médailles, beaucoup pl
incomparablement plus anciennes, que toutes celles d
Remains!"—KNORR, *Monumens des Catastrophes*.

Gideon Algernon Mantell

IN TWO VOLS.—VOL. 1.

CONTAINING

Fossil Vegetables, Zoophytes, Echinoderm

SECOND EDITION, ENTIRELY REWRITTEN.

LONDON:
HENRY G. BOHN, YORK STREET, COVENT

GARDEN.
MDCCCLIV

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TO

MY SONS,

WALTER MANTELL,

OF WELLINGTON, NEW ZEALAND,
AND

REGINALD NEVILLE MANTELL,

OF KENTUCKY, UNITED STATES,

This Work,

MY LAST ATTEMPT TO PROMOTE THE
ADVANCEMENT
OF SCIENTIFIC KNOWLEDGE,
IS MOST AFFECTIONATELY INSCRIBED.

G. A. M.

CHESTER SQUARE, PIMLICO,
Feb. 3, 1853.

[The above having been penned by the much-lamented author of the "Medals" some months previous to his decease, it is retained in this

posthumous edition of his favourite work as an appropriate dedication, dictated by the parental affection of one of the chief promoters of geological science in England, and addressed to his absent sons, whose works have already shown them to be enthusiastic labourers in the same field, both at home and in distant parts of the world.]

PREFATORY NOTE TO THE SECOND EDITION.

The untimely Decease of the lamented AUTHOR of the "MEDALS OF CREATION" during the progress of the present edition through the press has unavoidably delayed its publication.

The First Volume has been wholly rewritten by the Author.

The materials of the Second Volume had been elaborately revised and much enlarged by DR. MANTELL previously to his Decease. The EDITOR has laboured to carry out the intentions of the Author in rendering this part of the Work as complete a compendium as possible of the Palæontological history of the Organic Beings of which it treats, and in adapting it to the requirements of the Geological Student of the present time.

The various sources from which palæontological and zoological information has been derived have, for the most part, been adverted to in the text or in the footnotes. The EDITOR, however, has especially

to acknowledge the kindness of MR. J. MORRIS, F.G.S., in allowing him to refer to the proof-sheets of the forth-coming edition of his "Catalogue of British Fossils," and thereby affording him important assistance in making correct statements of the distribution of the Fossil Remains of the CRUSTACEA, INSECTA, and VERTEBRATA, in the strata of the BRITISH ISLANDS.

T. RUPERT JONES.

PREFACE TO THE FIRST EDITION.

In the first edition of the WONDERS OF GEOLOGY, an intention was expressed of immediately publishing, as a sequel to those volumes, "FIRST LESSONS," or an Introduction to the Study of Petrifactions, for persons wholly unacquainted with the nature of Fossil Remains; but the completion of the contemplated work was unavoidably postponed, from year to year, by the long and severe indisposition of the Author.

In the meanwhile several works professing the same object have issued from the press; and an enlarged edition of Sir C. Lyell's "ELEMENTS" has also appeared, in which the elementary principles of physical Geology are fully illustrated, and numerous figures given of the characteristic fossils of the several formations, or groups of strata. But that department of the science which especially treats of Organic Remains is necessarily considered in a cursory manner; and a work upon the plan originally contemplated by the Author seems still to be

required, to initiate the young and uninstructed in the study of those Medals of Creation—those electrotypes of nature—the mineralized remains of the plants and animals which successively flourished in the earlier ages of our planet, in periods incalculably remote, and long antecedent to all human history and tradition.

With this conviction the present volumes are offered, with such modifications of the original plan as circumstances have rendered necessary, as a guide for the Student and the Amateur Collector of fossil remains; for the intelligent Observer who may desire to possess a general knowledge of the subject, without intending to pursue Geology as a science; and for the Tourist who may wish, in the course of his travels, to employ profitably a leisure hour in quest of those interesting memorials of the ancient physical revolutions of our globe, which he will find everywhere presented to his observation.

CRESCENT LODGE,
CLAPHAM COMMON,
May, 1844.

ADDRESS TO THE READER.

> "Some books are to be tasted—others to be swallowed —and some few to be chewed and digested; that is, some Books are to be read only in parts—others to be read, but not curiously—and some few to be read wholly and with diligence and attention."—LORD BACON'S ESSAYS.

Anxious that the "COURTEOUS READER" should derive from this work all the information it is designed to impart, the Author presumes to offer a

few words in explanation of the plan upon which it has been constructed, and some suggestions as to the best means of rendering its contents most available to the varied tastes and pursuits of different classes of readers.

In its arrangement, a three-fold object was had in view; namely, in the first place, to present such an epitome of PALÆONTOLOGY, the science which treats of the fossil remains of the ancient inhabitants of the Globe, as shall enable the intelligent Observer to comprehend the nature of the principal discoveries in modern Geology, and the method of investigation by which such highly interesting, and unexpected results, have been obtained..

Secondly, to assist the COLLECTOR in his search for Organic Remains,—directing attention to those objects which possess the highest interest, and are especially deserving of accurate examination—instructing him in the art of developing and preserving the specimens he may discover—and pointing out the means to be pursued, for ascertaining their nature, and their relation to existing plants or animals.

Thirdly, to place before the STUDENT a familiar exposition of the elementary principles of Palæontology, based upon a general knowledge of the structure of vegetable and animal organization; to excite in his mind a desire for further information, and prepare him for the perusal and study of works of a higher order than these unpretending volumes; and to point out the sources from which the required instruction may be derived.

Although fully aware of the imperfect manner in which these intentions are fulfilled, the Author hopes

that the indulgence claimed by one of the most able writers of our times may be extended to him; and that, "if the design be good upon the whole, the work will not be censured too severely for those faults, from which, in parts, its very nature would scarcely allow it to be free."[1]

[1] Sir E. B. Lytton—preface to the second edition of "THE DISOWNED."

With regard to the best means of making use of these volumes, the advice of the great founder of Inductive Philosophy, on the Study of Books in general, expressed in the quotation prefixed to this address, is peculiarly applicable to the different classes of readers for whom the work is designed.

Thus, "*the Book may be tasted, that is, read only in parts*," by the intelligent reader, who requires but a general acquaintance with the subjects it embraces. The perusal of the introductory and concluding remarks of each chapter, of the general descriptions of fossil remains, and of the circumstances under which they occur,—omitting the scientific terms and descriptions,—and a cursory examination of the illustrations, will probably satisfy his curiosity; and the work may be transferred to the library for occasional reference, or taken as a travelling companion and guide to some interesting geological district.

But the Book "*must be swallowed, that is, read, but not curiously*," by the reader desirous of forming a collection of organic remains. A general acquaintance with its contents, and a careful investigation of the characters of the fossils, and comparison with the figures and descriptions, will be requisite to enable the amateur collector to

determine the nature of the specimens he may discover.

By the STUDENT the Book "*must be digested, that is, read wholly, and with diligence and attention*." He should fully comprehend one subject before he advances to the consideration of another, and should test the solidity of his knowledge by practical research. He should visit some of the localities described; collect specimens, and develope them with his own hands; examine their structure microscopically; nor rest satisfied until he has determined their general characters, and ascertained their generic and specific relations. Nor is this an arduous or irksome task; by a moderate degree of attention, a mind of average ability may quickly overcome the apparent difficulties, and will find in the knowledge thus acquired, and in the accession of mental vigour which such investigations never fail to impart, an ample reward for any expenditure of time and trouble.

It is, indeed, within the power of every intelligent reader, by assiduity and perseverance, to attain the high privilege of those who walk in the midst of wonders, in circumstances where the uninformed and uninquiring eye can perceive neither novelty nor beauty; and of being

"Even as one,
Who by some secret gift of
soul or eye,
In every spot beneath the
smiling sun.
Sees where the Springs of
living Waters lie!"

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DIRECTIONS TO THE BINDER.

PLATE I.—Frontispiece to Vol. I.

PLATE II. Frontispiece to Vol. II.

PLATES III., IV., V., and VI., to follow the Table of Contents, and be placed opposite the description of each.

LIGN. 247, to face page 770.

DESCRIPTION OF THE

FRONTISPIECE OF VOL. I.

PLATE I.

Fig. 1. A FERN in Coal-shale, from Leicestershire.

2. A CRUSTACEAN in Limestone, from Solenhofen.

3. A FISH (*Pycnodus rhombus*) in Limestone; from near Castel-a-mare.

4. Half the Lower Jaw of a HYENA, from a fissure in a sandstone rock, near Maidstone.

5. An AMMONITE, from the Isle of Portland.

DESCRIPTION OF THE VIGNETTE OF VOL. I.

A Group of Fossils, containing

AMMONITES MANTELLII, from the *Chalk-marl*, Sussex.

TURRILITES COSTATUS, from the *Lower Chalk*, Rouen.

CHONDRITES BIGNORIENSIS, from the *Chalk-marl*, Sussex.

ECHINUS and FUSUS, from

Tertiary strata, Palermo.

DESCRIPTION OF PLATE II.

The Frontispiece of Vol. II.

A Fossil Fish of the Salmon tribe, allied to the SMELT;
from the Chalk, near Lewes, in Sussex.
[See Vol. II. pages 626 and 628.]


1
3
4
2
5
7
8
10

J. Dinkel del. G. Scharf lithog.

Printed by Hullmandel & Walton

DESCRIPTION OF PLATE III.

Incrustations, and Fossil Plants.

Figs. 1, 2, 3. Twigs of Larch and Hawthorn, coated with tufa, or travertine, from having been exposed to the dripping of an incrusting spring; from Russia; see p. 39.

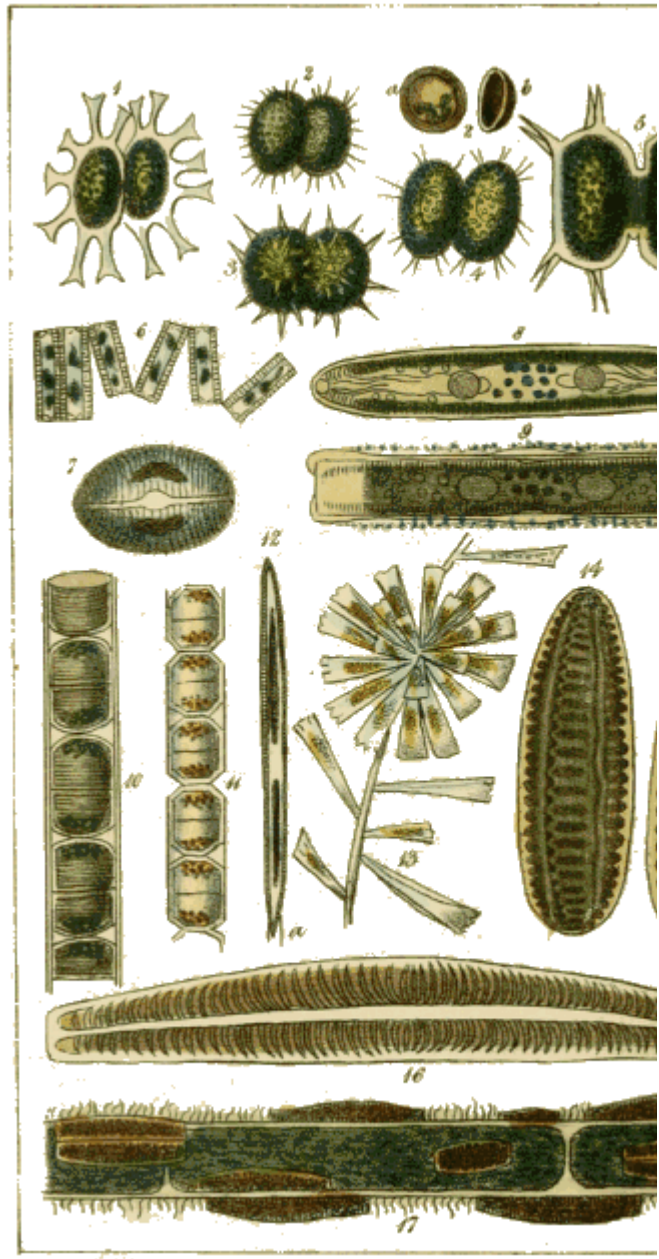
5. A branch of recent *Chara*, with its fruit, with a thin pellicle of incrustation. Matlock.

6, 7. Hazel-nuts, from Belfast Lough: fig. 6 is lined with crystals of calcareous spar; fig. 7 is filled with a solid mass of the same mineral; see p. 71.

4, 8. Impressions of Dicotyledonous Leaves in Gypseous Marlstone, from Stradella, near Pavia; see p. 201.

9. Eocene Lacustrine or Fresh-water Limestone, from East Cliff Bay, Isle of Wight, with stems and seeds of Charge: slightly magnified; see p. 195.

10. Encrusted Twigs, from Matlock; the vegetable matter has perished, and left tubular cavities; see p. 39, and p. 873.



J. Dinkel del. G. Scharf lithog.

Printed by Hullmandel & Walton

DESCRIPTION OF PLATE IV.

Various species of recent Diatomaceæ, to illustrate the Fossil remains of this Tribe of Vegetables.

For detailed descriptions, see pages 87-100.

Figs. 1 to 5. Various kinds of *Xanthidia*: figs. 2, 3, 4, — found in a pond on Clapham Common, and fig. 1. living in a pond near Westpoint, United States.

1.— Xanthidium *furcatum*: $^1/_{24}$ of a line in diameter.

2.— ——— *hirsutum*: $^1/_{36}$.

3.— ——— *aculeatum*: $^1/_{24}$.

4.— ——— *fasciculatum*: $^1/_{24}$.

5.— ——————— variety of the above.

2*.— Pyxidicula operculata; Carlsbad, Bohemia: $^1/_{48}$ of a line in diameter.

6.— Bacillaria vulgaris. $^1/_{36}$ of a line in diameter. Pond on Clapham Common.

7.— Cocconeis scutellum: from the Baltic: $^1/_{24}$ of a line.

8.— Navicula viridis: $^1/_6$ of a line. Ponds on Clapham Common.

9.— The same; a side view; showing the currents produced in the water by the animal when in locomotion.

10.— Gallionella lineata: $^{1}/_{36}$ of a line. Ponds on Clapham Common.

11.— Gallionella moniliformis: $^{1}/_{72}$ of a line.

12.— Synhedra ulna: $^{1}/_{9}$ of a line: the point *a*, marks the pedicle of attachment. Ponds on Clapham and Wandsworth Commons.

13.— Podosphenia gracilis: $^{1}/_{12}$ of a line; attached to a thread of *Calothria* and having by self-division formed a radiating cluster. Common in the ditches communicating with the Thames in Battersea-fields.

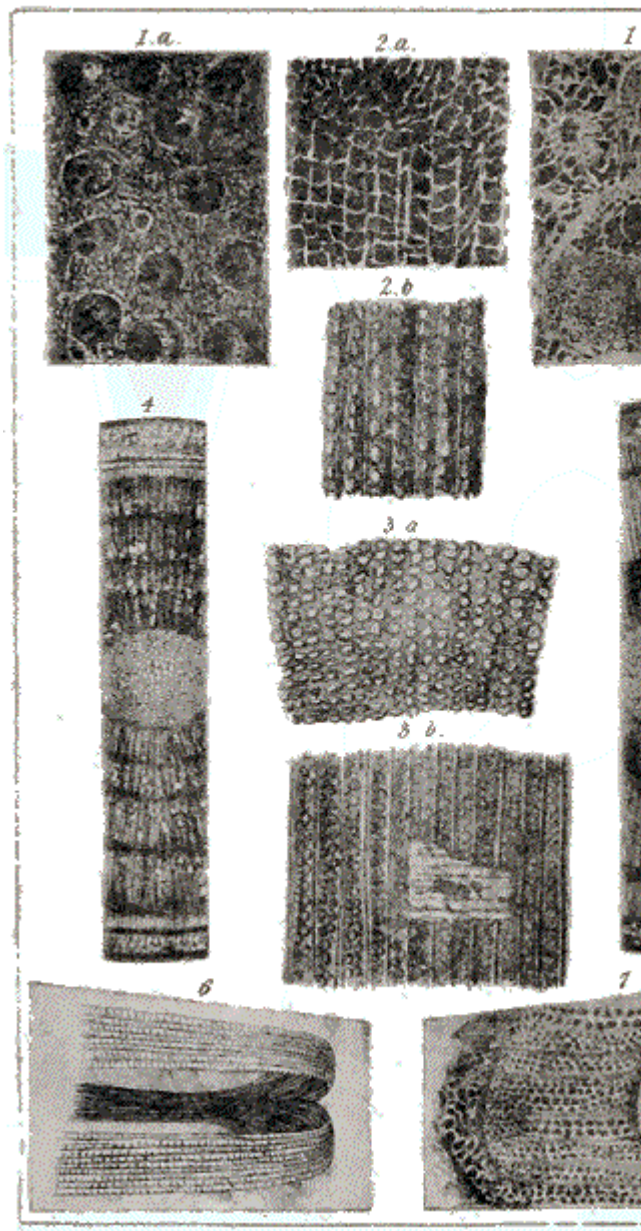
14.— Navicula splendida: $^{1}/_{12}$ of a line in diameter.

15.— Lateral view of the same.

16.— Eunotia turgida: $^{1}/_{14}$ of a line; the empty shell, with sixty-five ribs, viewed laterally.

17.— A living group of the same: $^{1}/_{20}$ of a line: a piece of *Conferva rivularis*, beset with these animalcules. The smaller species are *E. Westermanni*.

[All the above organisms were figured and described by Ehrenberg as animals (*Polygastrica*), and are comprised in his family *Bacillaria*; they are now, however, regarded as unquestionably vegetable structures, belonging to the family of Algæ, termed *Diatomaceæ*.]


1.a.
2.a.
1.b
2.b
4
3.a
3.b.
6
7

J. Dinkel del. G. Scharf lithog.

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DESCRIPTION OF PLATE V.

Illustrative of the Structure of Fossil Vegetables.

Fig. 1.— Polished transverse section of silicified Monocotyledonous Wood, from Antigua; p. 185.

1*a*.— Magnified 20 times linear.

1*b*.— Magnified 75 times linear.

2*a*.— Transverse section of silicified Coniferous Wood (*Abies Benstedi*) from the Kentish Rag, near Maidstone (Iguanodon quarry), × 120 linear; p. 173.

2*b*.— Vertical or longitudinal section of the same, × 250 linear.

3*a*.— Transverse section of calcareous coniferous wood, from Willingdon, Sussex, × 80 linear; p. 173.

3*b*.— Longitudinal section of the above, × 120 linear.

4.— Slice of a transverse section of a recent Dicotyledonous Stem; showing, 1st, Pith or medullary column, occupying the centre; 2d, Four bands of woody layers, separated by condensed lines of elongated tissue in series, and having large regular openings of vessels, with numerous medullary rays running continuously from the central pith to the bark; 3d, the bark. (*From Mr. Witham.*)

5.— Slice of a transverse section of a recent gymnospermous phanerogamic stem (of a Cycas), having a central pith, with woody layers separated by a condensed line, and consisting of elongated cellular tissue, arranged in a regular series; medullary rays and bark. (*From Mr. Witham.*)

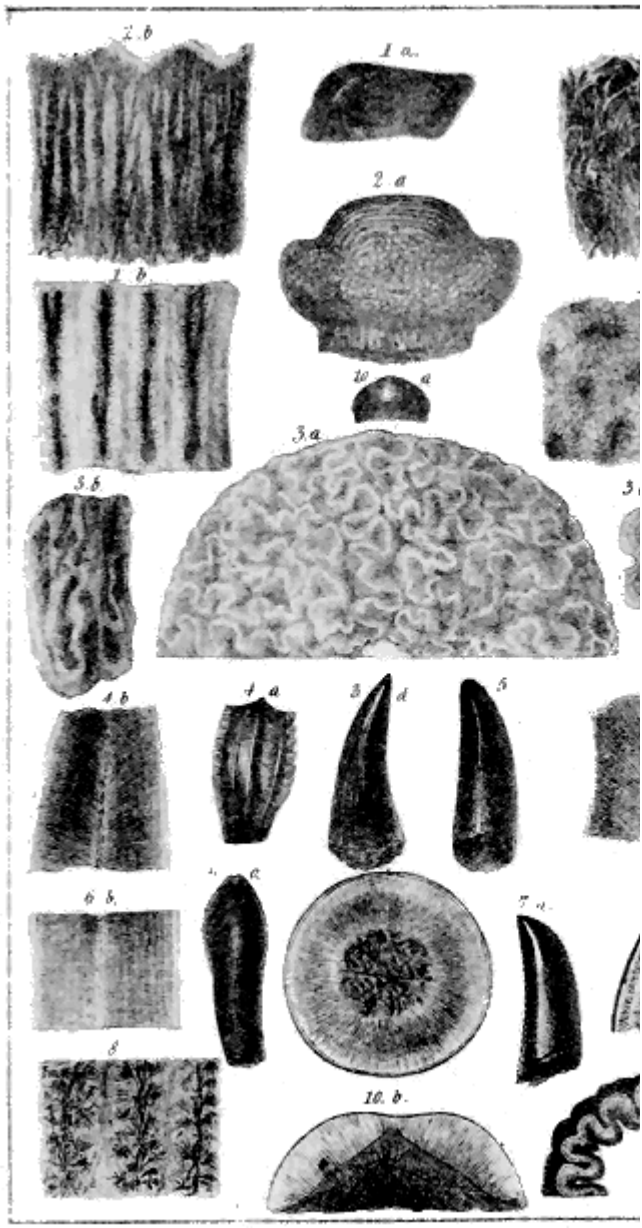
6.— Bundles of vascular tissue in Stigmaria ficoides, × 12 linear. See p. 135. The two strands of vessels that appear as if on the surface (and are of a looser texture) are part of the vascular tissue of the stem, and become inflected (that is, bent over), and give rise to a band of vessels (the darker band seen between the above), that passes towards the bark or cortical covering.

7.— Portion of a transverse section of one of the bundles of vascular tissue of *Sigillaria elegans*, × 20 linear. (From *M. Brongniart.*) See p. 131.

The convex portion on the left, and which in the original stem is situated towards the centre, is composed of the medullary vascular tissue formed of vessels irregularly disposed.

The longitudinal bundles are the woody fibres arranged in a radiated circle: the smooth interspaces are medullary rays.

The two distinct roundish spots of vascular tissue on the right of the ligneous zone occur irregularly on the outside of the woody circle, and are supposed to be detached bundles of the ligneous zone extending towards the leaves. See p. 131.


2. b
1. a.
2. a
1. b.
10 a
3. a.
3. b.
4. b
4. a
5
6. b.
8
10. b.

J. Dinkel del. G. Scharf lithog.

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DESCRIPTION OF PLATE VI.

Illustrative of the Structure of Fossil Teeth.

Fig. 1[a]. Tooth of *Psammodus porosus*, from the
— Mountain Limestone. See p. 587.
1[b]. Vertical section, a portion × 75 linear.
—
1[c]. Transverse section of the same, × 75.
—
2[a]. Tooth of *Ptychodus polygurus*, from the Chalk,
— near Lewes. See p. 585.
2[b]. Portion of longitudinal section, × 20.
—
2[c]. Portion of transverse section, × 20.
—
3[b]. Tooth of the *Labyrinthodon Jægeri*, from the
— New Red sandstone near Wirtemberg; half the natural size: the specimen presented by Dr. Jæger. See p. 742.
3[a]. A moiety of a transverse polished section, ×
— 20.
3[b]. Portion of a vertical section near the apex,
— × 20.
3[c]. One of the anfractuosities of fig. 3[a] × ×.
—
4[a]. Crown or upper portion of a tooth of a
— young *Iguanodon*, from Tilgate Forest. See p. 697.

4[b]. Portion of a vertical section of the above, × 20.

4[c]. A small portion of a transverse section of the same, × 20.

5. Tooth of *Goniopholis*, Tilgate Forest: half the natural size. See p. 678.

6[a]. Tooth of a reptile (probably of the *Hylæosaurus*), from Tilgate Forest; half the natural size. See p. 690.

6[b]. Portion of a vertical section of the same, × 20.

7[a]. Tooth of *Megalosaurus*, from Tilgate Forest. See p. 687.

7[b]. Portion of a vertical section of the same, × 10.

8. A small portion of a vertical section of a tooth of *Dendrodus*. See p. 618.

9. Portion of a transverse section of the base of a tooth of *Ichthyosaurus*, × 20. See p. 665.

10[a]. Tooth of *Lepidotus*, Tilgate Forest. See p. 606.

10[b]. The upper figure is a transverse section, and the lower a vertical section of the same, × 20.

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THE MEDALS OF CREATION.

INTRODUCTION.

"GEOLOGY, in the magnitude and sublimity of the objects of which it treats, ranks next to ASTRONOMY in the scale of the Sciences."—*Sir J. F. W. Herschel.*

GEOLOGY, a term signifying a discourse on the Earth, (from two Greek words: viz. γή, *ge*, the earth; and λόγος, *logos*, a discourse,) is the science which treats of the physical structure of the planet on which we live, and of the nature and causes of the successive changes which have taken place in the organic and inorganic kingdoms, from the remotest period to the present time, and is therefore intimately connected with every department of

natural philosophy.

While in common with other scientific pursuits it yields the noblest and purest pleasures of which the human mind is susceptible, it has peculiar claims on our attention, since it offers inexhaustible and varied fields of intellectual research, and its cultivation, beyond that of any other science, is in a great measure independent of external circumstances; for it can be followed in whatever condition of life we maybe placed, and wherever our fortunes may lead us.

The eulogium passed by a distinguished living philosopher on scientific knowledge in general, is strikingly applicable to geological investigations. "The highest worldly-prosperity, so far from being incompatible with them, supplies additional advantages for their pursuit; they may be alike enjoyed in the intervals of the most active business, while the calm and dispassionate interest with which they fill the mind, renders them a most delightful retreat from the agitations and dissensions of the world, and from the conflict of passions, prejudices, and interests, in which the man of business finds himself continually involved."[2]

[2] Sir J. F. W. Herschel, "Discourse on the Study of Natural Philosophy."

From the present advanced state of geological science, particularly of that department which it is the more especial object of these volumes to elucidate, namely PALÆONTOLOGY,[3] or the study of Organic Remains,—it seems scarcely credible, that but little more than a century ago it was a matter of serious question with naturalists, whether the petrified shells imbedded in the rocks and strata

were indeed shells that had been secreted by molluscous animals; or whether these bodies, together with the teeth, bones, leaves, wood, &c. found in a fossil state, were not formed by what was then termed the plastic power of the earth; in like manner as minerals, metals, and crystals.

> [3] Palæontology: from παλαιος, *palaios*, ancient—οντα, *onta*, beings—λόγος, *logos*, a discourse.

In a "Natural History of England," published towards the end of the last century, it is gravely observed that at Bethersden in Kent, a kind of stone is found full of shells, "*which is a proof that shells and the animals we find in them living, have no necessary connexion*." Another amusing instance of the ignorance on such subjects which prevailed at no remote period, occurs in a "History of the County of Surrey," in which it is stated that in a search for coal near Guildford the borers broke, and "this was thought by Mr. Peter Lely, the Astrologer, to have been the work of subterranean spirits, who wrenched off the augers of the miners, lest their secret haunts should be invaded."

But in the latter part of the seventeenth century, there were several eminent men in England who were greatly in advance of the age in which they lived, and strenuously exerted themselves to discover and promulgate the true principles of Geology. Among these, Dr. MARTIN LISTER, physician to Queen Anne, was one of the most distinguished. This accomplished naturalist, in his great work on shells, which remains to this day a splendid monument of his labours, and of the talents and filial affection of his two daughters, by whom all the plates were engraved, figures and describes many fossil shells as

real animal productions, and carefully compares them with recent species. He also recognised the distinction of strata by the organic remains they contain; and to him the honour is due of having first suggested the construction of geological maps;[4] he was likewise well acquainted with the position and extent of the Chalk and other strata of the South of England.[5]

[4] See Notes on the Progress of Geology in England, by W. H. Fitton, M.D. &c. *Philos. Mag.* vols. i. and ii. for 1832 and 1833.

[5] This celebrated physician and British geologist died in 1712, and was interred in the old church at Clapham; where a tablet to his memory is affixed to the outside of the north wall of St. Paul's Chapel.

From the foreign writers, who at an early period had obtained some correct notions of the structure of our planet, and of the nature of the revolutions it had undergone, I select the following beautiful and philosophical illustration of the physical mutations to which the surface of the earth is perpetually subjected. It is from an Arabic manuscript of the thirteenth century;[6] the narrative is supposed to be related by Rhidhz, an allegorical personage.

[6] Quoted by Sir C. Lyell in his "Principles of Geology."

"I passed one day by a very ancient and populous city, and I asked one of its inhabitants how long it had been founded? 'It is, indeed, a mighty city,' replied he; 'we know not how long it has existed, and our ancestors were on this subject as ignorant as ourselves.' Some centuries afterwards I passed by the same place, but I could not perceive the slightest vestige of the city; and I demanded of a peasant, who was gathering herbs upon its former site, how long it had been destroyed? 'In sooth, a strange question,' replied he, 'the ground here has never been different

from what you now behold it.' 'Was there not,' said I, 'of old a splendid city here?' 'Never,' answered he, 'so far as we know, and never did our fathers speak to us of any such.'

"On revisiting the spot, after the lapse of other centuries, I found the sea in the same place, and on its shores were a party of fishermen, of whom I asked how long the land had been covered by the waters? 'Is this a question,' said they, 'for a man like you? this spot has always been what it is now.'

"I again returned ages afterwards, and the sea had disappeared. I inquired of a man who stood alone upon the ground, how long ago the change had taken place, and he gave me the same answer that I had received before.

"Lastly, on coming back again, after an equal lapse of time, I found there a flourishing city, more populous and more rich in buildings than the city I had seen the first time; and when I fain would have informed myself regarding its origin, the inhabitants answered me, 'Its rise is lost in remote antiquity—we are ignorant how long it has existed, and our fathers were on this subject no wiser than ourselves.'"

We may smile at the ignorance of the inhabitants of the fabled cities, but are we in a condition to give a more satisfactory reply should it be inquired of us, "What are the physical changes which the country you inhabit has undergone?"—and yet cautious observation, and patient and unprejudiced investigation, are alone necessary to enable us to answer the interrogation.

Dismissing from his mind all preconceived opinions, the student must be prepared to learn that the earth's surface has been, and still is, subject to perpetual mutation,—that the sea and land are continually changing place,—that what is now dry land was once the bottom of the deep, and that the bed of the present ocean will, in its turn, be elevated above the water and become land,—that all the solid materials of the globe have been in a softened, fluid, or gaseous state,—that the relics of countless myriads

of animals and plants are entombed in the rocks and strata,—and that vast mountain-chains, and extensive regions, are wholly composed of the petrified remains of beings that lived and died in periods long antecedent to the creation of the human race. Astounding as are these propositions, they rest upon evidence so clear and incontrovertible, that they cannot fail to be admitted by every intelligent and unprejudiced reader, who will bestow but a moderate share of attention to the examination of the phenomena, of which the following pages present a familiar exposition.

I cannot conclude these introductory observations, without adverting to the incalculable benefits which result from scientific pursuits in general, and of Geology in particular. An able modern writer has justly remarked:—"It is fearfully true, that nine-tenths of the immorality which pervades the better classes of society, originate from the want of an interesting occupation to fill up the vacant time; and as the study of the natural sciences is as attractive as it is beneficial, it must necessarily exert a moral and even religious influence upon the young and inquiring mind. The youth who is fond of scientific pursuits will not enter into revelry, for frivolous or vicious excitements will have no fascination for him. The overflowing cup, the unmeaning or dishonest game, will not entice him. If any one doubts the beneficial influence of these studies on the morals and character, I would ask him to point out the immoral young man who is devotedly attached to any branch of natural science: I never knew such an one. There may be such individuals—for religion only can change the heart—but if there be, they are very rare exceptions; and the loud clamours which are always raised against the

man of science who errs, prove how rarely the study of the works of the Creator fails to exert an ennobling effect upon a well-regulated mind. Fortunate, indeed, are the youth of either sex, who early imbibe a taste for natural knowledge, and whose predilections are not thwarted by injudicious friends."

And while Geology exerts this hallowing influence on the character, it possesses the great advantage of presenting subjects adapted to every capacity; on some of its investigations the highest intellectual powers and the most profound acquirements in exact science are required; while many of its problems may be solved by any one who has eyes and will use them; and innumerable facts illustrative of the ancient condition of our planet, and of its inhabitants, may be gathered by any diligent and intelligent observer.

But it is surely unnecessary to dwell on the interest and importance of a study, which instructs us that every pebble we tread upon bears the impress of the Almighty's hand, and affords evidence of Creative wisdom; that every grain of sand, every particle of dust scattered by the wind, may be composed of the aggregated skeletons of beings, so minute as to elude our unassisted vision, but which possessed an organization as marvellous as our own; —a science whose discoveries have realized the wildest imaginings of the poet,—whose realities far surpass in grandeur and sublimity the most imposing fictions of romance;—a science, whose empire is the earth, the ocean, the atmosphere, the heavens;—whose speculations embrace all elements, all space, all time;—objects the most minute, objects the most colossal;—carrying its researches into the smallest

atom which the microscope can render accessible to our visual organs,—and comprehending all the phenomena in the boundless Universe, which the powers of the telescope can reveal.

And as no branch of natural philosophy can more strongly impress the mind with that deep sense of humility and dependence, which the contemplation of the works of the Eternal is calculated to inspire, so none can more powerfully encourage our aspirations after truth and wisdom. Every walk we take offers subjects for profound meditation,—every pebble that attracts our notice, matter for serious reflection; and contemplating the incessant dissolution and renovation which are taking place around us in the organic and inorganic kingdoms of nature, we are struck with the force and beauty of the exclamation of the poet—

"My heart is awed within me,
when I think
Of the great miracle which
still goes on
In silence round me—the
perpetual work
Of THY Creation, finished,
yet renewed
For ever!

PRELIMINARY REMARKS.

ON THE PLAN OF THE WORK, AND THE ARRANGEMENT AND SUBDIVISION OF THE SUBJECTS IT EMBRACES.

WITH the view of economizing space, I would refer the reader to the following volumes for figures and descriptions of such fossils as are illustrated therein: by this arrangement I hope to afford the student a comprehensive view of Palæontology, and yet restrict this work within the limits which as a manual it would be inconvenient to exceed; at the same time it will be complete in itself, and afford all the information required by the amateur collector and general reader.

I. DR. BUCKLAND'S *Bridgewater Treatise*: 2 vols. 8vo.—These volumes contain numerous excellent figures of organic remains; and as the work is, or

ought to be, found in every good public or private library in the kingdom, it will be accessible to most of my readers.

II. *The Wonders of Geology, or a Familiar Exposition of Geological Phenomena*; *sixth* edition, in two vols, with coloured plates, and numerous figures; by the AUTHOR. Price 18*s.*—This work is designed to afford a general view of Geological phenomena, divested as much as possible of scientific language: it is illustrated by numerous figures of organic remains.

III. *Geological Excursions round the Isle of Wight and along the adjacent Coasts of Hampshire and Dorsetshire.* One volume, richly illustrated. By the AUTHOR. Price 12*s.*

IV. *Petrifactions and their Teachings; or a Hand-book to the Gallery of Organic Remains in the British Museum.* One vol. with many original figures of the most interesting objects. By the AUTHOR.[7] Price 5*s.*

[7] The three works above named consist of four volumes uniform with the present edition of the "Medals of Creation:" this series of six volumes comprises the popular geological works of the AUTHOR.

V. *A Pictorial Atlas of Fossil Remains;* consisting of Coloured Illustrations selected from "Parkinson's Organic Remains of a Former World," and Artis' "Antediluvian Phytology." 1 vol. 4to. with seventy-four coloured plates, and several lignographs, containing nearly 900 figures of fossils. By the AUTHOR. Price 2*l.* 2*s.*

To the above may be added DANA'S *Mineralogy*, which treats of the various mineral substances that

enter into the composition of the rocks and strata in which the fossil remains are imbedded.

A good geological map of Great Britain is indispensable. The small map published by the Society for the Diffusion of Useful Knowledge, edited by Sir R. Murchison, price 5*s.*, is an excellent compendium; but Mr. Knipe's large "*Geological Map of the British Isles*" is the most complete and convenient for the traveller: price 3*l.* 3*s.* By reference to the map, the geological structure, and the prevailing fossils of a district, may be ascertained.

The above works are referred to as follows: viz.

Bd. Dr. Buckland's Treatise.

Wond. The Wonders of Geology.

Geol. I. of W. Geology of the Isle of Wight.

Petrifactions. Petrifactions and their Teachings.

Pict. Atlas. Pictorial Atlas of Organic Remains.

The following works, to which reference will often be made, are thus denoted:—

Foss. Flor. The Fossil Flora of Great Britain, by Dr. Lindley, and W. Hutton, Esq. 3 vols. 8vo.

Vég. Foss. Histoire des Végétans: Fossiles, par M. Adolphe Brongniart. 1 vol. 4 to.

Geol. Trans. Transactions of the Geological Society of London. 5 vols. 4to.; and New Series, in 5 vols.

Geol. Proc. Geological Proceedings.

—— *Journ.* ———— Quarterly Journal.

Sil. Syst. The Silurian System, by Sir R. I. Murchison. 2 vols. 4to. with plates and map.

Org. Rem. Parkinson's Organic Remains of a Former World. 3 vols. 4to.

Oss. Foss. Ossemens Fossiles, par Baron Cuvier. 5 vols. 4to. 5$^{me.}$ edit.

Min. Conch. Sowerby's Mineral Conchology. 6 vols. 8vo.

Odont. Odontography; a Treatise on the Comparative Anatomy of the Teeth, by Professor Owen. 2 vols. 8vo.

Brit. Mam. British Fossil Mammalia; by the same Author. 1 vol. 8vo.

Brit. Rep. Reports on British Fossil Reptiles in the British Association Transactions for 1839, and 1841; by the same Author.

Phil. York. Geology of Yorkshire, by Professor John Phillips. 2 vols. 4to.

South. D. Fossils of the South Downs, 1 vol. 4to. 42 plates by the Author. 1822.

Geol. S. E. Geology of the South-east of England. 1 vol. 8vo. by the same.

Tilg. For. Fossils of Tilgate Forest. 1 vol. 4to. 20 plates; by the same. 1827.

Poiss. Foss. Recherches sur les Poissons Fossiles, par M. Agassiz. 4 vols. 4to, and 2 vols, folio.

Man. Geol. Manual or Elements of Geology, by Sir C.

Lyell. 1 vol. 8vo. Edit. 1852.

The following abbreviations are also employed:—

§ 1. *Relative to the Rocks or Strata.*

Drift. Alluvial deposits, or Drift.

Tert. Tertiary. *Lond. C.* London clay.

Cret. Cretaceous formation. *U. Ch.* Upper chalk. *L. Ch.* Lower chalk.

Trias. New Red Sandstone, or Triassic deposits.

Carb. Carboniferous or Coal formation.

Mt. L. Mountain or Carboniferous limestone.

Devon. Devonian or Old Red Sandstone formation.

Sil. Syst. Silurian System, or formation.

§ 2. *Relative to Organic Remains.*

nat. Natural size.

× Magnified in diameter: *e.g.* × 8, magnified eight diameters, &c.

× × Highly magnified; the degree not accurately determined.

inv. Invisible to the naked eye.

— Less than natural: *e.g.* —$^{2}/_{3}$, reduced to two-thirds the diameter of the original.

Lign. Lignograph or woodcut.

Explanation of Terms.—Upon the occurrence of a scientific word apparently requiring explanation, the *meaning*, where practicable, is for the most part given in a parenthesis; for example, Caulopteris (*fern-stem*); Phascotherium (*pouch-animal*); carboniferous (*coal-bearing*); except in the case of arbitrary names, and of those whose derivation cannot be concisely expressed.[8] With the view of rendering these volumes more generally useful, English terminology is in many instances made use of, though involving inelegance of expression.

[8] Upwards of 300 scientific terms are explained in the Glossary, "Wonders," vol. ii. p. 915-921.

The work is divided into four parts: the first is an *Introduction to the Study of Organic Remains*; the second treats of *Fossil Botany*; the third embraces *Fossil Zoology*; and the fourth, under the head of *Geological Excursions*, illustrates the principles enunciated in the course of the work, by practical observations on a few instructive British localities.

PART I.

1. On the British Strata and their Fossils.
2. Arrangement and Characters of the British Formations.
3. On the Nature of Fossils or Organic Remains.
4. On Mineralized Vegetable Remains, and the mode of conducting their investigation.
5. On Peat, Lignite, and Coal.

PART II.

FOSSIL BOTANY.

Classification of Fossil Vegetables.

1. On the Fossil Remains of Cryptogamiæ.
2. " " Diatomaceæ.
3. " " Ferns.
4. " " Sigillariæ.
5. " " Lepidodendra.
6. " " Cycadaceæ.
7. " " Coniferæ.
8. " " Palms.
9. " " Angiosperms.

Retrospect.

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PART III.

FOSSIL ZOOLOGY.

On the Fossil Remains of the Animal Kingdom.

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2. " Polypifera.
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a. Crinoidea, or Lily-shaped animals.
b. Asteriada, or Star-Fishes.
c. Echinida, or Sea-Urchins.
4. Foraminifera.
5. Shell-bearing Mollusca.
6. Articulated animals; comprising
a. Crustaceans.
b. Insects.
7. Fishes.
8. Reptiles.
9. Birds.
10. Mammalia.
11. Man.

Retrospect.

PART IV.

I. GEOLOGICAL EXCURSIONS in various parts of England,
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PART I.

CHAPTER I.

ON THE NATURE AND ARRANGEMENT OF THE BRITISH STRATA, AND THEIR FOSSILS.

> "To discover order and intelligence in scenes of apparent wildness and confusion is the pleasing task of the geological inquirer."—DR. PARIS.

THE solid materials of which the earth is composed, from the surface to the greatest depths within the reach of human observation, consist of minerals and fossils.

MINERALS are inorganic substances formed by natural operations, and are the product of chemical or electro-chemical action.

FOSSILS are the durable remains of animals and vegetables which have been imbedded in the strata by natural causes in remote periods, and subsequently more or less altered in structure and composition by mechanical and chemical agencies.

The soft and delicate parts of animal and vegetable organisms rapidly decompose after death; but the firmer and denser structures, such as the bones and teeth of the former, and the woody fibre of the latter, possess considerable durability, and

under certain conditions will resist decay for many years, or even centuries; and when deeply imbedded in the earth, protected from atmospheric influences, and subjected to the conservative effects of various mineral solutions, the most perishable tissues often resist decomposition, and becoming transformed into stone, may endure for incalculable periods of time. The calcareous and siliceous cases or frustules of numerous microscopic plants are so indestructible, and occur in such inconceivable quantities, that the belief of some eminent naturalists of the last century, that every grain of flint and lime in certain rocks, may have been elaborated by the energies of vitality, can no longer be regarded as an extravagant hypothesis. Some idea may be formed of the large proportion of the solid materials of the globe that has unquestionably originated from this source, by a reference to the list of strata which are wholly, or in great part, composed of animal and vegetable structures, given in the "Wonders of Geology," p. 888.

There are also immense tracts of country that consist in a great measure of the remains of plants in the state of anthracite, coal, lignite, &c.; and districts covered with peat-bogs and subterranean forests.

Although these relics of animal and vegetable organisms are found in almost every sedimentary deposit, yet they occur far more abundantly, and in a better state of preservation, in some strata than in others: nor are they equally distributed throughout the same bed, but are heaped together in particular localities, and occur but sparingly, or are altogether absent, in other layers of the same rock. Neither are the remains of the same kinds of animals and plants found indiscriminately in strata of different ages: on

the contrary, many species are restricted to the most ancient, others to the most recent formations; while some genera range through the entire series of deposits, and also appear as denizens of the existing seas. Hence organic remains acquire a high degree of importance, not only from the intrinsic interest they possess as objects of natural history, but also for the light they shed on the physical condition of our planet in the remotest ages, and for the data they afford as to the successive physical revolutions which the surface of the earth has undergone.

Fossils have been eloquently and appropriately termed MEDALS OF CREATION; for as an accomplished numismatist, even when the inscription of an ancient and unknown coin is illegible, can from the half-obliterated effigy, and from the style of art, determine with precision the people by whom, and the period when, it was struck; in like manner the geologist can decipher these natural memorials, interpret the hieroglyphics with which they are inscribed, and from apparently the most insignificant relics, trace the history of beings of whom no other records are extant, and ascertain the forms and habits of unknown types of organization whose races were swept from the face of the earth, ere the creation of man and the creatures which are his contemporaries. Well might the illustrious Bergman exclaim, "*Sunt instar nummorum memorialium, quæ de præteritis globi nostri fatis testantur, ubi omnia silent monumenta historica*."

To derive from these Medals of Creation all the information they are capable of affording, regard therefore must be had not only to their peculiar characters, but also to the geological relations of the strata in which they are imbedded. Data may be thus

obtained by which the relative age of a formation or group of strata can be determined, as well as the mode of deposition, and the agency by which it was effected; whether in the bed of an ocean, or of a lake, or estuary,—by the action of the sea, or of rivers, or running streams,—by the effects of icebergs or glaciers,—by slow processes through long periods of time, or by sudden inundations or deluges,—or by the agency of volcanoes and earthquakes.

The discovery that particular fossils are confined to certain deposits, was soon productive of important results, which greatly tended to the advancement of modern Geology; for although Dr. Lister, more than a century before, had obtained a glimpse of this law, its principles were neither understood nor regarded in this country until the late Dr. William Smith, by his own unaided exertions, proved by numerous observations on the British strata, its value and applicability for the identification of a deposit, in districts remote from each other.

This phenomenon did not escape the notice of the distinguished French philosophers, MM. Cuvier and Brongniart, who in their admirable work, "*Géographie Minéralogique des Environs de Paris*," enunciated the same principle:—

"Le moyen que nous avons employé pour reconnoitre au milieu d'un si grand nombre de lits calcaires, un lit déjà, observé, dans un canton très-éloigné, est pris de la nature des fossiles renfermés dans chaque couche; ces fossiles sont toujours généralement les mêmes dans les couches correspondantes, et présentent d'un système de couche à un autre système, des différences d'espèces assez notables. C'est un signe de reconnoissance qui jusqu'à présent ne nous a pas trompés."[9]

[9] Géog. Min. Oss. Foss. tom. ii. p. 266.

Now, though recent discoveries have shown that this rule has many exceptions, and that its too stringent adoption has been productive of some erroneous generalizations, yet if employed with due caution it is fraught with the most interesting results, and is the only certain basis of our knowledge respecting the appearance, continuance, and extinction, of the lost races of animals and plants, which were once denizens of our planet.

ROCKS AND STRATA.

In the "Wonders of Geology" will be found a comprehensive sketch of the composition and arrangement of the several formations or groups of strata; and a reference to that work will afford the student the necessary information on this branch of Geology. For the convenience of the general reader I subjoin a synoptical view of the characters and relations of the British fossiliferous deposits.

The total thickness of the entire series of rocks within the scope of human examination, is estimated at from fifteen to twenty miles, reckoning from the summits of the highest mountains to the greatest depths hitherto penetrated; and as this vertical section scarcely amounts to $^{1}/_{400}$th of the diameter of the globe, it is familiarly termed the Earth's crust. The substances of which the sedimentary strata are composed have been deposited by the action of water, and subsequently more or less modified in structure and composition by heat, and by electro-chemical forces. The superficial accumulations of water-worn detritus, consisting of gravel, boulders, sand, clay, &c. are termed *Drift*, or *Alluvial* deposits. When the successive layers in which the sediments subsided are obvious, the deposits are said to be

stratified; when the nature of the materials has been altered by igneous action or high temperature, but the lines of stratification are not wholly effaced, the rocks are denominated *metamorphic* (*transformed*). When all traces of organic remains and of sedimentary deposition are lost, and the mass is crystalline, and composed of known products of igneous action, such rocks are named *plutonic*, as granite, sienite, trap, basalt, porphyry, and the like. Lastly, rocks resembling the lavas, scoria, and other substances emitted by burning mountains still in activity, are called *volcanic*.

The sedimentary origin ascribed to ancient crystalline rocks is, of course, hypothetical, since all evidence of aqueous deposition is wanting, and the minerals (*mica*, *quartz*, and *felspar*) of which they are so largely constituted, are not readily soluble in water under ordinary circumstances. But rocks unquestionably deposited by water, when exposed to intense heat under great pressure, acquire a crystalline structure (*Wond.* p. 864); and a series of changes, from a loose earthy deposit, to compact volcanic lava, may be traced in numerous instances, so as to leave but little doubt that the rocks called primitive or primary, *may* have originally been either argillaceous, siliceous, or calcareous strata, abounding in organic remains (*Wond.* p. 873). These crystalline masses have been formed at successive periods; for granite is found of all ages, occurring in the most ancient, as well as in comparatively modern epochs. The difference between the composition and aspect of these rocks, and those of recent volcanoes, is with much probability ascribed to the fact that the latter are of sub-aerial origin; that is, were erupted on the surface, and the gaseous products in consequence escaped; while the former were ejected

at great depths, either beneath the sea, or under immense accumulations of other deposits, and being thus subjected to great pressure, the volatile elements were confined, and formed new combinations: in like manner as chalk when burnt in the open air is converted into lime, the carbonic acid gas escaping; but when exposed to the same degree of heat in a closed iron tube, is transformed into granular marble (*Wond.* p. 104).

From these ancient crystalline rocks generally underlying the sedimentary deposits, and never appearing as if they had been ejected from a crater, the term *hypogene*[10] (*nether-formed*) is employed by Sir C. Lyell to designate the whole class; and they are subdivided into, 1. *plutonic*, those in which all traces of sedimentary origin are lost, as granite; and 2. *metamorphic*, those which still manifest traces of stratification, as mica-schist, &c.

[10] Nether-formed, from ιπο, *hypo*, under; and γίνομαι, ginomai, to be formed.

The fossiliferous rocks are, for the convenience of study, separated into three grand divisions.

1. The TERTIARY; comprising the deposits between the Chalk and the superficial Drift and modern Alluvium.

2. The SECONDARY; from the *Chalk* to the *Trias or New Red*, inclusive.

3. The PALÆOZOIC; from the *Permian* to the *Silurian*; including the vast series of unfossiliferous slate rocks termed the *Cambrian*, in which all traces of organic remains are lost.

In the following arrangement the strata are enumerated as if lying in regular sequence, one beneath the other; but in nature such an unbroken series has never been observed. A few groups only occur in a serial order, and these but rarely in their original position. The beds are for the most part disrupted, and lie in various angles of inclination; sometimes they are completely retroverted, the newer strata underlying those upon which they were originally deposited. The order of succession has been ascertained by careful observation of the relative superposition of the respective members of the series in different countries; and from an immense number of facts collected by able observers in every part of the globe.

This synopsis presents a chronological arrangement of the rocks according to the present state of geological knowledge, but it must not be supposed that these rigid distinctions, these hard lines, which are necessary to facilitate the acquisition of a general idea of the phenomena attempted to be explained, exist in nature. By whatever names we designate geological periods, there appear to be no clearly defined boundaries between them in reference to the whole earth: such well marked lines may be seen in particular localities, but daily experience teaches us that there is a blending, and a gradual and insensible passage, from the lowest to the highest sedimentary strata, particularly in respect of fossil remains. The terms employed to designate formations can only be considered as expressing the predominance of certain characters, to be used provisionally, as a convenient mode of classifying and generalizing the facts collected, whilst that knowledge is accumulating which in after times will reveal the nature and order of succession of the

principal events in the earth's physical history.[11]

[11] "Wonders of Geology," p. 892.

Dr. Buckland's "Bridgewater Treatise" (Vol. II. *frontispiece*) contains a comprehensive Diagram of the rocks and strata of which the crust of the earth is composed; it was drawn by the late Mr. Thomas Webster.

CHAPTER II.

SYNOPSIS OF THE BRITISH STRATA.

"Hard lines are admissible in Science, whose object is not to imitate Nature, but to interpret her works."—GREENOUGH.

The classification of the stratified rocks is based on three principal characters; namely, 1, the mineral structure; 2, the order of superposition; and 3, the nature of the organic remains; the following synopsis has been drawn up in accordance with these principles.[12]

[12] See "Wonders of Geology," vol. i. pp. 200-207, for a Synoptical Table of the principal rocks.

CHRONOLOGICAL

ARRANGEMENT OF THE BRITISH FORMATIONS.

COMMENCING WITH THE UPPERMOST OR NEWEST DEPOSITS.

Modern or Human Epoch.

ALLUVIAL DEPOSITS: remains of Man and existing species of mammalia.

Post-Pliocene.

DRIFT; Boulder clay; Till; &c. comprising the superficial irregular accumulations of transported materials, consisting of gravel, boulders, sand, clay, &c.

Observations.—These beds have been formed by a variety of causes; by land-floods and inundations, by irruptions of the sea, and by the agency of glaciers and icebergs. They are the catacombs of the extinct colossal mammalia—of the mastodon, mammoth, rhinoceros, hippopotamus, elk, horse, ox, whale, &c. They cannot be definitively separated from those of the Modern or Human epoch, for the gravel beds near Geneva, which closely resemble the newest tertiary drift in materials and position, abound in bones of animals, almost all of which belong to existing species.[13]

[13] See M. Pictet's "*Palæontologie*."

Tertiary Epochs.

An extensive series, comprising many isolated groups of marine and lacustrine deposits, containing fossil remains of animals and vegetables of all classes; the greater number of genera and species in the most ancient or lowermost beds belong to extinct types.

Subdivisions:—

1. The PLIOCENE[14] (*more new*, or *recent*.[15] *Wond.* p. 221); strata in which the shells are for the most part of recent species, having only about ten per cent of extinct forms. (*Norwich Crag.*)

2. The MIOCENE (*less recent*,[16] *Wond.* p. 221); containing about 20 per cent of recent species of shells. (*Suffolk Crag.*)

3. The EOCENE (*dawn of recent*,[17] in allusion to the first appearance of recent species—*Wond.* p. 226); the most ancient tertiary strata contain but very few existing species of shells; not more than five per cent. (*London, Hants, and Paris basins.*)

[14] In the present state of our knowledge, this arrangement is of great utility, but it will probably require considerable modification, and must, perhaps, hereafter be abandoned; for it cannot be doubted, that strata in which no recent species have yet been found, may yield them to more accurate and extended observations, and those in which only a few recent species are associated with a large number of extinct forms, may have these proportions reversed.

[15] From πλειων, *pleion*, more; and καινος, *kainos*, recent.

[16] From μείων, *meion*, less, and recent.

[17] From ἠως, *eos*, the dawn or commencement, and *recent*.

Obs.—The marine are often associated with fresh-water deposits, and the general characters of the Tertiary system are alternations of marine and lacustrine strata. In England the most important Tertiary deposits are those of the London basin, the Isle of Sheppey, the south-western coasts of Sussex and Hampshire, the

north of the Isle of Wight, and the eastern coasts of Essex, Norfolk, Suffolk. (*Wond.* p. 226.)

Secondary Epochs.

THE CRETACEOUS or CHALK FORMATION. (*Wond.* p. 296). A marine formation, comprising a vast series of beds of limestone, sandstone, marl, and clay, &c.; characterized by remains of extinct zoophytes, mollusks, cephalopods, echinoderms, crustaceans, fishes, &c.; lacertians, crocodilians, chelonians, and other extinct reptiles; drifted coniferous and dicotyledonous wood and foliage, fuci, &c.

Subdivisions:—

1. The *Maestricht beds*. Friable coralline and shelly limestones, with flints and chert.
2. *Upper Chalk*, with flints } *Craie blanche* of the French geologists.
3. *Lower Chalk*, without flints
4. *Chalk-marl* — *Craie tufeau.*
5. *Firestone*, Malm-rock, Upper Greensand, or Glauconite } *Glauconie crayeuse.*
6. *Galt*, or Folkstone-marl — *Glauconie sableuse.*

7. *Shanklin*, or Lower Greensand—*Formation néocomien*; which is divided into *N. supérieur*, the English upper divisions of the Greensand or Kentish rag; and *N. inférieur*, the lower beds of sand and clay, of the southern shore of the Isle of Wight, at Atherfield. [18]

[18] Another subdivision, with *other* names (chiefly derived from French localities), has lately been proposed by M. D'Orbigny; which I notice with the more regret, since this eminent naturalist formerly repudiated the censurable practice of many modern systematists, of changing established names of strata and fossils, without any just cause. The British geologist will smile to see the Wealden Formation—so eminently distinguished in England and Germany by its extent, thickness, and remarkable fauna and flora,—ranked as a subordinate member of the "*Formation néocomien*," of France.

Obs.—The Maestricht beds are chiefly composed of fawn-

coloured limestones of friable texture; containing peculiar species of corals, shells, fishes, reptiles, &c. The *Chalk* is generally white, but in some localities is of a deep red, in others of a yellow colour; nodules, layers, and veins of flint occur in the upper, but are seldom present in the lower chalk. The *Marl* is an argillaceous limestone, which generally prevails beneath the white chalk; it sometimes contains a large intermixture of green or chlorite sand, and then is called *Firestone*, or *Glauconite*. The *Galt* is a stiff, blue or blackish clay, abounding in shells which frequently retain their pearly lustre. The *Greensand* is a triple alternation of sands and sandstones with clays; and beds of cherty limestone called *Kentish Rag*.

The WEALDEN; a formation, whose fluviatile character was first observed and established by the researches of the author (*Wond.* p. 360). A series of clays, sands, sandstones and limestones, with layers of lignite, and extensive coal-fields; characterized by the remains of several peculiar terrestrial reptiles, namely, *Iguanodon*, *Hylæosaurus*, *Pelorosaurus*, *Megalosaurus*; *Crocodilians* and *Chelonians*; *Enaliosaurians*; *Pterodactyles*, &c.; Fishes of fluviatile and marine genera; Insects of several orders; fresh-water mollusks and crustaceans; conifers, cycads, ferns, &c.

Subdivisions:—

1. *Weald-clay*, with Sussex or Petworth marbles.
2. *Tilgate-grit*, and *Hastings sands*.
3. *Ashburnham clays*, shales, and grey limestones.
4. *Purbeck beds*; argillaceous and calcareous shales, and fresh-water limestones and marbles. Petrified forest, and layers of vegetable earth; with Cycads and Conifers.

Obs.—Clays and limestones, almost wholly composed of fresh-water snail-shells, and minute crustaceans, generally occupy the

uppermost place in the series in Sussex; sands and sandstones, with shales, and lignite, prevail in the middle; while in the lowermost, argillaceous beds, with shelly marbles or limestones, again appear; and, buried beneath the whole, is a petrified pine-forest, with the trees still erect, and the vegetable mould undisturbed! The upper clay beds and marbles form the deep valleys or Wealds of Kent and Sussex, and the middle series constitutes the Forest-Ridge. The Purbeck strata are obscurely seen in some of the deepest valleys of eastern Sussex; they emerge on the Dorsetshire coast, form the Island or Peninsula whose name they bear, and surmount the northern brow of the Isle of Portland. On the southern coast of the Isle of Wight, the Wealden beds emerge from beneath the Greensand strata between Atherfield and Compton Bay on the western limit, and in Sandown Bay on the eastern; and their characteristic fossils are continually being washed up on the sea-shore.

THE JURASSIC OR OOLITIC FORMATION. (*Wond.* pp. 202, and 491). A marine formation of great extent and thickness, consisting of strata of limestone and clay, which abound in extinct species and genera of marine shells, Corals, Insects, Fishes, and terrestrial and marine Reptiles. Land plants of many peculiar types, and the remains of two genera of MAMMALIA.

Subdivisions:—

Upper Oolite of Portland, Wilts, Bucks, Berks, &c.

1. *Portland Oolite.* Limestone of an oolitic structure, abounding in ammonites, trigoniæ, &c. and other marine exuviæ. Green and ferruginous sands—layers of chert.
2. *Kimmeridge clay.* Blue clay, with septaria, and bands of sandy concretions—marine shells and other organic remains—*ostrea deltoidea*. Beds of lignite.

Middle Oolite of Oxford, Bucks, Yorkshire, &c.

1. *Coral oolite*, or Coral rag. Limestone composed of corals, with shells and echinites.
2. *Oxford clay*; with septaria and numerous fossils. Beds of calcareous grit, called *Kelloway-rock* swarming with organic remains.

Lower Oolite of Gloucestershire, Oxfordshire, and Northamptonshire.

1. *Cornbrash*—a coarse shelly limestone.
2. *Forest marble*; concretions of fissile arenaceous limestone—coarse shelly oolite —sand, grit, and blue clay.
3. *Great oolite*—calcareous oolitic limestone and freestone; reptiles, corals, &c., upper beds full of shells.

Stonesfield slate;—terrestrial plants, insects, reptiles, *Mammalia*.

4. *Fullers earth beds*;—marls and clays, with fuller's earth—sandy limestones and shells.
5. *Inferior oolite*—coarse limestone—conglomerated masses of terebratulæ and other shells—ferruginous sand, and concretionary blocks of sandy limestone, and shells.

Lower Oolite, of Brora in Scotland.

1. *Shelly Limestones*—alternation of sandstones, shales, and ironstone; land-plants.
2. *Ferruginous limestone*, with carbonized wood and shells.

3. *Sandstone and shale; with two beds of coal.*

Lower Oolite of the Yorkshire coast.

1. *Cornbrash*—a provincial term for a bluish grey rubbly limestone, with intervening layers of clay.
2. *Sandstones and clays*, with land-plants, thin beds of coal and shale—calcareous sandstone and shelly limestone.
3. *Sandstone*—often carbonaceous, with clays; coal-beds, and ironstone, with remains of vegetables.
4. Limestone; ferruginous and concretionary sands.

Obs.—The difference observable between the lower beds of the Oolite in the midland counties, and those of Yorkshire and Scotland, is a fact of considerable interest. The fluvio-marine accumulations of vegetable matter in the state of coal, with the remains of land-plants at Scarborough and Brora, together with the presence of insects, fresh-water crustaceans, mammalia, and terrestrial plants, in the Stonesfield slate, attest the existence of neighbouring land, and the action of rivers and currents.

THE LIAS. (*Wond.* p. 521) A series of clays, shales, and limestones, with marine shells, cephalopoda, crinoidea , and fishes in great abundance; reptiles, (particularly of two extinct genera, *Plesiosaurus*, and *Ichthyosaurus*,) in immense numbers. Drifted wood and land plants: coniferæ, cycadesæ &c.

Subdivisions:—

1. Upper Lias shale, full of saurian remains, belemnites, ammonites, &c. intercalated with the lowermost beds of the Oolite: nodules and beds of limestone.

2. Lias marlstone; calcareous, sandy, and ferruginous strata, very rich in terebratulæ and other marine shells.
3. Lower Lias clay and shale, abounding in *gryphea incurva*, and other marine shells; intercalations of sands and clays, with nodules of limestone.
4. Lias rock; a series of laminated limestones, with clay partings. Bone-bed, with numerous remains of fishes.

Obs.—The Lias is the grand depository of those tribes of marine reptiles, the *Ichthyosauri* and *Plesiosauri*, whose remarkable forms, structure, and state of preservation, have excited the attention even of the most incurious. The collection of these remains in the British Museum, principally formed by Mr. Hawkins, is unrivalled. [19]

[19] See "Petrifactions," p. 337-367.

THE TRIAS; or NEW RED SANDSTONE FORMATION,[20] (*Wond.* p. 533). This group of rocks consists of variegated marls, sandstones, and conglomerates, frequently of a red colour, with marine shells, crinoideans, fishes, and reptiles; marine and terrestrial plants. This series contains extensive deposits of rock-salt, and brine-springs.

[20] Called by some geologists *Poikilitic* (variegated) group.

This formation comprises the *Trias*, or triple group, *viz.* the *Keuper*, *Muschelkalk*, and *Upper Bunter Sandstein*, of the German geologists.

Subdivisions:—

1. Variegated red, blue, and white marls, and shales, with gypsum and beds of rock-salt. (*Marnes irisées* of the French.)

2. Variegated red and white sandstones.
3. Conglomerates formed of the detritus of the older rocks.
4. Bed mottled sandstone, and marls. (*Grès bigarré* of the French.)

Obs.—To this formation belong the principal deposits in Leicestershire and other midland counties of England. Fossils are not generally abundant, but some localities yield highly interesting remains. The shelly limestone of Germany, called Muschelkalk, which contains the *Lily Encrinite*, &c. does not occur in England. Remains of Conifers allied to the Yew and Araucaria, are found near Coventry; and peculiar reptiles (*Labyrinthodons*) near Warwick.

Palæozoic Epochs.

The PERMIAN FORMATION. (*Wond.* p. 533). The separation of the strata now termed *Permian* from the *Triassic*, with which they were formerly classed, was first proposed by Sir Roderick Murchison, and is based on the fact that the fossils hitherto discovered are entirely distinct from any that occur in the Trias and subsequent formations; it is, therefore, inferred, that after the deposition of the so-called Permian strata, a complete change took place in the faunas and floras of the lands and seas, and the Trias is *at present* regarded as the dawn of a new system of organic beings.

The strata comprised in this group are variegated blue and red marls and sandstones, like those of the Triassic; magnesian or dolomitic limestones; and conglomerates more or less coloured with peroxide of iron.

Subdivisions:—

1. Red and white marls.

2. Yellow magnesian limestones, and dolomitic conglomerates of Yorkshire and Durham.
3. Marl-slate in thin layers, containing reptiles and fishes. The Keuper schiefer or copper-schist of Mansfeld.
4. Marls and variegated sandstones, sands, and clays.

Obs.—This group includes the *Lower Bunter*, *Zechstein*, and *Rothliegendes*[21] of the German geologists. The *Permian* comprises all the deposits that intervene between the Triassic above, and the Carboniferous below; and it is believed that this formation contains but one type of animal and vegetable life.

[21] Signifying *Red-dead-layer*; it is a German mining term denoting that the copper of the upper bed has died out; this layer not being metalliferous.

THE CARBONIFEROUS, or COAL FORMATION. (*Wond.* pp. 660-748). Sandstones, grits, shales, layers of ironstone, and clay, with immense beds of coal; fresh-water limestones sparingly; marine limestones abundantly.

Subdivisions:—

1. *The Coal Measures.*—Sandstones, shales, and grits, with numerous beds and seams of Coal; ironstone nodules. Land plants in profusion. Intercalations of bands of limestone with fresh-water bivalves and crustaceans in some districts; and with marine shells in others.

2. *Millstone Grit.*—Sandstones, shales, and quartzose conglomerates and grit, (*provincially*, Millstone-grit): with shales and thin seams of coal, and plants of the coal-measures in some localities. The conglomerates and grits have evidently resulted from the destruction of granitic rocks.
3. *Carboniferous*, or *Mountain Limestone*.—A series, nearly 1,000 feet in thickness, of limestones and flagstones, abounding in crinoideans, corals, and marine shells and crustaceans; with layers and nodules of chert. Ores of lead, zinc, copper, barytes; fluor spar, &c. Limestones, with innumerable shells of the genera Productus, Spirifer, Goniatites, Orthocera, Bellerophon, &c. Several varieties of black, bluish grey, and variegated marbles. Coal occurs in the mountain limestone of some parts of Russia.

Obs.—The strata comprised in the carboniferous (coal-hearing) system, consist of sandstones more or less felspathic, and of dark bituminous shales with innumerable ferns, and other vascular cryptogamiæ, and coniferæ, &c. The uppermost group is composed of numerous alternations of coal, clay, shale, ironstone, and sandstone; the middle, of sandstones, shales, clays, and quartzose conglomerates, generally of a dull red colour; and the lowermost, of crystalline limestones with occasional layers of chert, abounding in marine shells, corals, crinoidea, and other exuviæ. These lower limestones are the principal repositories of the lead ores of Derbyshire.

THE DEVONIAN or OLD RED FORMATION. (*Wond.* pp. 204 and 751). Conglomerates, quartzose grits, sandstones, marls , and limestones; the prevailing colour is a dull red. Shells, corals, and ganoid fishes, of a very peculiar type. Reptiles, (TELERPETON;

Batrachians? Chelonians?); the most ancient reptilian remains hitherto discovered. *Ferns*, *Lepidodendrons*, and other trees of the carboniferous flora; fluviatile plants with batrachian ova(?).

Subdivisions:—

1. Sandstone, quartzose conglomerates, and shale, with but few fossils.
2. Flagstones, marls, and concretionary limestones; provincially termed *corn-stones*; laminated reddish and greenish micaceous sandstones (*prov. tilestones*). Peculiar genera of fish; orthocerata, and many species of marine shells.

Obs.—The term Devonian, by which the series of strata comprehended in this formation is now generally distinguished by geologists, was first proposed by Sir R. Murchison, as being more precise than the name formerly applied to this group. In Scotland, where the formation is of vast extent, it was first characterized by its peculiar ganoid fishes (Pterichthys, Coccosteus, Cephalaspis), and will probably always there retain the original name of Old Red.[22] In Devonshire it is marked by the presence of shells of a character intermediate between those of the Silurian and Carboniferous systems.

The sandstones are in various states of induration, and when slaty, are employed for roofing. The red colour predominates in the marls, and is derived from peroxide of iron. The formation of these rocks has manifestly resulted from the waste of ancient slate rocks, the detritus of which is cemented together into coarse conglomerates. In South Devonshire (at Torquay, Babbicombe, &c.), beautiful coralline marbles occur in this formation.

[22] See the charming volume of Mr. Hugh Miller, entitled "The Old Red Sandstone, or New Walks in an Old Field."

THE SILURIAN SYSTEM. (*Wond.* p. 765). Marine limestones, sandstones, shales, and calcareous flagstones, characterized by peculiar types of corals,

crinoideans, mollusks, and crustaceans, constitute this important and extensive system of rocks; the *Grauwacké*, or Transition series of the earlier geologists.

Subdivisions:—

UPPER SILURIAN.

1. *Ludlow rocks*;—slightly micaceous grey-coloured sandstones. Blue and grey argillaceous limestones. Dark-coloured shales and flagstones, with concretions of earthy limestone, containing marine shells, Orthocerata, Spirifers, and Trilobites. *Fishes.*
2. *Wenlock*, or *Dudley limestone*;—sub-crystalline blue and grey limestone, abounding in Trilobites, Crinoidea, Polyparia, Spirifers, Orthocerata, &c.
3. *Wenlock shale*;—dark grey argillaceous shale, with nodules of sandstone.

LOWER SILURIAN.

1. *Caradoc sandstone*;—shelly limestones, and finely laminated, slightly micaceous, greenish sandstones. Corals, Shells, Trilobites.
2. *Llandeilo flags and limestones.* Freestone, conglomerates, grits, and limestones. Dark-coloured flags. Beds of schist with abundance of Trilobites and shells. The lowermost beds are full of small bivalves, termed *Lingulæ.*

Obs.—The *Silurian System*, (so named by Sir R. Murchison, from

the *Silures*, the ancient Britons who inhabited those parts of our island in which the geological relations of these strata were first recognised by him,) occupies the border counties of England and Wales, and spreads over a vast area of both North and South Wales, intervening between the Carboniferous series and the Cambrian or ancient slate-rocks of that country.[23] The strata are entirely of marine origin, and many of the beds (as the well-known Dudley or Wenlock limestone) are composed of shells, corals, crinoideans, and remains of that remarkable family of crustaceans termed Trilobites, cemented together by carbonate of lime. A few remains of Fishes occur: Reptiles are unknown. No vegetable relics, excepting *Fuci*, have been found in Britain below the *Devonian* or *Old Red formation*.[24]

[23] "THE SILURIAN SYSTEM, founded on Geological Researches in the Border Counties of England and Wales." In two parts, royal 4to., with map, sections, &c., by Sir R. I. Murchison, G.C. St.S. &c. In studying the beautiful map which accompanies the work, it must be borne in mind that ten years have elapsed since Sir R. Murchison abrogated the boundary line that separates the Cambrian and Silurian rocks in this chart, from the conviction that those deposits constitute but one natural system (see *Wond.* p. 803). For an account of the Silurian rocks of other countries, see "GEOLOGY OF RUSSIA," by the same Author. A summary of the characters of the Silurian System, by Sir R. Murchison, is given in *Geolog. Journal*, vol. viii. pp. 173-183.

[24] "THE SILURIAN SYSTEM" contains excellent figures of all the organic remains known at the period of its publication.

The CAMBRIAN FORMATION. This term is applied to a largely developed series of unfossiliferous slate-rocks and conglomerates, many thousand yards in thickness.

Obs.—Certain beds of dark-coloured schists containing a few

corals, fuci, and shells, are referred to the uppermost part of this formation by some eminent geologists, but it is more consonant to the established system of classification to regard these fossiliferous beds as the lowermost of the Silurian rocks. The fineness of grain, general aspect, hardness, and texture of these strata, are well known, from the general employment of slate for economical purposes. These rocks extend over a great part of Cumberland, Westmoreland, and Lancashire, reaching to elevations of 3,000 feet, and giving rise to the grand scenery of the Lakes, and of North Wales.

Hypogene Rocks. (*Wond.* p. 806.)

Non-fossiliferous.

METAMORPHIC (*transformed*) or stratified crystalline rocks.

Subdivisions.—

1. *Mica-schist System.* (*Wond.* p. 843.) Probably sedimentary rocks altered by high temperature. Mica-slate, Quartz-rock, Crystalline limestone, Hornblende schist, &c.
2. *Gneiss System.* Layers of Gneiss, Sienite and Quartz-rock, alternating with Clay-slate, Mica-schist, &c.

PLUTONIC ROCKS; unstratified crystalline masses.

Granitic System. (*Wond.* p. 844.) Granite—a rock composed of mica, quartz, and felspar; Porphyry; Serpentine; Trap. These rocks occur in amorphous or shapeless masses, and in dykes and veins.

> *Obs.*—No fossils have been detected in these rocks: but the intense igneous action which the masses appear to have undergone, may have obliterated all evidence of animal and

vegetable structures, should any have been present, as well as the lines of stratification. By the aid of the microscope, we may yet perhaps solve the mystery which shrouds the origin of these rocks, and the student may take up the investigation with the certainty of obtaining much valuable information, even should the search for organic structures prove abortive. It is not, however, improbable that the siliceous frustules of diatomaceæ may have escaped destruction, and remain to reward the researches of some skillful and patient observer.

Volcanic Rocks. (*Wond.* p. 806.)

The products of subterranean fire or heat, erupted from profound depths through fissures in the Earth's crust, whether in ancient or modern times.

Subdivisions.—

1. *Trap, Basalt, Toadstone, Volcanic-tuff*; the erupted materials of ancient extinct volcanoes.
2. *Lavas, Scoriæ, Pumice, Ashes*; ejected by modern volcanoes.

Obs.—These igneous products are of all ages, and they traverse alike the hypogene rocks and the older and newer sedimentary deposits. Their characters, and the effects they have produced, are considered in the work to which reference is made.

By a reference to the geological map of England (*Wond.* pl. i. vol. i.), it will be seen, that the several formations appear on the surface in a somewhat chronological order, as we pass from the eastern or south-eastern part of the Island to the west or north-west. Thus the principal Tertiary deposits are situated in the eastern and south-eastern parts; and proceeding towards the north-west, we traverse successively the *Secondary*—the *Chalk*, *Oolite*, *Lias* and *Trias*; then the *Palæozoic*—*Permian*, *Carboniferous*, and *Devonian*; next the *Silurian* and

Cambrian; and at length *metamorphic* and *primary* rocks appear. It is this distribution of the strata of the respective formations that has determined the characters of the physical geography of England. The Alpine or mountainous districts, which extend north and south along the western portion of England and Wales, from Cornwall to Cumberland, are formed by the elevated masses of the Silurian, Cambrian, and Metamorphic rocks. These are succeeded by a band of the Carboniferous and Triassic deposits, with a few intrusions of metamorphic and plutonic rocks, that stretches from the coast of Devonshire, through the midland counties, by Leicestershire and Derbyshire, to Newcastle. On the south-east of this tract, the Oolite and Cretaceous formations, chiefly made up of argillaceous and calcareous strata, constitute a diversified agricultural district, extending from the southern shores of Hants and Dorset to the coast of Yorkshire. The Wealden occupies the country lying between the Chalk Downs of Sussex, Hants, Surrey, and Kent. The Tertiary deposits lie in basins or depressions of the upper cretaceous rocks in the south-eastern and eastern maritime districts, and on an extensive area of these beds stands the metropolis of England; lastly, irregular accumulations of Drift, containing mammalian remains in some localities, are spread over the surface of the ancient formations, and form the immediate subsoil of the most fertile regions.

CHAPTER III.

ON THE NATURE OF FOSSILS, OR ORGANIC REMAINS.

FOSSILS; PETRIFACTIONS.—It is very generally the case, that persons who are not conversant with the nature of organic remains, suppose that all fossils are petrifactions; and unless a specimen has the aspect and hardness of stone, they regard it as of modern origin, and devoid of interest. Hence they are surprised to find among the choicest treasures in the cabinet of the geologist, shells and corals as perfect in form, as if recently collected from the sea-shore; bones as little changed, as if they had been interred but for a short period; and teeth possessing their sharp edges and enamel unimpaired. In my early researches I fell into this error, and threw away many beautiful shells that were associated with casts of ammonites in the marl at Hamsey, supposing, from their perfect state, that they had been accidentally imbedded, and were not genuine fossils. But the state of preservation, and the degree of change which an organic body has undergone in the mineral kingdom, have no necessary relation to its antiquity. The shells in some of the ancient secondary strata are frequently as little changed as those in modern tertiary deposits. I have collected from the lowermost clays of the Wealden, fresh-water shells with traces of the epidermis, and the ligament by which the valves were held together, perfect; and bones of reptiles from the strata of Tilgate Forest, as light and porous as those of the bears and hyenas, from the Caverns of Germany. On the other hand, fossil remains from the newest tertiary formations are often completely petrified, that is, permeated by, or transmuted into, stone.

The words *fossil* and *petrifaction* are so commonly used as synonymous terms, even by educated persons, that it is necessary to define the sense in which they are employed in these volumes.

Fossils are the durable parts of animal and vegetable structures imbedded in rocks and strata by natural causes at a remote period; thus wood in a state of lignite, bog-wood, and coal, or of siliceous or calcareous stone, is *fossil wood*; and bones or shells, whether in an earthy and decaying state, or permeated by calc-spar, flint, or iron, and converted into a hard mineral substance, are alike *fossil bones* or *shells*.

Petrifactions are the remains of animals and vegetables in which the original structure is converted into stone, or, in other words, is *petrified*; such are the silicified stems of trees from Antigua, and Germany, and the calcified bones and shells in the Oolitic and Wealden limestones. Such petrifactions may be correctly termed fossil plants, bones, or shells; but similar organic remains, though of equal antiquity, which have not undergone such changes, are not petrifactions in the proper meaning of that term.

The process by which petrifaction is effected is still involved in obscurity; mineral solutions have permeated the original tissues, and the organic molecules have been replaced by mineral molecules, but how this transmutation is produced is not understood. Mr. Dana's observations and Mr. Jeffery's experiments have, however, thrown much light on the process of silicification.[25]

[25] See *Wond.* p. 100.

Incrustations.—Another prevalent error is that of considering Incrustations to be fossils or petrifactions; a mistake which is sanctioned by the custom of calling waters that are charged with calcareous earth (*lime*), and deposit it in considerable quantity, petrifying springs; as those of Matlock, and other places in Derbyshire. (*Wond.* p. 76.) But incrustations are not petrifactions; stems and branches of trees, skulls, bones, shells, &c., are simply invested with a calcareous coating or crust, which is generally porous and friable, but often crystalline and compact. The inclosed bodies are not permeated by the stony matter; if the mass be broken, or the incrustation removed, we find the twig, or stem, either dry and shrivelled, as in the specimens, figs. 2, 3, 4, Plate III.; or tubular cavities are left by the decay and removal of the vegetable structure, as in fig. 10, Plate III.

But although incrustations be not petrifactions, natural specimens, (not the so-called petrified nests and twigs, in which the bad taste of the guardians of the Derbyshire springs is embodied, and dispersed all over England,) are objects of considerable interest, as illustrative of a process, by which important changes are effected in the mineral kingdom. Thus springs as clear and sparkling as poet ever feigned or sung, may transform beds of loose sand and gravel into rock, and porous stone into solid marble, and cover extensive tracts of country with layers of concretionary and crystalline limestone. This process is effected in the following manner. Most fresh water holds in solution a certain proportion of carbonate of lime; and changes of temperature, as well as other causes, will occasion this calcareous earth to be in part or wholly precipitated. The *fur*, as it is called, that lines a kettle or boiler which has been long in

use, affords a familiar illustration of this fact. At the temperature of 60° lime is soluble in 700 times its weight of water; and if to the solution a small portion of carbonic acid be added, a carbonate of lime is formed, which is thrown down in an insoluble state. But if the carbonic acid be in such quantity as to supersaturate the lime, it is again rendered soluble in water: it is thus that carbonate of lime, held in solution by an excess of carbonic acid, not in actual combination with the lime, but contained in the water, and acting as a menstruum, is commonly found in all waters. An absorption of carbonic acid, or a loss of that portion which exists in excess, will therefore occasion the lime to be set free, and precipitated on the foreign bodies in the water, as stones, twigs, leaves, &c.

The substance thus deposited is termed *tufa*, or travertine;[26] and in some parts of Italy, and of our own Island, it constitutes beds of stone of great extent, in which bones, shells, and the impressions of leaves and stems, are preserved. The stalactites and stalagmites of caverns have a similar origin; many of these caves are of incalculable antiquity, and beneath their stalagmitic floors, the bones and teeth of extinct carnivorous animals are found in vast quantities.

[26] *Travertine*, so called from the river *Tibur*, whose waters are loaded with calcareous earth—*Tiburtina*, Ital. *travertina*.

SILICIFICATION, or petrifaction by Silex or Flint.—Silex, or the earth of flint, is held in solution in large proportions, in certain thermal or boiling springs, which, on cooling, deposit the siliceous matter (in the same manner as the travertine is precipitated from incrusting streams) on foreign substances, and produce exquisite chalcedonic infiltrations of mosses,

&c. But this operation is now only known to be in activity in the immediate neighbourhood of foci of volcanic action, as in the celebrated Geysers of Iceland (*Wond.* p. 95), and the boiling springs of the volcano of Tongariro, in New Zealand (98). We have everywhere evidence that in former periods, the petrifaction, as well as the incrustation of organic bodies by silex, was carried on to an immense extent; and, doubtless, far beneath the surface, the same operation is at the present moment in constant progress, and effecting as important changes in the consolidation of loose materials, as in the earlier geological epochs.

The various states in which silex occurs have depended on its fluidity; in quartz crystals the solution appears to have been complete; in agate and chalcedony it was in a gelatinous state, assuming a spheroidal or orbicular disposition, according to the motion given to its particles. Its condition appears also to have been modified by the influence of organic matter. In some polished slices of siliceous nodules the transition from flint to agate, chalcedony, and crystallized quartz, is beautifully shown. The curious fact, that the cavities of echinites in chalk are almost invariably filled with flint, while their crustaceous cases are changed into calc-spar, is probably, in many instances, to be attributed to the animal matter having undergone silicification; for the soft gelatinous parts are those which appear to have been most susceptible of this transmutation. In some specimens, the oyster is changed into flint, while the shell is converted into crystallized carbonate of lime. In a Trigonia from Tisbury, formerly in the cabinet of the late Miss Benett, of Norton House, near Warminster, the body of the

mollusk was completely metamorphosed into a pure chalcedony, the branchiæ or gills being as clearly defined as when the animal was recent. In specimens of wood from Australia (presented to the British Museum by Sir Thomas Mitchell), which are thoroughly permeated by silex, there are on the external surface some spots of chalcedony that have apparently originated from the exudation of the liquid silex from the interior in viscid globules filled with air, which burst, and then collapsed, and became solidified in their present form.

In silicified wood the permeation of the vegetable tissues by the mineral matter, appears to have been effected by solutions of silex of a high temperature. In some examples the mineralization is simply a replacement: the original substance has been removed atom by atom, and the silex substituted in its place.

One of the most eminent naturalists and chemists of the United States, Mr. Dana,[27] suggests that the reason why silica is so common a material in the constitution of fossil wood and shells, as well as in pseudo-morphic crystals,[28] is the ready solution of silex in water at a high temperature (a fact affirmed by Bergman[29]) under great pressure, whenever an alkali is present, as is seen at the present time in many volcanic regions, and its deposition again when the water cools. A mere heated aqueous solution of silica, under high pressure, is sufficient to explain the phenomenon of the silicification of organic structures. Mr. Dana states that a crystal of calc-spar in such a fluid being exposed to solution, from the action of the heated water alone, the silica deposits itself gradually on a reduction of

temperature, and takes the place of the lime, atom by atom, as soon as set free. Every silicified fossil is an example of this pseudo-morphism; but there seems to be no union of the silica with the lime, for silicate of lime is of rare occurrence.[30]

[27] American Journal of Science for January 1845.

[28] Pseudo-morphic crystals are crystals moulded in the cavities left by other crystals which they have replaced. See Dr. Blum on Pseudo-morphous minerals.

[29] Bergman first determined the solubility of silex in simple water, aided by heat, and demonstrated its existence in the Geysers and other boiling springs of Iceland.—*Parkinson, Org. Rem.* vol. i. p. 324.

[30] See my "Notes on a Microscopical Examination of Chalk and Flint," Annals of Natural History, August 1845.

I proceed to consider the various states in which the remains of animals and plants are preserved in the mineral kingdom, and shall occasionally offer suggestions for collecting and preparing specimens; but particular instructions on this head will be given in the sequel, when the different kinds of fossils are respectively considered.

FOSSIL ANIMAL REMAINS.

ANIMAL REMAINS.—Of the higher orders of animals, the more durable portions of the skeleton, as the bones and teeth, are almost the only parts that occur in a fossil state; except in some remarkable instances, in which entire carcasses of extinct species

of Elephant, and of Rhinoceros, have been found imbedded in solid ice, and frozen gravel. (*Wond.* p. 152.) The countries of arctic regions are now the only localities in which such phenomena are likely to be met with; it appears, however, that in some remote period, the bodies of large mammalia were transported by icebergs into temperate regions, where the ice melted, and the animals either sunk to the bottom of the sea, or were drifted into estuaries, or stranded on the shore: the soft parts then decomposed, and the skeletons and detached bones were left imbedded in the silt, sand, or shingle.

In this manner alone can be explained the occurrence of bones and teeth of the mammoth, rhinoceros, hippopotamus, &c. so common in the alluvial or drifted deposits of this country; for these relics, though extremely friable, and buried in shingle, boulders, and other transported materials, are not water-worn, but in numerous instances remain as sharp and perfect as when recent. In the ancient shingle of Brighton cliffs (*Wond.* p. 114), I have found bones and teeth of horse, deer, ox, whale, &c. impacted with quartz and granite pebbles and boulders; the bones, though crumbling to pieces if not very carefully removed, being entire, and the whole mass held together by calcareous spar, deposited by water that had, during the lapse of ages, percolated through the chalk-rubble above.

Fossil bones are found in four different states: 1. With their animal matter, as in the bones of the Mastodons from Big-bone Lick, Kentucky. 2. With the animal matter removed. 3. With the earthy matter partly removed, 4. With the animal matter carbonized, or converted into bitumen; this change is common in the blue Lias clay; the bones retain their

usual quantity of phosphate of lime, but the animal matter is converted into carbon. This alteration appears to have taken place unconnected with a high temperature, and to have been a spontaneous change in a moist situation, to which air had no access.[31]

[31] Mr. Smee, London Med. Gazette, November 1840.

Another, and very remarkable condition, is that in which the phosphate of lime has been removed by the infiltration of water charged with sulphuric or carbonic acid, and the gelatin converted into leather by tannin; as is the case with bones and teeth of deer, horses, &c. obtained from a submerged forest of oak, larch, &c. near Ferry-bridge, in Yorkshire; of which there are many instructive specimens in the York Museum.[32]

[32] Communicated by Professor John Phillips.

The cancellated structure (that is, the little cells or pores) of the long-bones of mammalia, found in caverns in England and Germany, and in the breccia of Gibraltar, and the conglomerates of Ava and the Sub-Himalaya mountains, &c., are often filled with crystallized carbonate of lime. In the Wealden deposits the osseous carapaces and plastrons of Turtles, and the bones and teeth of Crocodiles, Lizards, &c., are almost without exception heavy, and of various shades of brown or umber, from the infiltration of solutions of carbonates and oxides of iron.

In some instances, bones of a jet black are imbedded in the white calciferous grit; the phosphoric acid in the original organism having combined with iron and produced a deep blue or

black phosphate of that mineral, and left the surrounding stone uncoloured.

Petrifaction by the infiltration of calcareous solutions is equally common; and the medullary cavities of the bones are frequently lined or filled with white calc-spar; brilliant pyrites also enters into the composition of these fossils, frosting over with a golden metallic deposit the cavities and fissures.

FOSSIL BONES.

The permeation of the teeth by mineral matter, produces beautiful examples of the tissues of those organs; the dentine is often stained throughout with a rich sienna tint, and sections viewed under the microscope by transmitted light, reveal the character and distribution of the calcigerous tubes more clearly even than in recent specimens.

It is extremely rare that osseous structures are found petrified by flint; among the many thousands of bones which I have extracted from the rocks, or have seen in collections, I know but of one instance of a silicified vertebra, that of a Mosasaurus, from a chalk-pit near Brighton; and a few bones and scales of fishes. But notwithstanding the weight and apparent solidity imparted by these modes of mineralization, the substance is generally rendered extremely brittle, so that the development of the bones from the stone in which they are imbedded, and the removal of the hard ferrugino-calcareous crust investing them, is no easy task, but requires much tact, experience, and patience, to execute successfully.

HINTS FOR COLLECTING FOSSIL BONES.—The light, friable, porous bones, require great care in

their removal from the deposit in which they are imbedded, whether it be clay, consolidated shingle, or limestone; if of considerable size, they will almost invariably break to pieces, and many examples will not admit of repair. It is therefore always desirable, before attempting to extract a large bone, to make a sketch of it; its form will thus be known, should it be destroyed; and if it crack into fragments that will admit of reunion, the drawing will be a valuable guide for the replacement of the separated parts. If only a few pieces remain, those which show any portion of the terminations, or joints, should be preserved, as they afford the most precise and important characters. The faithful record even of an imperfect and unknown fossil is not without value; and as the antiquary carefully preserves shreds of ancient manuscripts, in the hope that other documents may one day come to light, and enable him to interpret these now unintelligible records; so the geologist should treasure up every fragment of an undetermined organic remain, for the time may arrive, as I have often experienced, when specimens will be discovered that may illustrate its nature, and prove it to be of considerable interest.

The broken porous bones may be easily repaired by a hot weak solution of glue; and when the joinings are set, the bone should be saturated with thin glue, well brushed in, and the surface be sponged clean with very hot water before the cement is congealed. When dry, the specimens will be found to possess considerable firmness and durability.[33] By this process the tusks of mammoths and elephants may be restored, however much crushed; time, patience, and a little dexterity, only are required, to convert a heap of mere fragments into a valuable relic of the ancient world.

[33] A liquid, called "Neuber's liquid glue," is an excellent cement for this purpose: it is sold at No. 54, New Oxford Street, London.

When the bones are tolerably perfect, but dry and friable from the loss of their animal oil, they may be made durable by saturating them with drying oil, and exposing them to a considerable degree of heat; in this manner the magnificent skeletons of the sloth tribe, the Megatherium, and Mylodon, in the Hunterian Museum, were prepared. When a bone appears as if cracked into numerous pieces before its removal, but still preserves its form, the only method by which it can be successfully extracted, is by spreading over it a thick layer of plaster of Paris, which should be used of the consistence of cream; when it sets, (which, if the plaster be recently prepared, will be in the course of a few minutes,) the specimen may be carefully extricated, and the plaster removed or not, according to the nature of the fossil, and the parts to be displayed. The bones of the large reptiles which occur in the Wealden and Oolite, may be restored in the same manner. These remains are generally very brittle, and when imbedded in hard grit cannot be extracted whole: they will often fall to pieces on the slightest blow of the hammer or chisel. When of moderate size, it is best not to attempt their removal from the stone, but to trim the block into a convenient shape, and carefully chisel away the surrounding part, so as to expose the essential characters of the bone. In all cases this is an excellent method where practicable, for such specimens have a double interest; they are at once illustrative examples of the fossil, and of the rock in which it was deposited.

But many specimens will not admit of this

method; and with large ones it is inconvenient and undesirable, except where bones lie in juxtaposition. The large examples in Tilgate grit, (figured in the Fossils of Tilgate Forest,) were all extracted piecemeal from the rock: and most of the gigantic bones of the Iguanodon, &c. now in the British Museum, were originally in many hundred pieces, and were cemented together with glue in the manner above described; I have found no other method so convenient and effective.

When a bone is too imperfect to be united as a whole, it may be imbedded in Roman cement, or plaster of Paris, which when dry may be coloured of the prevailing tint of the rock. For large heavy specimens, the cement is preferable; it is of easy application, and the fissures and cracks of the bones may be filled up with it, taking care first to cover the parts with thin hot glue, or the cement, when it dries, will shrink and fall out. A thin coating of mastic varnish will restore the colour, and by excluding the air, tend to preserve the specimens.

The teeth have generally undergone the same changes as the bones with which they are associated. The teeth of elephants or mammoths that are imbedded in loose calcareous earth, like the loam and chalk-rubble of Brighton cliffs, and of Walton in Essex, are friable, and apt to split and separate in the direction of the vertical plates of dentine and bone: the pieces should be glued together, and when set, the tooth be thoroughly saturated with thin glue, used very hot, and the superfluous cement removed with a sponge wrung out as dry as possible from boiling water. If there be any portion of the jaw attached to the teeth, it must be carefully preserved; and search should be made for fragments of the

articulations, or parts of the joints and sockets.

In argillaceous strata, as the Lias-shale, London Clay, &c., the fossils are frequently saturated with brilliant pyrites, or sulphuret of iron; a mineral which decomposes upon exposure to the atmosphere, and occasions the destruction of the specimens. The fossils of the Isle of Sheppey are peculiarly obnoxious to this change.

FOSSIL ANIMAL REMAINS.

The remains of vertebrated animals in the Lias, very often occur as skeletons more or less perfect, the entire configuration of the original being preserved in many instances (*Bd.* pl. 7. *Petrifactions*, p. 340). But the deposit in which they lie is generally laminated, and the shale flakes off without great care; much time, labour, and practice are therefore required, to obtain specimens of any considerable size. To the late Miss Mary Anning, of Lyme Regis, the merit is due, of having first accomplished this difficult task; Mr. Hawkins has subsequently carried the art to perfection, as may be seen in the marvellous examples of Ichthyosauri and Plesiosauri, in the British Museum.[34]

[34] Petrifactions, Room IV. chap. iv. pp. 341, 376.

The small specimens, such as the detached paddles, groups of vertebræ and ribs, &c., that are likely to come under the collector's notice in his personal researches, are not difficult of preservation. Mr. Hawkins employed a strong watery solution of gum arabic as the cement, and plaster of Paris as the ground, using shallow wooden trays of well-seasoned wood, in which the specimens were permanently

imbedded: the bones, scales, &c. were then varnished with a solution of mastic, and the ground coloured bluish grey, to imitate the Lias. I have had considerable practice in the dissection of skeletons imbedded in Lias, and having found the method previously described answer every purpose, have not employed that recommended by Mr. Hawkins.

The scales of reptiles and fishes, either in connected masses or detached, are frequently met with in great perfection, and sometimes associated with the teeth and bones. In the Lias, even the remains of the skin and integuments (*Bd.* pl. 10) have been discovered. Whenever any part of a skeleton is found lying in shale or stone, the surrounding block should therefore be carefully examined, to ascertain if there be traces of the skin or integuments, before any part is removed by the chisel. The specimen of an Ichthyosaurian paddle, figured in the second volume of this work, affords a good illustration of the propriety of this caution. Around the bones are seen the carbonized remains of the cartilaginous fringe that supported the integuments, and thus the perfect form of the paddle has been ascertained; had the surrounding stone been chiselled away, the most important characters would have been obliterated, as probably they have been in numerous instances.

Nodular masses of indurated clay containing fishes, are often broken with difficulty in such a manner as will expose the enclosed fossil, for the nodule generally splits in various directions, and the specimen is irreparably mutilated or defaced. My friend Sir Woodbine Parish informs me that by subjecting such nodules to a high temperature—but not to a red heat—and then plunging them in cold

water, they may when dry, by a properly directed blow of a hammer, be readily fractured in a direction parallel with the plane of the imbedded fossil, and the fish be laid bare in the most favourable position.

The scales of fishes, and the integuments of marine reptiles, are not the only vestiges of the dermal coverings of vertebrated animals that are preserved by mineralization. Traces of the wing-integument of flying reptiles, and of the feathers of birds, are sometimes manifest: and even when every atom of the original structure has perished, the impression may remain, and afford satisfactory results. The footmarks of unknown animals are often preserved in the rocks, and the imprints of the feet of several species of bipeds, presumed to be birds of colossal size, in tracks as distinct as if but recently made, have been discovered in the New Red sandstone of North America; in the section on fossil birds, this highly interesting subject will be fully explained.

The student, even from this brief review, will perceive how many valuable facts may be unnoticed, and irretrievably lost, unless attention be paid to the various circumstances under which fossil remains are presented to his notice.

Of the invertebrated orders, the most durable, and consequently the most numerous relics, are shells and corals. The integuments of the eyes, antennæ, and wings of Insects occur; and the shelly coverings of Crustaceans are not uncommon; those of the Echinoderms, the Star-fishes, and of the Crinoidea or Lily-animals, are very abundant in certain deposits. Instructions for the collection and arrangement of these fossils will be given in the

chapters in which they are severally described.

PART II.

CHAPTER IV.

FOSSIL BOTANY.

FOSSIL VEGETABLES.—The remains of the vegetable kingdom are presented to the notice of the geologist in various conditions; in some instances these relics are but little changed in their aspect, as, for example, in the recent accumulations of mud and silt, at the bottoms of lakes and rivers, and in morasses, and peat-bogs. In tufaceous incrustations, the imprints of wood, and of leaves and stems, are often sharply defined on the solid masses of concretionary and crystalline limestone.

In the ancient deposits, vegetables are found in two different states. In the one their substance is completely permeated by mineral matter; it may be calcareous (*lime*), siliceous (*flint*), ferruginous (*iron*), or pyritous (*sulphuret of iron*); and yet both the external characters, and the internal structure, may be preserved. Such are the fossil trees of the Isle of

Portland, fragments of which so closely resemble decayed wood, as to deceive the casual observer, until by close examination of their texture and substance he finds that they possess the weight and hardness of stone. In the silicified wood which abounds in many of the tertiary strata, the most delicate tissues of the original are preserved, and by microscopical examination (see Pl. V.) may be displayed in a distinct and beautiful manner. In calcareous fossil wood the structure is also retained; and in many limestones, leaves and seed-vessels are well preserved.

The ligneous coverings, or the husks and shells, of nuciferous fruits, and the cones or strobili of Firs and Pines, are frequently met with in an excellent state of preservation; in some rare instances indications of flowers have been observed (*Lign.* 67). The parts of fructification in some of the fern tribe (*Lign.* 25 and 27), occur in coal-shale, and in the grit of Tilgate Forest (*Wond.* p. 394): the pollen, and the resinous secretions of pines and firs, have been discovered in tertiary marls, and in the Greensand. The well-known substance. Amber, so much in request for ornaments, is unquestionably of vegetable origin; it has been found impacted in the trunks of its parent trees (*Wond.* p. 242). The *fossil resin* discovered in the London clay, at Highgate and the Isle of Sheppey, is doubtless referable to the coniferæ found in that deposit.

In the Clathrariæ of Tilgate Forest, indications of a resinous secretion have been detected.

The *Diamond*, which is pure charcoal, is probably a vegetable secretion, that has acquired a crystalline structure by electro-chemical forces. It has been

converted into *Coke* and *Graphite* by the action of intense heat; and the electrical properties of the substance were changed, the Diamond being an insulator, and the Coke, a conductor of electricity. (*Wond.* p. 706.)

When the microscope is more extensively employed in investigations of this kind, it is probable that the siliceous spines and stars which begem the foliage of many plants (as the *Deutzia*, *Lithospermum officinale*, &c), will be discovered in a fossil state, for they are as indestructible as the frustules of Diatomaceæ, and the spicules of sponges which are so common in flint and chalcedony.

FOSSIL VEGETABLES.

But vegetables occur not only as petrified stems, leaves. and fruits, associated with other remains in the strata, but also in beds of great thickness and extent, consisting wholly of plants transmuted, by that peculiar process which vegetable matter undergoes when excluded from atmospheric influence, and under great pressure, into *Lignite*, and *Coal*. And there are intermediate stages of this process, in which the form and structure of the trees and plants are apparent; and a gradual transition may be traced, from the peat-wood and submerged forests of modern epochs, in which leaves, fruits, and trunks of indigenous species are preserved, to those ancient accumulations of carbonaceous matter, whose vegetable origin the eye of science can alone detect.

For the collection and preservation of fossil vegetables, with the exception of those which are permeated with. pyrites (as those of the Isle of Sheppey, &c.), but few instructions are required. The

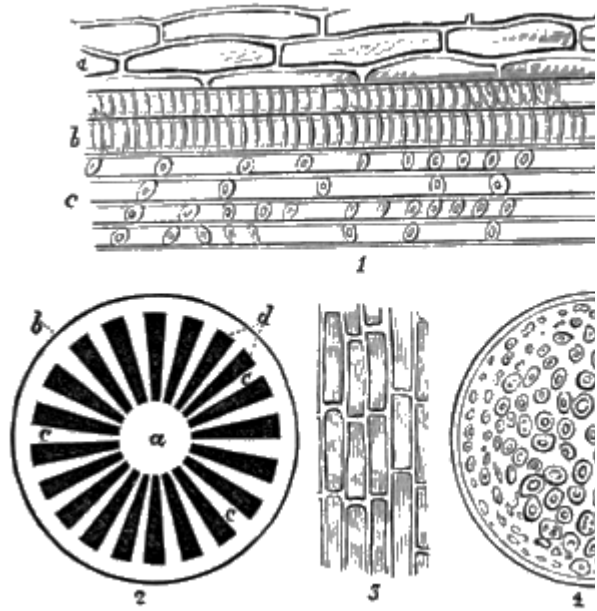
silicified and calcareous stems are generally easy of extraction, even when imbedded in hard stone, and if broken can be repaired with glue. When the stems bear the imprints of leaf-stalks (as in *Lign.* 31 and 54), the surrounding stone should be carefully examined, with the view of detecting impressions, or other indications of the foliage. Delicate leaves in clay, or shale, must not be washed; a thin coat of mastic varnish, or of gum-water, applied with a camel-hair pencil, will preserve them, and render them more distinct. When a leaf, fruit, seed-vessel, or other fragile object is attached to clay or friable sandstone, it is advisable to glue the specimen to a piece of thin wood or pasteboard, of suitable proportions.

The Sheppey fruits and other fossils permeated with iron pyrites, generally decompose after a few months' exposure to the air. The fruits, especially, are liable to decomposition; Mr. Bowerbank keeps his specimens in bottles of water; a solution of isinglass in spirits of wine is the best varnish to preserve such fossils, without obscuring their character and injuring their appearance: but even this method is often unavailing. The pyritified fir-cones of the Wealden decompose in like manner: I have had the misfortune to lose several unique and most instructive specimens from this cause; boiling them in linseed oil preserves them, but greatly impairs their appearance.

ON THE INVESTIGATION OF THE FOSSIL REMAINS OF VEGETABLES.

VEGETABLE ORGANIZATION.—As fragments of the stems, trunks, and branches, are very often the only

vestiges of fossil plants, a knowledge of the characters by which the principal divisions of the vegetable kingdom may be distinguished by their internal structure, is indispensable to the successful investigation of the Flora of the ancient world. Although I have treated of this subject in the Wonders of Geology, (*Wond.* p. 694,) it will here be necessary to present the student with more ample details. The excellent introductory botanical works of Dr. Lindley, and Professor Henslow, convey full information on this, and every other department of the science, and should be consulted by those who intend to make this branch of Geology their particular study. For the general reader, and amateur collector, the following brief notice of a few obvious essential characters of vegetable organization, may perhaps afford sufficient information, to enable them to understand the principles on which the successful investigation of the nature and affinities of fossil plants must be conducted.



LIGN. 1. SECTIONS OF RECENT VEGETABLES; illustrative of their inte
Lindley.)

Fig. 1.— Longitudinal Section of Coniferous Wood.
a. The Ducts,
b. Spiral Vessels,
c. Glandular vessels.

2.— Transverse section of a dicotyledonous stem.
a. Pith, or central column.
b. The bark.
c. Medullary rays.
d. Vascular tissue between the medullary rays.

3.— Elongated cellular tissue, forming the medullary rays.

4.— Transverse section of a monocotyledonous stem.

STRUCTURE OF VEGETABLES.

Every plant is essentially an aggregation of cells; [35] and the most simple forms of vegetation consist of a congeries of cells (*cellular tissue*) of the same kind, and have no visible fructification; such are the

sea-weeds (*algæ*, *conferæ*, &c.), mosses, and lichens. In the more complex tribes the cells become variously modified, are elongated into tubes or vessels (*vascular tissue*), some of which possess a spiral structure, and others have their sides studded with little glands. The vascular tissue consists of two kinds of vessels. 1. The *spiral vessels* or *tracheæ*: these are membraneous tubes, with conical extremities, having within a coil of elastic fibre spirally twisted, and capable of being unrolled (*Lign.* 1, *b.*). 2. The *ducts*; which are a modification of the structure of the spiral vessel; their extremities are rounded or conical, and their sides marked with transverse lines, rings, or bars. Their functions appear to be different from those of the spiral vessels, and they are found in situations where the latter never occur.

> [35] "A *cell* in botanical language, means a little bag composed of membrane, and containing a living substance capable of spontaneous growth by multiplication, or division of its parts. Of such little bodies, millions of which may be contained within the space of a cubic inch, all the soft parts of vegetables are composed; in sea-weeds they are often of large size."—Dr. Harvey's Sea-side Book, with which the reader is doubtless familiar.

The organization of the stem in the whole class of flowering plants, possesses characters so evident, as to afford the most important aid in the investigation of their fossil remains. Without dwelling on minor modifications, they are separable into two divisions, namely, the Endogenous (signifying *to grow from within*), and the Exogenous (*to grow from without*). Both possess vascular tissue, but so differently arranged in the two classes, as to constitute

distinctive characters which are seldom obliterated, although what was once a flexible stem, is now a mass of flint.

ENDOGENOUS STEMS.—As the seeds of the plants belonging to this division have but one cotyledon, or *seed-lobe*, as the Lily, they are also termed monocotyledonous; the reader therefore must remember that these terms are synonymous. These stems consist of an uniform mass of cellular tissue, in which bundles of vascular or woody fibre are imbedded; a transverse section presents a surface dotted over with spots, produced by the division of these groups of vessels, pretty uniformly distributed, but more densely arranged towards the circumference (*Lign. 1, fig. 4*). A slice of cane affords an illustration of this structure.

The increase of these stems is effected by the formation of new cells and bundles of vessels in the central axis, which force their way among the old tissue, and occasion the condensation of the latter towards the outer edge. These plants have neither pith, concentric circles of woody fibre, nor true bark; negative characters of the highest importance in the determination of fossil stems.

EXOGENOUS STEMS.—The seeds have two cotyledons, or seed-lobes, as in the Bean, hence the plants of this class are also called dicotyledonous. In these stems the cellular tissue forms a central column, or pith (*Lign. 1, fig. 2, a.*), and an external band, or cylinder, called the bark (*fig. 2, b.*); the two being connected by thin vertical plates, termed medullary rays, which are also formed of cells (*fig. 2, c, c.*); the diagram, *Lign. 1*, exhibits this arrangement. The interval between the pith and the bark, and the

interspaces of the vertical radiating plates (*fig. 2, d.*), are filled up by woody fibre or vascular tissue, consisting of spiral and other vessels. The ligneous structure of exogenous stems consists, therefore, of a cylinder formed of wedge-shaped processes, that extend between the medullary rays to the pith, and is surrounded by the bark; a new zone of woody fibre is added annually between the bark and the former cylinder, and from this mode of increase the term *exogenous* is derived: a transverse section of a branch of oak or ash will show this structure. The rings, or concentric circles, are the annual zones of wood; the fine lines radiating from the centre, or pith, to the circumference, or bark, are the medullary rays (*Lign. 1, fig. 2, c*: see also *Plate V. fig. 4*).

The organization above described, will be found more or less manifest in fossil wood, stems, and branches. The monocotyledonous structure is beautifully displayed in the silicified stems of palms from Antigua (*Plate V. fig. 1, 1ª.*): and the dicotyledonous, in petrified trees from Egypt. The pith, medullary rays, vascular tissue, and circles of growth, are preserved in the siliceous and calcareous wood found in many parts of England.

STRUCTURE OF CONIFERÆ.

STRUCTURE OF CONIFERÆ (*cone-bearing*).—The remains of a numerous family of dicotyledonous trees, termed *Coniferæ*, as the pine, fir, larch, &c., are so abundant in the stratified rocks, that it is necessary to describe in more detail the peculiarity of structure by which their stems and branches may be recognised. The most delicate woody tissue, as we have above stated, consists of elongated cells or tubes, of two kinds: in the one, the membrane of

which they are composed is smooth: in the other, the walls of the tubes are covered by little oval or circular bodies called glands (*Lign. 1, fig. 1, c.*). A branch of larch or pine, split longitudinally, and viewed by a powerful lens, will exhibit the appearance here described. This glandular structure is so constantly and largely developed in the coniferæ, that although it is also possessed by other aromatic trees, we shall rarely err in referring fossil wood in which this organization is apparent, to this family of vegetables (see *Plate V. figs. 2, 3*). These glands in the pines and firs, are supposed to be the cells which secrete a colourless volatile oil, that exudes in the state of turpentine.

From this general account of the vegetable structures that may be expected to occur in the mineral kingdom, the student will in some measure be prepared for the investigation of fossil trees and plants; but for the guidance of those who are wholly unacquainted with the principles on which the Natural System of Botany adopted in this work, is founded, I am induced to present the following concise view of the principal divisions of the vegetable kingdom, though it involves some repetition.

BOTANICAL PRINCIPLES.

The following summary is given nearly in Dr. Lindley's own language:—

BOTANICAL PRINCIPLES.—One of the first things that strikes an inquirer into the structure of plants, is the fact, that while all species are capable of propagating their race, the mode in which this function is effected is essentially different in different cases. In most tribes of plants, flowers are produced,

and these are succeeded by fruit, containing seed, which is shed, or scattered abroad, and grows into new individuals. But in certain families (the *Cryptogamia*), as Ferns, Mosses, Mushrooms, and the like, neither flowers, nor seeds properly so called, have been detected; but propagation is effected by the dispersion of grains or spores, which are usually generated in the substance of the plant, and seem to have but little analogy with true seeds. Hence the vegetable kingdom is separated into two distinct groups, namely, the *flowering* (*Phanerogamia*), and the *flowerless* (*Cryptogamia* or *Agamia*). As the former usually possess a highly developed system of spiral and other vessels, while the latter are either altogether destitute of them, or have them only in a few of the highest orders, and those in a peculiar state, the flowering plants are termed Vasculares, and the flowerless *Cellulares*. And as all the flowering, or vascular plants, when they form stems, increase by an extension of their ends, and a distension or enlargement of their circumference, but the flowerless or cellular plants form their stems simply by the addition of new matter to their points, the latter are called *Acrogens*, signifying increase from the summit.

Flowering plants are also for the most part furnished with respiratory or breathing organs (*stomata*), of which the flowerless vegetables are to a great extent destitute.

The flowering or vascular plants are also divisible into two well marked groups, namely, the *Exogens*, or *Dicotyledons*, and the *Endogens*, or *Monocotyledons*.

The EXOGENS (growing from without), increase by the addition of new woody matter to the outside

of the stems beneath the bark; and they are further characterized by the embryo having two or more cotyledons, or seed-lobes, hence they are also called *Dicotyledons*; such as the Elm, Beech, &c.

The ENDOGENS, as we have previously stated, increase by the addition of ligneous matter to the inside of their stems near the centre; and as the embryo in this class has but one cotyledon, they are likewise termed *monocotyledons*, as the Cane, Palm, &c. Again, exogenous plants have the young external wood connected with a central pith, by medullary processes; while endogens do not possess such a structure, having no central pith. In exogens the veins (venation) of the leaves, are disposed in meshes, like net-work, but in endogens the veins run parallel to each other.

The number of parts in the flower of an exogenous plant is usually five, or its multiples: in the endogens it is commonly three, or its multiples. In the germination, the young root of exogens is a mere extension of the radicle; but in endogens it is protruded from within.

Thus, in the flowering or vascular plants, we have two groups distinct from each other in their germination, the structure of their stems and leaves, their mode of growth, the arrangement of the parts of the flower, and in the structure of the embryo.

The vegetable kingdom is thus separated into three natural classes,—1, the *Exogens*, 2, the *Endogens*, 3, the *Acrogens*; but there are likewise other divisions, a knowledge of which is of great importance in the study of fossil botany; the sub-class termed GYMNOSPERMS especially requires notice.

In the strictly exogenous and endogenous plants, the fertilizing principle is communicated to the young seeds through the medium of a *stigma* and *style*, that terminate the case or pericarp in which the seeds are enclosed: but in another important group of the vegetable kingdom, the pollen is directly applied to the ovule, without the intervention of any pericarpial apparatus; hence these are termed *Gymnosperms*, signifying naked seeds. These plants have the same relation to the other exogens, as frogs and analogous reptiles bear to the other orders of their Class; they comprise the two natural orders *Coniferæ*, and *Cycadaceæ*.

The Gymnosperms also possess peculiarities of a subordinate nature: thus, many kinds have more than two cotyledons, and are therefore termed *polycotyledons*; again, the radicle usually adheres to the albumen in which the embryo lies, hence they are sometimes named *Synorhiza*. The veins of the leaves (in those whose leaves are veined), are either simple or forked; in which respect they approach the endogens on the one hand, and the acrogens on the other.

This concise definition of the natural divisions of the vegetable kingdom will enable the reader to comprehend the botanical principles which must guide him in his attempt to explore the ancient floras, whose fossil remains are generally found in a very fragmentary condition.

I need only add that M. Ad. Brongniart, in his great work on Fossil Plants, arranges the vegetable kingdom into five classes, viz.:—

1. Cellular Cryptogamia,[36] or Amphigens.

2. Vascular Cryptogamia,[37] or Acrogens.

3. Monocotyledons.[38]

4. Gymnospermous Dicotyledons.[39]

5. Angiospermous Dicotyledons.[40]

[36] Plants having the fructification concealed, and of cellular structure only.

[37] Plants having the fructification concealed, and with vessels, or vascular tissue.

[38] Flowering plants with one cotyledon; the Endogens.

[39] Plants with naked seeds; that is, destitute of a pericarp or case.

[40] Plants with the seeds in a receptacle or pericarp, with a style and stigma.

ON THE MODE OF INVESTIGATING FOSSIL REMAINS OF VEGETABLES.

INVESTIGATION OF FOSSIL PLANTS.

The distinguished authors of the British Fossil Flora justly remark, that a few isolated, and very imperfect data, exclusively afforded by the remains of the organs of vegetation, are but too often the sole guide to the class, order, or genus of the fossil plants which the geologist has to examine; hence, in most instances, a general idea only can be obtained of the nature of the original.[41] To facilitate the study of Fossil Botany they offer some practical suggestions, which have served as the basis of the following directions for the investigation of vegetable remains, and which the previous remarks will, we trust, render intelligible.

[41] Foss. Flor. vol. I. p. xxvi.

1. *The Trunk, or Stem.*—Examine if the wood in a transverse section be disposed in concentric circles (as *Plate V. fig 4*): if so, it belonged to an exogenous tree: if, on the contrary, the wood appears deposited

irregularly in spots (*Lign. 1, fig. 4*), then the original was endogenous. If a transverse section show remains of sinuous, unconnected layers, resembling arcs with their ends directed outwards, and of a solid structure, and imbedded among looser tissue, then it belonged to an arborescent fern; see the subjoined figures (*Lign. 2*).



LIGN. 2. SECTIONS OF FERN-

Transverse sections (half the diameter) of two stems of recent Arb
disposed in arcs. This structure is seen in the silicified trunks from Che

INVESTIGATION OF FOSSIL STEMS.

If the stem be in a state of preservation that will admit of the slicing or chipping off a piece for microscopical investigation, the process described at the conclusion of this section should be employed.

The following data may be thus obtained. If the structure be entirely cellular, and it can be satisfactorily ascertained that it never possessed vascular tissue, the original belonged to the *Cryptogamia*; *i.e.* to fuci, mosses, and the like.

If it consist of parallel tubes, and has neither pith, nor rays passing from the centre to the circumference, the tree or plant was *endogenous*, like the Palm. If any trace be present of tissue crossing the longitudinal tubes at right angles, and radiating from the centre to the circumference, this will prove the existence of medullary rays, and the original must have been *exogenous*, as the Oak, Elm, &c.: and if in a transverse section the tubes appear of equal size, the tree was probably *coniferous*, or *cycadeous* (*i.e.* related to the plants called *Cycas* and *Zamia*); but if larger tubes appear among the smaller ones, disposed in a definite manner (see *Plate V. fig. 4*), it belonged to some other tribe of exogenous plants.

If the walls of the tubes be studded with glands (*Lign. 1, fig. 1, c*; *Plate V. figs. 2b 3b*.); the fossil belongs to the Coniferæ.

If any vestige of a central pith be discovered, the exogenous nature of the original is undoubted, for no other class, as we previously stated, possesses a central cellular column.

The absence or presence of a true cortical investment, or bark, is important, for a distinct bark is the characteristic of the *exogenous* class:[42] a cortical integument, or rind, not separable from the enclosed structure, indicates the *monocotyledons*; and the entire absence of any rind, the *cryptogamia*.

[42] An apparent exception to this rule is found in the fossil genus Clathraria, described hereafter, which has a distinct hollow cortical cylinder, that separates from the internal axis: this is not true bark, but is formed by the consolidation of the bases of the petioles or leaf-stalks; see *Lign. 54*.

The markings on the stems, occasioned by the scars or cicatrices left by the separation of the petioles or leaf-stalks (as on the stalk of a cabbage), afford important evidence, since they are commonly present, even when the cylindrical trunk is compressed into a flat thin layer of coal; as we shall often have occasion to remark. In this place it need only be stated, that by these scars may be detected the position of the leaves, and the form of the bases of the petioles or leaf-stalks; their probable direction, whether they were opposite, alternate, verticillate or spirally disposed, deciduous or persistent, imbricated or remote. Even when no traces of the leaves remain, the origin of the branches, and their bifurcation, may perhaps be determinable.

2. *The Leaves.*—In a fossil state the texture and surface of the leaves are sometimes preserved; but in general the outline of the leaf, its division and arrangement, and its mode of venation, can alone be ascertained. The *venation*, that is, the form and distribution of the vascular tissue, or vessels, through the leaf, is the most important character for our guidance; and Dr. Lindley offers the following suggestions on this point. If the veins be all parallel, not branched, or only connected by little transverse bars, and the leaves undivided (as in the Lily or Hyacinth), the plant was probably endogenous; but if the leaf be divided or pinnated, it may be referable to Cycadeæ (*Lign. 45*).

Leaves having the veins of equal, or nearly equal thickness, and dichotomous (*forked*), or very fine, and simply divided, belong to the fern tribe; to this division an immense proportion of the foliage found in the carboniferous strata is referable; the genera of fossil ferns have been constructed principally from

the venation.

If the veins of a leaf be obviously of unequal thickness, and reticulated, or disposed in net-like meshes, as in the rose and apple, the original was dicotyledonous (*Plate III, figs. 4, 8*).

Leaves of a large size, destitute of veins, and irregularly divided, probably belong to fuci, or other marine plants (*Lign.* 10).

Such are the rules for the investigation and interpretation of the characters of stems and foliage, which have been preserved by mineralization. Their application is not difficult, and the student may by their assistance obtain some general indications as to the nature of the original trees or plants, whose petrified remains form the subject of his examination.

ON THE MICROSCOPICAL EXAMINATION OF FOSSIL VEGETABLES.

MICROSCOPICAL EXAMINATION.

Mr. Nicol, who first suggested the method now generally adopted for preparing fossil wood, coal, &c. for microscopical examination, and which was employed by Mr. Witham in the illustrations of his beautiful work on the structure of fossil plants,[43] has so clearly explained the process, that by a little practice the student will be able to prepare specimens sufficiently thin for every useful purpose. Several lapidaries in London, (see list at the end of this work,) polish and mount fossil vegetables and other substances, in a very superior manner; but their charges are high, and they frequently injure

specimens by grinding them too thin, and thus obliterating structure. I would recommend that a small chip of the specimen, if possible in a *radial* direction, should be examined by reflected light, always beginning with the lowest object-glass and eye-piece, and ascending to the highest power; at first without any preparation;[44] subsequently the object should be immersed in oil of turpentine, which will render it somewhat transparent, and it then should be examined by transmitted light. By this exploration we may detect structure, and ascertain if the specimen be worth the trouble or expense of further preparation.

[43] Observations on Fossil Vegetables. 4to. 1833.

[44] The drawings in *Plate V. figs.* 2 and 3, of fossil coniferous wood, were from chips seen by reflected light, and without any preparation.

Coal may be prepared for examination, by removing with a sharp knife a thin pellicle, or a minute scraping; immerse it in a drop of oil of turpentine on a piece of glass; then add a little Canada balsam, and hold the glass over the flame of a lamp till the balsam is spread evenly over the specimen. But without any preparation, the surface of coal recently broken may be successfully investigated. One of the most interesting examples of coniferous structure in coal that my cabinet contains, was discovered by my son in a piece lying on the fire, which had been cracked by the heat; and I have another fragment, showing the spiral vessels, and coniferous glands, which the Rev. J. B. Reade obtained under similar circumstances. But for choice

specimens, the following method is to be employed; and in many cases no other plan will succeed. Sections of teeth, bone, marble, &c. may be prepared by a like process.

MODE OF PREPARING SLICES OF FOSSIL WOOD FOR MICROSCOPICAL EXAMINATION.

"Let a thin slice be cut off from the fossil wood, in a direction perpendicular to the length of its fibres—the slice thus obtained must be ground perfectly flat, and polished. The polished surface is then to be cemented to a piece of plate glass (3 in. long and 1 in. wide) by Canada balsam—a thin layer of balsam must be applied to the polished surface of the slice, and also to one side of the glass—the slice and the glass are now to be laid on any thin plate of metal, and gradually heated over a slow fire, or a spirit lamp, to concentrate the balsam. The heat must not be so great as to throw the balsam into a state of ebullition; for if air bubbles be formed, it is difficult to get rid of them, and if not removed they will prevent the complete adhesion of the two surfaces when applied to each other; the heat of the metal should never be so great that the fingers may not be held in contact with it for a few seconds without inconvenience. When air bubbles are formed, they should be displaced by a small piece of wood tapering to a point; when the balsam is thought to be sufficiently concentrated, and all the air bubbles have disappeared, the slice and glass may be taken from the heated metal, and pressed closely together; a slight degree of pressure will suffice to expel the super-abundant balsam, and this will be facilitated by gently sliding the specimen to and fro on the

glass; by this kind of motion any air that may have got entangled when the two surfaces were brought in contact, will also be removed. When the whole is cooled down to the temperature of the air, and the balsam has become solid, that part which adheres to the surface of the glass surrounding the slice should be scraped off with the point of a penknife; and by this operation, it will at once be seen whether the balsam has undergone the requisite concentration; for if it flakes off before the knife, it will be found that the slice and glass will cohere so firmly, that in the subsequent grinding, there will be no risk of their separating from each other; but if the balsam has not been sufficiently concentrated, it will slide before the knife, and in that case the two bodies will not adhere with requisite firmness. If the layer of balsam applied to the two surfaces be not too thick, its due concentration will be accomplished in four or five minutes, provided the application of the heat be properly regulated. The slice must now be ground to that degree of thinness which will permit its structure to be seen by the help of a microscope. This will be accomplished by rubbing the slice, by a rapid circular motion with the hand, on a piece of sheet lead, supplied with a little emery (*size* No. 1.) moistened with water; when the emery ceases to act, the muddy matter remaining should be removed, and a fresh portion of emery applied; this must be repeated until the surface of the slice is perfectly flat; a sheet of copper must then be substituted for the lead, and the fossil ground as smooth as possible by flower of emery, freed from its coarser parts. The surface may then be polished by friction, with *crocus* or rotten stone, on a transverse section of any soft wood."[45]

[45] Mr. Witham, Observations on Fossil

Vegetables.

CHAPTER V.

ON PEAT-WOOD, LIGNITE, AND COAL.



LIGN. 3. NODULE OF IRONSTONE INCLOSING A FERN-LEA
Coalbrook Dale.

Fig. 1.— The nodule in its natural state.
2, 3. The same, split open longitudinally. The leaf remains attache
— the impression of its upper surface is seen on fig. 3.
4.— Outline of the form of the leaf, which is a species of Pecopte

PEAT-WOOD, LIGNITE, AND COAL.

Before entering upon the examination of the specific and generic characters of fossil plants, and the natural relations of the extinct forms with those of the existing Floras, it will be requisite to notice

those vast beds of vegetable matter, in various states of carbonization, which occur in the palæozoic, secondary, and tertiary formations.

SUBMERGED FORESTS. PEAT.—The phenomenon of extensive tracts of marsh-land, with layers of prostrate trees of all ages, lying but a few feet beneath the common alluvial soil, is of frequent occurrence, both inland, and in many places along the shores of our island. (*Geol. S. E.* p. 18). These submerged forests are generally situated below the level of the sea, and afford unquestionable proof of subsidences of the land. The trees are of the kinds indigenous to the districts in which they occur; and leaves and seeds of the hazel, beech, elm, &c. are often preserved in the silt in which the prostrate forests are imbedded. On the Sussex coast there are accumulations of this kind, at Bexhill, Pevensey levels, Felpham, &c.

The extensive subterranean forests exposed in the Fens of Lincolnshire by the operations carried on for draining that district, must be familiar to those who travel by the Great Northern Railway: the protruding upright stems, broken off at a short distance above the primitive soil, will remind the geological observer of the petrified forest of the Isle of Portland.

The wood in these cases has undergone no change but that of being dyed black, by an impregnation of solutions of iron; and many trunks are in so sound a state as to be employed in building. The oak timbers of the Royal George, lately raised up from off Portsmouth, after being immersed in silt about sixty years, closely resemble in colour and texture the wood of the submerged forests. Skeletons of deer, horse, swine, &c. are occasionally found

imbedded in these subterranean accumulations of vegetable remains; and sometimes canoes, formed of the trunk of an oak, constructed by the aboriginal inhabitants of Britain, with stone implements called celts, are met with at considerable depths.

In the peat-bogs of Ireland (*Wond.* p. 66), large forest trees often occur, together with the skeletons of the elk, deer, and other animals of the chase; and in a few instances the bodies of the primitive hunters, wrapped in skins, have been discovered.

In Belfast Lough, a bed of peat is situated beneath the ordinary level of the waters, but is generally left bare at the ebb tides. Trunks and branches of trees, with vast quantities of hazel nuts, are imbedded in the peat; the whole being covered by layers of sand, and blue clay, or silt. In most cases the pericarps of the nuts are empty, the kernels having perished; but on the eastern side of the Lough, which is bounded by limestone rocks, they contain calc-spar, which in some examples forms a lining of delicate crystals (*Plate V. fig. 6*); while in others the kernel is transmuted into calcareous spar (see *Plate III. fig. 7*); but the pericarps are unchanged, and in the state of common dried nut-shells; the water which deposited the spar in their cavities not having left a particle of mineral matter in the ligneous substance through which it had filtrated.

In a subterranean forest at Ferry-bridge, Yorkshire, hazel nuts in a similar mineralized state occur, and the branches and stems of the trees have undergone a like change; the central ligneous axis is petrified, while the outer zones have undergone no lapidification, but remain in the state of dry rotten wood.[46]

[46] Specimens are preserved in the Museum at York.

PEAT.—LIGNITE.—BROWN COAL.

LIGNITE, BROWN COAL, OR CANNEL COAL; these are terms employed to designate certain varieties of carbonized wood, in which the ligneous structure is more or less distinctly preserved. Lignite may be regarded as an imperfect coal, for in its chemical properties it holds an intermediate place between peat and bituminous coal. It is for the most part found in tertiary formations, but is not unfrequent in ancient secondary deposits, and may occur in the earliest sedimentary rocks which contain vegetable remains.

The newer deposits of *Brown or wood-coal*, are commonly situated in depressions or basins, as if they had been produced by the submergence of woods and forests, in a swamp or morass; and in many instances the ligneous structure is distinct in one part of the bed, while in another the mass is a pure black coal, differing in no respect from true coal, except that it is less dense.

Bovey Coal.—One of the most instructive deposits of brown coal in England, is that of Bovey Heathfield, near Chudleigh in Devonshire, which is of considerable thickness and extent, and presents all the characters of a true coal-field; namely, beds of carbonized vegetables, alternating with layers of clay and marl. The Bovey coal is in the state of bituminized wood, the vascular tissue (which is coniferous in the specimens that have come under my notice) being apparent. It is easily chipped or split, and leaves a considerable quantity of white ashes after combustion. The layers of coal vary in

thickness from one foot to three feet; and there are eighteen or twenty in a depth of about 120 feet; this coal-field extends seven or eight miles. No leaves or fruits have been discovered; bitumen occurs both in the coal and in the intermediate clays. Calcareous spar, and iron pyrites, prevail in many of the strata. In some places this brown coal is covered by a bed of peat, in which trunks and cones of firs are imbedded. The whole series appears to have been a lacustrine deposit; probably formed in a lake, into whose basin rafts of pine forests were drifted by periodical land-floods. (Org. Rem. I. p. 327).

The brown-coal formations on the banks of the Rhine, present the same phenomena on a more extended scale, and complicated with changes induced by volcanic action. In Iceland, where at the present time forests are unknown, there are extensive deposits of lignite of a peculiar kind, termed *surturbrand*.

JET.—WEALDEN COAL.

Jet.—The beautiful substance called Jet, is a compact lignite, and the vascular tissue may be detected even in the most solid masses; when prepared in very thin slices, it appears of a rich brown colour by transmitted light, and the woody texture is visible to the naked eye. Jet is found in great purity and abundance in the cliffs of alum-shale on the Yorkshire coast, which were celebrated in the early centuries for the production of this substance. At Whitby and Scarborough extensive manufactories of ornaments and trinkets of jet are established. The sandstone cliffs near Whitby contain masses of a very compact variety, locally termed stone-jet. In the front of the cliff, on the north-west

side of Haiburn Wyke, the stump of a tree was observed in an erect position, about three feet high, and fifteen inches in diameter; the roots traversed a bed of shale, and were in the state of coarse jet, but the trunk, which extended into the sandstone, was in part silicified, while other portions were decayed and had a sooty aspect.[47]

[47] Geological Survey of the Yorkshire Coast; by Rev. G. Young; 1828; p. 197.

Thin seams and layers, and nodular masses, as well as regular coal-fields of lignite, occur in the tertiary formations. At Castle Hill, near Newhaven, in Sussex (*Wond.* p. 239), a seam of lignite resembling the surturbrand of Iceland, a few inches thick, is interposed between strata of red marl in which are carbonized leaves of dicotyledonous trees.

At Alum Bay in the Isle of Wight, a layer of lignite occurs between the beds of vertical gravel and sand of that interesting locality.

WEALDEN COAL.—The Wealden formation, in some districts, contains layers of lignite, which alternate with finely laminated micaceous sandstones, marls, and clays, abounding in minute carbonized fragments of fern-leaves, with fresh-water shells, and entomostracous crustaceans. This series of strata so strikingly resembles in its general aspect the characters of a coal-field, that some years since extensive works were undertaken in Sussex, in the expectation that coal might be obtained of suitable quality for economical purposes. The search was unsuccessful, but the attempt deserves not the censure that was bestowed upon it, in the infancy of geological science;[48] for experience has since shown, that although the true coal-measures are only

found beneath the Triassic and Permian formations, good combustible bituminous coal is not necessarily restricted to any period or series of strata, but may occur wherever the local conditions were favourable to the accumulation and bituminization of vegetable matter. In fact, the coal-fields of the north of Germany are of the Wealden epoch; and this coal more closely approaches in its chemical characters the black-coal of the ancient carboniferous formations, than any of the lignites and brown-coals of the tertiary strata. Some of the beds are highly bituminous, especially those of Schaumberg, and of the principality of Bückeburg, which may rank with the best English Newcastle coal; but those layers which are derived from coniferous trees and plants are more laminated, and somewhat resemble the brown-coal. These deposits have originated for the most part from carbonized conifers and cycads, with a few ferns and lycopodiaceæ, or club-mosses.

[48] See Sir J. F. W. Herschel's Discourse on Nat. Phil.

The brown-coal of Hohen-Warte by the Osterweld, is chiefly formed of the *Abies Linkii*, and *Pterophyllum Lyellianum*, whose leaves and twigs, closely impacted together, are generally of a brownish colour, have a glossy surface, and, when soaked in water, are perfectly flexible. The other modification of Wealden coal appears to have undergone a greater degree of pressure, and of exclusion from the atmosphere; no ligneous structure is apparent, but indistinct impressions of leaves are perceptible, and these are chiefly of ferns and club-mosses. This coal has probably resulted from an accumulation of plants of less firm texture, and more perishable, than those of which the former is

composed.[49]

[49] See Dr. Bunker's Mon. Norddeutsch. Weald.

Many interesting facts relating to the carbonization of vegetables, came under my observation during my researches in the Wealden strata; and it is a subject of regret to me, that circumstances prevented my following up the investigation of those still imperfectly explored deposits. Small nodular portions of coal, in which no structure is apparent, often occur in the calciferous grit of Tilgate Forest; and sometimes large masses of lignite, fissured in every direction, and having the interstices filled with white calcareous spar.[50] Some of the sandstones are discoloured by the abundance of minute particles of lignite, produced by the disintegration of ferns peculiar to the country of the Iguanodon.

[50] A fine specimen of this kind is in the British Museum.

The original structure and composition of a plant doubtless affected its carbonization; for in the same layer of stone, the stems of Endogenites, hereafter described, invariably possess a thick, outer crust, of coal; while those of Clathrariæ, plants allied to the Cycads, have not a particle of carbonaceous matter, but are surrounded by a reddish brown earthy substance. The nature of the stratum in which the plants were imbedded, must also have influenced the process of bituminization. Masses of vegetables buried beneath beds of tenacious clay, by which the escape of the gaseous elements set free by decomposition was prevented, must have been placed under the most favourable conditions for their

conversion into lignite and coal.

That the production of lignite is still going on there can be no doubt; and the following instance of a bed of recent origin, affords an instructive illustration of the subject . Near Limerick, in the district of Maine, one of the States of North America, there are peat-bogs of considerable extent, in which a substance similar to cannel-coal is found at the depth of three or four feet from the surface, amidst the remains of rotten logs of wood, and *beaver-sticks*: [51] the peat is twenty feet thick, and rests upon white sand. This coal was discovered on digging a ditch to drain a portion of the bog, for the purpose of obtaining peat for manure. The substance is a true bituminous coal, containing more bitumen than is found in any other variety,[52] Polished sections of the compact masses exhibit the peculiar structure of coniferous trees, and prove that the coal was derived from a species allied to the American fir.

[51] Pieces of wood fashioned by the beavers for the construction of their dams.

[52] An analysis of 100 grains gave the following results:—Bitumen 72; carbon, 21; oxide of iron, 4; silica, 1; oxide of manganese, 2; = 100.

COAL.

COAL.—We proceed to the examination of that remarkable substance which has resulted from the perfect bituminization of the vegetables of the most ancient Flora which geological researches have brought to light, and to which the term *Coal* is commonly restricted.

Although Balthazar Klein in the sixteenth century

affirmed that coal owed its formation to wood and other vegetable substances,[53] yet I can well remember when many eminent geologists were sceptical on this point; and the truth in this, as in most other questions of natural philosophy, was established with difficulty. The experiments and observations of the late Dr. Macculloch, mainly contributed to solve the problem as to the vegetable nature of this substance; and that eminent chemist and geologist successfully traced the transition of vegetable matter from peat-wood, brown-coal, lignite, and jet, to coal, anthracite, graphite, and plumbago. Nor must the meritorious labours of that accomplished naturalist, and excellent man, the late Mr. Parkinson, author of the "*Organic Remains of a Former World*," in this field of research, be forgotten. [54] The first volume of that work, which treats on fossil plants, contains much original information on the transmutation of vegetables into the various mineral substances in which the nature and original structure of the originals are altogether changed and obliterated; it may still be consulted by the student with advantage.

[53] Sternberg's "Flore du Monde Primitif."

[54] See my "Pictorial Atlas of Organic Remains," 1850.

Although the vegetable origin of all coal will not admit of question, yet evidence of the internal organization of the plants of which it is composed, is not always attainable; for the most perfect coal has undergone a complete liquefaction, and if any portions of the structure remain, they appear under the microscope as if imbedded in a pure bituminous mass. The slaty coal generally preserves traces of cellular or vascular tissue, and the spiral vessels, and

the dotted cells of coniferous trees, may readily be detected in chips or slices, prepared in the manner previously pointed out (*ante*, p. 66.). In many examples the cells are filled with an amber-coloured resinous substance; in others the organization is so well preserved, that on the exposed surface of a piece of coal cracked by exposure to heat, the vascular tissue, spiral vessels, and cells studded with glands, may be detected. Even in the white ashes left after combustion, traces of the spiral vessels are often discernible under a highly magnifying powder. Some beds of coal are wholly composed of minute leaves and disintegrated foliage; and if a mass recently extracted from the mine be split asunder, the surface is seen to be covered with flexible pellicles of carbonized leaves and fibres, matted together; and flake after flake may be peeled off through a thickness of many inches, and the same structure be apparent. Rarely are any large trunks or branches observable in the coal; the appearance of many beds being that of a deposit of foliage, shed and accumulated in a forest, (as may be observable in existing pine-districts,) and consolidated by pressure, while undergoing that peculiar change by which vegetable matter is converted into a carbonaceous mass.

In fine, a gradual transition may be traced from the peat-wood and submerged forests of modern times, in which leaves, fruits, and trunks of indigenous trees and plants are preserved, to those vast deposits of mineral coal, formed by the bituminization of the extinct Floras which flourished in the palæozoic ages.

The geological position of the ancient coal, the manner in which it is interstratified with layers of

clay, shale, micaceous sandstone, grit, and ironstone —in some districts associated with beds of fresh-water shells (*Sil. Syst.* p. 84)—in others alternating with strata containing marine remains,—are fully treated of in *Wond.* pp. 729-733, and *Bd.* p. 525; and it is not within the scope of the present work to dwell in detail upon what may be termed the physical geology of the carboniferous deposits. But a few observations on the phenomena presented by these accumulations of bituminized vegetables and their associated strata, are necessary to render the subsequent remarks on the habits and affinities of the plants composing the palæozoic Flora intelligible to the general reader.

While the essential conditions for the conversion of vegetable substances into coal appear to be the imbedding of large quantities of recent trees and plants in a deposit which shall exclude the air, and prevent the escape of the gaseous elements when released by decomposition from their organic combination, so, according to the more or less perfect manner in which these conditions are fulfilled, will result coal, jet, lignite, brown-coal, or peat-wood; or a mass of partially carbonized vegetables, like that observable when new-mown hay undergoes spontaneous combustion, from bituminous fermentation in the atmosphere (*Wond.* p. 701. *Org. Rem.* I. p. 181).

The manner in which the carboniferous strata have been deposited, has been a subject of much discussion. Some contend that the coal-measures were originally in the state of peat-bogs, and that the successive layers were formed by the subsidences of forests which grew on the sites now occupied by their carbonized remains; others suppose that the

vegetable matter originated from rafts, like those of the Mississippi, which floated out to sea, and became engulfed; while many affirm that the coal-measures were accumulated in inland seas or lakes, the successive beds of vegetable matter being supplied by periodical land-floods; and the supporters of each hypothesis bring numerous facts in corroboration of their respective opinions. There can, I think, be no doubt that the production of coal has taken place under each of these conditions, and that at different periods, and in various localities, all these causes have been in operation; in some instances singly, in others in combination. Coal may have been formed at the bottom of fresh-water lakes, as in those instances where it is associated with fresh-water shells and crustaceans, as at Burdie House (*Wond.* p. 693), and in some of the Derbyshire and Yorkshire deposits; in the beds of rivers and estuaries, as in the Wealden, and in the Shrewsbury coal-field;[55] and from drifted forests, like the rafts of the American rivers, transported into the sea, and engulfed in the abyss of the ocean;[56] and the remains of terrestrial, lacustrine, and marine animals, may accordingly be found associated with it.[57] But though many coal-fields (or basins, as they are termed, because they occupy depressions) have evidently been produced by different, and local agencies, the sedimentary deposits and coal-beds comprised in the carboniferous formations, setting aside unimportant variations, present a remarkable uniformity of character in their nature and arrangement, not only throughout Great Britain and Europe, but in every other part of the known world.

[55] In this coal-field are beds of limestone several feet thick, abounding in cyprides, fresh-water mollusks, &c.—*Sil. Syst.* p, 84.

[56] The immense thicknesss of some coal-beds, without any intercalations of earthy materials, seems to be inexplicable on any other supposition but that of accumulations of drift-wood and plants. In the Great Exhibition of 1851, there was exhibited, on the outside of the west end of the Crystal Palace, a section of the lowest bed of coal from Tividale Colliery in South Staffordshire, the total thickness of which was 29 feet, with no intermixture whatever of sediment, except some thin shaly partings: the entire mass was composed of carbonized vegetables.

[57] Sir R. I. Murchison has treated this subject with great ability: see *Sil. Syst.* chap, xi., and the illustrative maps opposite, p. 152.

STRATIFICATION OF A COAL-FIELD.

STRATIFICATION OF A COAL-FIELD.—The group of strata constituting a coal-field consists of an alternation of layers of coal and of clay, of variable thickness, resting, very generally, on grit, or marine limestone abounding in shells, corals, and crinoidea.

My late excellent friend, Mr. Bakewell, used to exemplify the manner in which the beds of coal are interstratified with layers of clay and shale, by the following apt illustration; let a series of mussel-shells be placed one within the other, and a layer of clay be interposed between each; the shells will represent the beds of coal, and the partitions of clay the earthy strata intercalated between the carboniferous layers; now, if one side of the series of shells be raised to indicate the general rise of the strata in that direction, and the whole be dislocated by partial cracks and fissures, the general arrangement and subsequent displacement of the beds will be

represented.

The principal feature which arrests attention on the examination of the section of a coal-pit, is the uniform presence of a thick bed of clay beneath every layer of coal; but a still more extraordinary fact remains to be mentioned, namely, that a common plant of the coal strata, called Stigmaria, (hereafter described, see *Lign.* 36, 38,) invariably occurs, more or less abundantly, in this bed of under-day, although very rarely to be met with in the coal or shale above. This phenomenon, long since noticed by Martin, Macculloch, and other authors, but whose value was not duly estimated till the recent observations of Mr. Logan, (*Geol. Proc.* vol. iii. p. 275,) is also found to prevail throughout the Welsh coal formation, which is upwards of twelve thousand feet in thickness, and contains more than sixty beds of coal, and as many of clay with stigmariæ; the Appalachian coal-measures of the United States present the same characters.[58] To place this fact before the student in a clear point of view, I will describe one of the triple series of beds which compose a coal-field.

[58] See Prof. Rogers, in the Proceedings of the American Geologists, p. 453; and Sir C. Lyell's Travels in America.

1. *Under-clay*; the lowermost stratum. A tough argillaceous substance, which upon drying becomes a grey friable earth: it is occasionally black, from the presence of carbonaceous matter. It contains innumerable stems of stigmariæ, which are generally of considerable length, and have their rootlets or fibres (see *Lign. 38*) attached, and extending in every direction through the clay: these stems commonly lie parallel with the planes of the bed, and nearer to the

top than to the bottom.

2. *Coal.* A carbonized mass, in which the external forms of the plants and trees composing it are obliterated, but the internal structure remains; large trunks or stems, and leaves, are rarely distinguishable in it, but the presence of coniferous wood in many beds of coal, proves that this arises, not from the absence of trees, but from their external forms having been obliterated.

3. *The Roof*, or upper bed. This generally consists of slaty clay, abounding in leaves, trunks, stems, branches, and fruits, and contains layers and nodules of ironstone, inclosing leaves, insects, crustaceans, &c.

In some localities beds of fresh-water mussels, and in others of marine shells, are intercalated; layers of shale, finely laminated clay, micaceous sand and grit, and pebbles of limestone, granite, sandstone, and other rocks, are often present. The most illustrative examples of the foliage of the carboniferous flora are found in this deposit, which appears to be an accumulation of drifted materials derived from other rocks, and promiscuously intermingled with the dense foliage and stems of a prostrate forest; the whole having been transported from a distance by a powerful current or flood.

ORIGIN AND NATURE OF COAL.

Thus we have, in the first place, spread uniformly over the bottom, and constituting the bed on which the coal reposes, a stratum of clay (*Under-clay*), composed of fine pulverulent materials, which may have once constituted the soil of a vast plain or savannah; the only remains found in it are the roots

of gigantic trees (see *Lign. 36*); for such the stigmariæ are now proved to have been, and not aquatic plants, as was formerly supposed (*Bd.* p. 476).

Secondly, a bituminous mass (Coal), composed of coniferous wood, gigantic ferns, club-mosses, &c.; occasionally with trunks of trees penetrating vertically through it.

Thirdly, a deposit of drift or water-worn materials (*the Roof*), mixed with the foliage and stems of numerous species of terrestrial plants; the whole appearing to have been subjected to the action of currents. The first, or *Under-clay*, may have been the natural soil, in which the stigmariæ grew; the next,—the *Coal*,—the carbonized stems, and other remains of the trees to which the roots belonged: and the last, or uppermost, forming the roof of the coal, may have resulted from the foliage and branches of a prostrate forest, overwhelmed and buried beneath the transported detritus of distant rocks.

These phenomena may be explained by supposing the inundation of a thickly-wooded plain from an irruption of the sea; or of a vast inland lake, occasioned by the sudden removal of some barrier; or by a subsidence of the tract of country on which the forest grew. But when we find an accumulation of strata, in which triple deposits of this kind are repeated some thirty or forty times through a thickness of many thousand feet, this solution of the problem is not satisfactory. Not only subsidence after subsidence must have taken place, but the first submergence have been followed by an elevation of the land—another soil, fit for the growth of forest trees, must have been produced—another generation of vegetables, of precisely the same species and

genera, have sprung up, and arrived at maturity—and then another subsidence, and another accumulation of drift. And these periodical oscillations in the relative level of the land and water must have gone on uninterruptedly through a long period of time, not in one district or country only, but in various parts of the world, during the same geological epoch. At present I do not think we have data sufficient to explain these phenomena; what has been advanced may, perhaps, serve to elicit further information, by pointing out the difficulties in which the question is involved, and showing what interesting fields of discovery are still unexplored, and how comprehensive and important are the objects that come within the scope of geological investigation.[59]

[59] I would refer the student for a fuller consideration of the phenomena thus briefly noticed, to the 6th edition of my Wonders of Geology, pp. 669, 718, 731.

I will conclude this chapter with the following beautiful reflections of Dr. Buckland on the origin and nature of Coal, and the changes it undergoes when rendered subservient to the necessities and luxuries of man.

"Few persons are aware of the remote and wonderful events in the economy of our planet, and of the complicated applications of human industry and science, which are involved in the production of the coal that supplies with fuel the metropolis of England.

"The most early stage to which we can carry back its origin, was among the swamps and forests of the

primeval earth, where it flourished in the form of gigantic Calamites, and stately *Lepidodendra*, and *Sigillariæ*. From their native bed, these plants were transported into some adjacent lake, or estuary, or sea. Here they floated on the waters, until they sank saturated to the bottom, and being buried in the detritus of adjacent lands, became transferred to a new estate among the members of the mineral kingdom. A long interment followed, during which a course of chemical changes, and new combinations of their vegetable elements, converted them to the mineral condition of coal. By the elevating force of subterranean agency, these beds of coal have been uplifted from beneath the waters, to a new position in the hills and mountains, where they are accessible to the industry of man. From this fourth stage, coal has been removed by the labours of the miner, assisted by the arts and sciences, that have co-operated to produce the steam-engine, and the safety-lamp. Returned once more to the light of day, and a second time committed to the waters, it has, by the aid of navigation, been conveyed to the scene of its next and most considerable change by fire; a change during which it becomes subservient to the most important wants and conveniences of man. In this seventh stage of its long eventful history, it seems, to the vulgar eye, to undergo annihilation; its elements are, indeed, released from the mineral combinations which they have maintained for ages, but their apparent destruction is only the commencement of new successions of change and of activity. Set free from their long imprisonment, they return to their native atmosphere, from which they were absorbed by the primeval vegetation of the earth. To-morrow they may contribute to the substance of timber, in the trees of our existing

forests; and having for a while resumed their place in the living vegetable kingdom, may, ere long, be applied a second time to the use and benefit of man. And when decay or fire shall once more consign them to the earth, or to the atmosphere, the same elements will enter on some further department of their perpetual ministration in the economy of the material world."[60]

[60] Bd p. 481.

CHAPTER VI.

FOSSIL VEGETABLES.

In the present section of this work, I propose to explain the botanical arrangement and nomenclature of fossil plants; and figure and describe one or more species of the genera that are most likely to come under the observation of the student, either in public or private collections, or in the course of his researches in the field.

To determine the botanical relations of fossil leaves and stems, reference must be had to works expressly devoted to the subject; namely, the "*British Fossil Flora*," by Dr. Lindley and Mr. Hutton, and the "*Histoire des Végétaux Fossiles*," by M. Adolphe Brongniart. The classification of the last-named eminent botanist is here adopted, as the most easy of application.

With regard to the nomenclature, it may be necessary to remark, that when a fossil plant undoubtedly belongs to a recent genus, the usual botanical name is employed: for example, *Equisetum Lyellii*; when the fossil does not possess all the generic characters, yet is evidently allied to a recent genus, the term *ites* (from λιθος, *lithos*, stone), is added—as *Equisetites*, *Palmacites*, &c.; and this termination is invariably adopted by some authors. When the fossil plant differs altogether from any known type, it is distinguished by some arbitrary generic name, as *Bucklandia*, *Sigillaria*, &c.

There are also a few provisional genera for the reception of fossil leaves, fruits, and stems, whose characters and relations are but imperfectly known; as Carpolithes, Endogenites, &c. Upon these principles the present arrangement has been founded: the progress of discovery will, of course, be continually adding to the list, and the classification require to be modified.

FOSSIL CRYPTOGAMIA.

The following account of the principal types of the ancient floras whose relics are preserved in the mineral kingdom, though commencing with those of the most simple structure, the *Cryptogamia*, and advancing to the higher orders, is not strictly botanical; for it was found convenient, in some instances, to notice certain species and genera of different orders under the same head, from their occurrence in the same geological formations.

It is estimated that not more than two thousand species of plants have been discovered in a fossil state, while the known recent species amount to upwards of eighty thousand.

CELLULAR CRYPTOGAMIA; ALGÆ.—The plants designated by botanists *Algæ*, and commonly known as sea-weeds, lavers, and fresh-water mosses, are of the most simple structure—mere aggregations of cells—but present innumerable varieties of form and magnitude: many species are mere vesicles of such minuteness as to be invisible to the unassisted eye, except accumulated in countless myriads, when they appear as a green, purple, or reddish, slime in the water; or as a film on wood or stone, or on the ground, in damp situations; while others are tough branched marine plants, many fathoms in length.

The Algæ form three principal groups: 1. the *jointless*, as the Fuci, the Dulses, Tangles, and Lavers: 2. the *jointed*, which are composed of thread-like articulated tubes; such are the fresh-water Confervæ: 3. the *disjointed*, or Brittle-worts, so called from their spontaneous self-division, which is in some kinds complete, in others only partial; and these, by separating transversely, and leaving each cell or frustule attached at the angles, produce those beautiful chains of angular green transparent cases, so constantly seen under the microscope when substances from fresh-water streams or lakes are submitted to examination.

As many of these forms are endowed with spontaneous motion, and possess other properties common to animal organization, it is not surprising that their vegetable nature was doubted, and that even so profound a naturalist as M. Ehrenberg placed them in the animal kingdom: the greater number being comprised in his family of *Bacillariæ*, were described in the former edition of this work, as Infusoria or Animalcules; in conformity with the classification of the illustrious microscopist, whose

splendid works and indefatigable labours have so greatly promoted the advancement of microscopical investigation.[61]

[61] The whole of the objects called *Infusoria* in the first edition of "The Medals of Creation" belong to various kinds of Diatomaceæ.

FOSSIL DIATOMACEÆ.

These minute vegetable organisms are placed by botanists in two tribes, the *Diatomaceæ* or the *Brittle-worts*, and the *Desmidieæ*. The latter are exclusively inhabitants of fresh-water, while a large proportion of the former are marine plants. Some naturalists (M. Brébisson) restrict the name *Diatomaceæ* to those species which secrete siliceous envelopes; and that of *Desmidieæ* to those whose structures are not siliceous, and are reducible by heat to carbon. As the durable parts of these plants alone concern the geologist, the name *Diatomaceæ* will be employed as a general term in reference to their fossil remains.

These tribes of Algæ abound in every lake and stream of fresh-water, in every pool or bay, and throughout the ocean from the equator to the poles. Certain kinds of sea-weeds secrete carbonate of lime; but the Diatomaceæ have the power of separating silex, or the earth of flint, from the water, by some unknown process, and their tissues are composed of pure quartz: hence, under the microscope, their remains, consisting wholly of rock crystal, exhibit the most exquisite forms, elaborately fretted and ornamented (see *Lign. 4*). After the death and decomposition of these plants, their durable frustules or cases appear as colourless discs, cups, spheres, shields, &c., and these accumulate at the bottom of

the water in such inconceivable numbers, as to form strata of great thickness and extent. Slowly, imperceptibly, and incessantly, are the vital energies of these atoms separating from the element in which they live the most refractory and enduring of mineral substances, silex, and elaborating it into imperishable structures, and thus adding enormous contributions to the accumulations of detritus, which make up the sedimentary rocks of the crust of the globe.

The extent of this infinitesimal flora throughout regions where no other forms of vegetation are known, is strikingly demonstrated by the observations of our eminent botanical traveller. Dr. Joseph Hooker, in his account of the Antarctic regions.[62]

[62] "On the Botany of the South Polar Regions;" in Sir J. Ross's Voyage of Discovery.

"Everywhere," Dr. Hooker states, "the waters and the ice alike abound in these microscopic vegetables. Though too small to be visible to the unassisted eye, their aggregated masses stained the iceberg and pack-ice wherever the latter were washed by the sea, and imparted a pale ochreous colour to the ice. From the south of the belt of ice which encircles the globe, to the highest latitudes reached by man, this vegetation is everywhere conspicuous, from the contrast between its colour and that of the white snow and ice in which it is imbedded.

"In the 80° of south latitude all the surface ice carried along by currents, and the sides of every berg, and the base of the great Victoria barrier itself —a perpendicular wall of ice, from one to two hundred feet above the sea level—were tinged brown

from this cause, as if the waters were charged with oxide of iron. The majority of these plants consist of simple vegetable cells enclosed in indestructible silex; and it is obvious that the death of such multitudes must form sedimentary deposits of immense extent.

"The universal existence of such an invisible vegetation as that of the Antarctic Ocean is a truly wonderful fact, and the more so from its being unaccompanied by plants of a high order. This ocean swarms with mollusca, and entomostracous crustaceans, small whales, and porpoises; and the sea with penguins and seals, and the air with birds; the animal kingdom is everywhere present, the larger creatures preying on the smaller, and these again on those more minute; all living nature seems to be carnivorous. This microscopic vegetation is the sole nutrition of the herbivorous animals; and it may likewise serve to purify the atmosphere, and thus execute in the Antarctic latitudes the office of the trees and grasses of the temperate regions, and the broad foliage of the palms of the tropics."

Dr. Hooker also remarks that the siliceous envelopes of the same kinds of diatomaceæ now living in the waters of the South Polar Ocean, have contributed in past ages to the formation of European strata; for the tripoli and the phonolite stones of the Rhine, contain the siliceous envelopes of identical species.

Such are the comments of one of our most distinguished botanists, on the phenomena under review. The reader will perhaps ask, what then are the essential characters which separate the animal from the vegetable kingdom? To this question it is

impossible to give a satisfactory reply: perhaps the only distinction that will be generally admitted by zoologists and botanists is the following:—*animals require organic substances for their support; vegetables derive their sustenance from inorganic matter*.

RECENT DIATOMACEÆ.

RECENT DIATOMACEÆ. *Plate IV.*—To familiarize the reader with the nature of these vegetable organisms, a few recent species are represented in Plate IV., coloured as they appear when alive, under the microscope; the figures are magnified as expressed by the fractions.

Xanthidium. Plate IV. figs. 1, 2, 3, 4, 5.—The case or frustule of this genus consists of a hollow, siliceous globe, beset with spines. The increase of the Xanthidia by self-division, produces the double appearance in the figures, all of which are in the progress of separation.[63]

[63] The organisms so abundant in the flint and chalk, and which were referred by M. Ehrenberg to this genus, and consequently described under the name of Xanthidia by myself and others, are certainly in nowise related to the recent forms: they are flexible envelopes, and probably belong to zoophytes; as will be shown in the sequel.

Pyxidiculum. Plate IV. fig. 2.—The case is a little saucer-shaped box, and is invested by a membrane.

Bacillaria. Plate IV. fig. 6.—A simple siliceous frustule, of a prismatic shape, forming a brilliant chain, which often appears in zigzag, in consequence of incomplete self-division. An immense number and variety of forms are placed in this family by

Ehrenberg, with a multitude of generic and specific names. The fresh-water species inhabit every pond and lake, and the marine every sea. Fossil species are equally abundant.

Cocconeis. Plate IV. fig. 7.—This is a very elegant type; the frustule consists of a simple siliceous case, with a central opening; it never occurs in chains like the former. It has been found fossil near Cassel.

Navicula. Plate IV. figs. 8, 9, 14, 15.—The plants of this genus are free, and float in the water apparently by the agency of cilia. Their case is a boat-like envelope with six openings, composed of pure silex, and in many species is exquisitely ornamented. Figs. 8 and 9. show a living *Navicula*, viewed in front, and in profile: in *fig.* 9 are represented the currents produced when the body is moving through the water; after Ehrenberg. Fossil *Naviculæ* abound in many tertiary strata.

Galionella. Plate IV. figs. 10, 11.—These algæ are free, and the frustules of a cylindrical, globular, or discoidal form; they occur in chains, in consequence of the self-division being imperfect, and the new individuals remaining attached to the old. The *Galionellæ* are most abundant and prolific, and inhabit every pool, stream, and lake: fossil species occur in the Virginian marls, and other strata.

Synhedra. Plate IV. fig. 12.—The frustules are siliceous, and of a slender, elongated form. The plant is attached by the base (*fig. 12 a.*) in youth, and afterwards becomes free. It is found fossil in the Mountain-meal of Santa Flora, and many other deposits.

Podosphenia. Plate IV. fig. 13.—The frustule is

cruciform, or wedge-shaped, and attached in youth by the small end, but afterwards becomes free. These plants are often arranged in clusters, as in the figure. M. Ehrenberg states that they inhabit the sea, and not fresh-water; but I have found them in streams communicating with the Thames. *Podospheniæ* abound in the polishing slate of Bilin.

Eunotia. Plate IV. figs. 16, 17.—The frustule is siliceous, and either simple or bivalve; flat below, and convex, and often richly dentated above. An empty case is shown *fig. 16*; and a group of living *Eunotice* attached to a stem of conferva, *fig. 17*. Several fossil species have been discovered at Santa Flora.

That the general reader, whose attention is for the first time directed to this subject, may be prepared for the enormous deposits of fossil diatomaceæ that are found in some formations, I subjoin the observations of Dr. Bailey on an elegant fragile species, which hangs together in clusters, appearing like spiral chains, and is about $^{1}/_{20}$ of a line in diameter; it is named *Meridion vernale*.

"This fresh-water plant is seen in immense quantities in the mountain brooks around West Point, the bottoms of which are literally covered in the first warm days of spring with a ferruginous-coloured mucous matter, about a quarter of an inch thick, that, on examination by the microscope, proves to be filled with millions and millions of these exquisitely beautiful siliceous organisms. Every submerged stone, twig, and spear of grass, is enveloped by them; and the waving plume-like appearance of a filamentous body covered in this manner, is often extremely elegant. Alcohol

completely dissolves the endochrome (*soft colouring matter*) of this species, and the frustules are left as colourless as glass, and resist the action of fire."[64]

[64] Trans. Amer. Assoc. Geolog. 1843, p. 152.

The yellow or ochreous scum observable in ponds, ditches, and stagnant pools, is an aggregation of diatomaceæ, whose frustules are feriniginous, and of such extreme minuteness, that a billion of their cases would not be more than a cubic inch in bulk. [65]

[65] Ehrenberg.

FOSSIL DIATOMACEÆ.—From this notice of a few recent types, we proceed to the investigation of the fossil remains of this tribe of Algæ.

In peat-bogs and swamps, both of modern and ancient date, masses of a white marly or siliceous paste (*hydrate of silica*), are often observed, and these are found upon microscopical observation to be wholly made up of the frustules of *Naviculæ*, *Bacillariæ*, *Galionellæ*, &c., with an intermixture of the needle-like spicules of fresh-water sponges. Many of the peat-bogs of Ireland contain layers of a white earthy substance, which, when dry, is of the appearance and consistence of friable chalk, and entirely consists of the siliceous cases of various kinds of diatomaceæ.



LIGN. 4. SILICEOUS FRUSTULES OF DIATOMACEÆ, AND SPICULES OF SPONGILLÆ;
from a deposit on the banks of the river Bann, Ireland.
(*Seen by transmitted light, and highly magnified.*)

FOSSIL DIATOMACEÆ OF IRELAND.

FOSSIL DIATOMACEÆ FROM IRELAND, *Lign.* 4.—Dr. Drummond describes a bed of this kind near the base of the Mourne Mountains, in the County of Down, Ireland. It consists of a very light white substance, resembling in appearance carbonate of magnesia: it has a coarse and somewhat fibrous fracture, and is easily reduced to powder. It is almost entirely siliceous, and is composed of the cases of diatomaceæ of the usual fresh-water species, without any admixture of inorganic matter.[66]

[66] Mag. Nat. Hist. New Series, vol. iii. p. 353, July 1839.

On the banks of the river Bann, in the same county, there is an extensive stratum of a similar earth, and which, from being in much request for polishing plate, is locally known as Lord Roden's

plate powder. This earth is wholly made up of the siliceous frustules of many kinds of this tribe of Algæ, and a few grains under the microscope yield a great variety of exquisite forms: figures of several are given in *Lign.* 4, from specimens of this earth, with which I was favoured by the Countess of Caledon. They comprise two or three species of Navicula, Galionella, Coscinodiscus, Gomphonema, Bacillaria, Stauroneis, &c., and spicules or spines of fresh-water sponges.[67]

[67] The names of the usual kinds of Diatomaceous frustules may be learnt by reference to Mr. Andrew Pritchard's abstract (with coloured figures) of Ehrenberg's Infusoria. The splendid work of Mr. Ralfs, on the British Desmidieæ, 1 vol. 4to, with coloured plates, is the best guide for those who wish to study the recent plants.

Beds of siliceous marl—that is, of argillaceous earth combined with a large amount of minute particles of silex, all of which prove to be organisms when examined by a high magnifying power,—have been found in numerous places not only in England, but all over the world, since M. Ehrenberg first directed attention to their nature and origin.

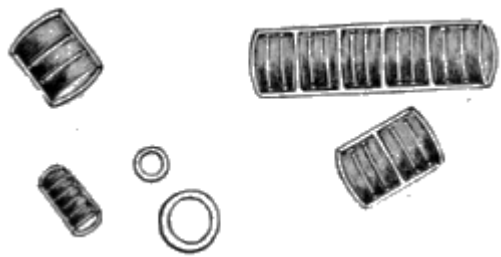
Near Bryansford (Newcastle), Binstwick in Holderness, and in the Fens of Lincolnshire and Cambridgeshire, extensive fresh-water microphytal deposits have been discovered and examined.

From our Antipodes I have received many examples of these vegetable earths. My eldest son, Mr. Walter Mantell, discovered an extensive bed of white marl on the banks of the great brackish-water lake of Waihora, in the middle island of New Zealand, consisting entirely of frustules of Bacillariæ.

From New Plymouth he obtained some new and exquisite forms of Navicula, Stauroneis, &c.; ranges of low hillocks of sand, of considerable extent, being made up of microphytes (*microscopic plants*).[68]

[68] See a Memoir on the Geology and Fossil Remains of New Zealand, from the researches of Walter Mantell, Esq.—*Geol. Journal*, vol. vi. *pl.* 29.

Mr. Dean, of Clapham Common, informs me that a large quantity of white earth sent from New Zealand as native magnesia, he found to consist wholly of frustules of diatomaceæ, chiefly of *Galionellæ*. (See *Lign. 5.*)



LIGN. 5.
FOSSIL. GALIOMELLÆ; *highly magnified.*

In America, recent beds of this kind of great extent have been observed and examined by that distinguished microscopist, Dr. Bailey, Professor of Chemistry in the Military Academy at West Point: and the pages of that excellent scientific periodical, Silliman's *American Journal of Science*, are enriched with figures and descriptions of the microphytes of which they are mainly composed.

But the Tertiary formations contain strata of this nature, which far surpass in the abundance and variety of their organic contents, any of the modern

deposits we have noticed. The *Polierschiefer*, or *polishing-slate* of Bilin, is stated, by M. Ehrenberg, to form a series of strata fourteen feet in thickness, entirely made up of the siliceous shells of *Galionellæ*, of such extreme minuteness, that a cubic inch of the stone contains forty-one thousand millions. The *Berghmehl* (*mountain-meal*, or *fossil farina*), of San Flora, in Tuscany, is one mass of these organisms.

In Lapland a similar earth is met with, which, in times of scarcity, is mixed by the inhabitants with the ground bark of trees, for food; some of this earth was found to contain twenty different species of algæ.

In the district of Soos, near Egra, in Bohemia, a fine white infusorial earth occurs, about three feet beneath the surface; this substance, when dried, appears to the naked eve like pure magnesia, but under the microscope is seen to be mainly constituted of elegant disciform cases of a species of *Campilodiscus*, of which figures are given, *Lign. 111, figs. 1, 2*.

Some beds of porcelain-earth M. Ehrenberg found to be in a great measure made up of concentric articulated rings, entire and in fragments (see *Lign. 6*), which he believes to be bacillariæ.

FOSSIL DIATOMACEÆ OF VIRGINIA.

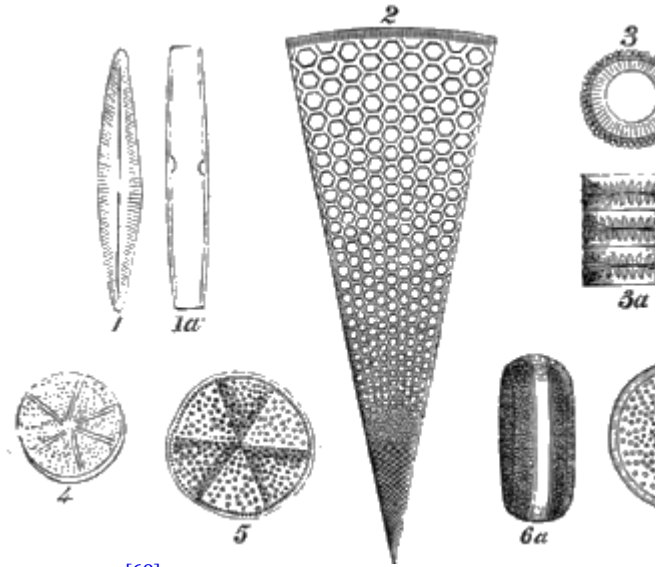


LIGN. 6 ORGANIC BODIES IN PORCELAIN EARTH; *highly magnified.*

FOSSIL DIATOMACEÆ OF THE RICHMOND-EARTH; VIRGINIA.—The town of Richmond, in Virginia, is built on strata of siliceous marl of great extent, which earth; highly magnified. have a total thickness, beneath and around the town, of more than twenty feet. These marls, whose organic composition was first detected by Professor W. B. Rogers, are referred by that eminent American geologist, to the older tertiary (*eocene*, or *miocene*) formations. They occupy considerable districts, spreading out into sterile tracts along the flanks of the hills, their siliceous character rendering them unfavourable to vegetation. The investigations of Dr. Bailey have shown that the frustules so abundant in this earth, consist of several species of Navicula (*Lign. 1, fig. 1, 1a.*), Galionella (*Lign. 1. fig. 3, 3a.*), *Actinocyclus* (*Lign. 1, figs. 4, 5*), &c.

The most remarkable forms are disciform frustules, having their surfaces elaborately ornamented with hexagonal spots disposed in curves, and bearing some resemblance to the engine-turned case of a watch. *Lign. 7, fig. 2*, is a small segment of a disc, very highly magnified. These frustules vary in size from $^{1}/_{100}$ to $^{1}/_{1000}$ of an inch in diameter; they are named *Coscinodiscus* (*sieve-like disc*), and there

are several species: one less richly sculptured, *C. patina*, is figured *Lign. 7, fig. 6*. Circular bodies, with five or six lines radiating from the centre to the circumference, like the spokes of a wheel, hence named *Actinocyclus* (*Lign. 7, figs. 4, 5*), and spicules of Sponges, are also abundant.



LIGN. 7. MICROPHYTES[69] FROM THE RICHMOND-EARTH; *highly magnified.*

Tertiary. Virginia.

Fig. 1.— NAVICULA. 1*a*. Side view.

2.— COSCINODISCUS RADIATUS; a portion of the circular shield.

3.— GALIONELLA SULCATA; the upper figure shows the transverse face of one of the frustules.
3*a*.—Three united cells viewed laterally.

4, 5. ACTINOCYCLUS. Two species.
—

6.— COSCINODISCUS PATINA; transverse view. 6*a*. Lateral view.

[69] As the term *Infusorial-earth* must be

> abandoned, it will be convenient to substitute a name simply expressive of the nature of the most abundant organisms that enter into the composition of these deposits: that of *Microphyta*, or *Microphytes*, (from μικρος, *mikros*, small, and φυτον, *phyton*, a plant), signifying very minute vegetables, may perhaps be admissible: in this sense the word microphytal is employed in these pages.

When a few grains of the marl are prepared, and mounted on a glass, almost all these varieties will be manifest, so largely is this earth composed of organic structures; in fact, very few inorganic particles are intermixed, the merest pellicle left by the evaporation of a drop of water in which some of the marl has been mixed, teeming with the most beautiful structures.

At Petersburg, in Virginia, a sandy marl occurs, interstratified with deposits which, from their shells, are referred to the older tertiary formations. Probably this marl is a continuation of that of Richmond, but it is full of many new forms, associated with those common in the earth of the latter locality.[70]

> [70] Dr. Bailey, with great liberality, has so amply supplied myself and other observers with specimens of these deposits for examination, that the fossils above described are familiar to all British microscopists. Figures of many of those organisms are given in the American Journal of Science.

It is an interesting fact, (first observed by Mr. Hamlin Lee,) that the common Scallop (*Pecten maximus*), as well as the Barnacle (*Balanus*), feed on diatomaceæ, and their stomachs generally contain

numerous cases of Coscinodisci, Dichtyochi, Actinocycli, &c.: a slide prepared and mounted with the contents of the stomachs of these mollusks, presents an assemblage of forms identical with those found in the tertiary earths of Virginia.[71]

[71] See my "Thoughts on Animalcules," p. 103.

In the mud of the quicksands on the shore at Brighton, Mr. Reginald Mantell found recent Coscinodisci, &c. associated with fossil polythalamia that had been washed out of the chalk, and precipitated with the frustules of the recent diatomaceæ, into the sediments now in progress.

The prevalence of marine and fresh-water forms in the same deposit is not unusual; and the remarks of Dr. Bailey on this fact are so pertinent, that I insert them, as a salutary caution against hasty generalizations on subjects connected with these investigations. After describing a species of Galionella (*G. moniliformis*), as an inhabitant only of salt and brackish water, and stating that he had also found it sixty miles up the Hudson River, near West Point, Dr. Bailey observes—"The Fauna and Flora of the Hudson at this place would, if in a fossil state, be rather puzzling to the geologist, on account of the singular mixture of marine and fluviatile species. While *Valisneria* and *Potamogeton* (two common fresh-water plants), grow in such vast quantities, in some places, as to prevent the passage of a boat, and the shore is strewn with fluviatile shells (such as Planorbis, Physa, &c.) in a living state, yet the above plants are entangled with Algæ (sea-weeds), and marine parasitic zoophytes; while the rocks below low-water mark are covered with Balani (*barnacles*) and minute corallines, and the marine Flora is

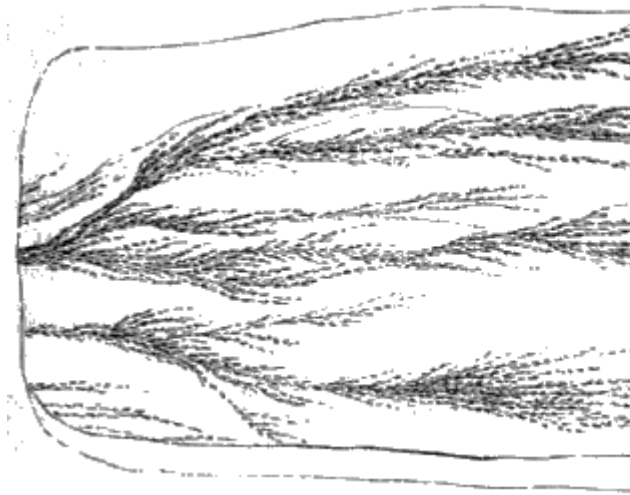
represented by vast quantities of very elegant sea plants."[72]

[72] American Journal of Science, vol. x. p. 41.

I must here close this extended notice of the fossil remains of a class of vegetable organisms, which, though for the most part invisible to the unassisted eye as individual forms, constitute by their inconceivable multitudes an important element in the formation of sedimentary deposits. The fact of their having been formerly treated of as animalcules, and generally regarded as belonging to the animal kingdom, rendered a full consideration of the phenomena necessary, in order to place the subject before the reader in a clear and comprehensive point of view.[73]

[73] As both the recent and fossil frustules of Diatomaceæ are beautiful objects for the microscope and polariscope, they are in much request. Specimens mounted on glass slides may be had of Mr. Topping, and Mr. Poulton. See Appendix.

CONFERVITES.—The cellular aquatic plants named Confervæ are sometimes found in transparent quartz pebbles, and in chalk, appearing as delicate simple or branched filaments, which, by the aid of the microscope, are seen to be articulated. Seven species are described by authors, but the vegetable nature of some of these is doubtful. A beautiful species in Chalk, first noticed by the late Samuel Woodward, Esq. (author of the Geology of Norfolk), is here figured.



LIGN. 8. CONFERVITES WOODWARDI
Chalk. Norfolk.

FOSSIL FUCOIDS.

FOSSIL FUCOIDS.—Of the tribe of Algæ which comprises the sea-weeds that are not articulated, many fossil species occur in very ancient, as well as in modern, fossiliferous deposits. In the Lower Silurian rocks of North America, beds of limestone of great extent are full of a large digitated Fucus (*Fucoides Alleghaniensis*).[74] The Firestone or Malm-rock of Bignor in Sussex abounds in a ramose variety (*Fucoides Targionii*, *Vég. Foss.* p. 56), of which specimens are figured in the vignette of this volume, and in *Lign. 9.*

[74] Figured and described in Dr. Harlan's Medical and Physical Researches: Philadelphia, 1835, p. 393.

CHONDRITES.—These fossil algæ approach nearest to the living species of *Chondrus* (hence the name of the genus). The frond is thick, branched,

dichotomous, with cylindrical or claviform divisions, with a smooth surface and without tubercles. The substance of the Bignor fossils is a white friable earth, which strikingly contrasts with the dark grey malm-rock that forms the matrix. As the Sussex Chalk Chondrites appear to be distinct from the Tertiary species named by M. Brongniart *C. Targionii*, I have, at the suggestion of Mr. Morris, substituted *C. Bignoriensis*, to indicate the locality in Sussex in which I discovered it forty years since. In the chalk-flints ramose fuci occasionally occur, but not in a state of preservation that admits of the determination of the forms of the originals.



LIGN. 9.
CHONDRITES BIGNORIENSIS; *nat.*
Malm-rock. Bignor, Sussex.

The tertiary marls and limestones of Monte Bolca yield several beautiful species of Algæ, one of which is figured in *Lign. 10*. It is referred to the fossil genus *Delesserites* (Sternberg), which includes those algæ that have thin, and flat or undulated, smooth, membranous fronds, with a median rib.

Of the little plants comprised in the class of cellular cryptogamia, which have stems, leaves, and fructification, but no true vessels, two or three species of Moss and Liverwort have been met with in tertiary strata. Mosses as well as Fuci are occasionally imbedded in quartz pebbles, in which they appear of their natural colour, and apparently floating in the transparent medium. A beautiful green moss, with a Conferva twined round its base, is figured *Lign. 11*, p. 104, from a specimen described by the late Dr. Macculloch. It is supposed to be related to *Hypnum* (*Geol. Trans.* vol. ii.).

MOCHA-STONES.

MOSS-AGATES AND MOCHA-STONES.—The beautiful siliceous pebbles called Moss-agates, and Mocha-stones, will so often come under the notice of the collector, that, although but extremely few, if any, of these objects contain organic remains, the arborescent substances they inclose being merely metallic oxides, a few remarks on their nature may be expected. The late Dr. Macculloch paid considerable attention to the investigation of these bodies, and believed that some of the objects imbedded in the pure and compact quartz were really of vegetable or animal origin; the specimen figured *Lign. 11* is of this kind; the fossils being apparently cellular cryptogamous plants. In *Geol. Trans*, vol. ii., other examples are figured and described by the same sagacious observer. Mr. Bowerbank is of opinion that spongeous structure enters into the composition of almost all the moss-agates, and I have no doubt that in some instances such organisms are present: but in by far the greater number of agates and mocha-stones the inclosed

bodies are mere crystallizations; they are arborescent or dendritical oxides of manganese, copper, chlorite, iron, &c.



LIGN. 10 DELESSERITES (FUCOIDES) LAMOUROUXII.
Monte Bolca. (*Vég. Foss. Br.*)



LIGN. 11.
MOSS AND CONFERVA,
in transparent quartz, × 3.

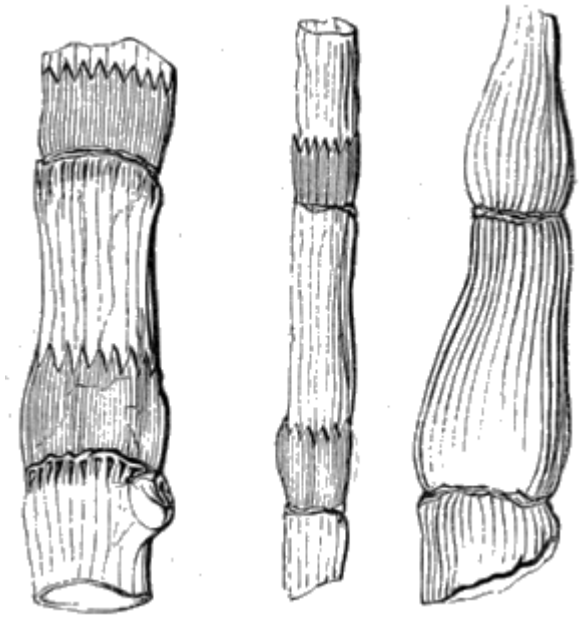
M. Brongniart, who carefully examined a great number of agates and pebbles, with the view of determining if vegetable substances were ever imbedded in them, could not detect a single instance in which the apparent mosses, confervæ, or algæ, were organic; in every case the mineral origin of the pseudo-vegetation was, in his opinion, unequivocal. Some of the beautiful green arborescent bodies in quartz pebbles, even under the microscope, present so close a resemblance to confervæ and mosses, that it is difficult to persuade oneself they are not vegetable structures; but the observations of M.

Brongniart appear to me conclusive as to their mineral nature.[75] With the exception of three or four species of *Jungermannia*, and four or five of *Muscites* in Amber, M. Brongniart states that he knows but one true fossil plant of the family of Mosses; the *Muscites Tournalii* from the fresh-water tertiary deposits of Armissan.

[75] See Histoire des Végétaux Fossiles, pp. 29-34.

VASCULAR, OR ACROGENOUS CRYPTOGAMIA.—These plants, as the name implies, possess a more complicated structure than the preceding, having vascular tissue as varied as in the phanerogamia.

EQUISETACEÆ.—The common species of Equisetum, or Marestail, is a plant that grows in marshy tracts, and on the banks of ditches and rivers; it has a jointed stalk, garnished with elegant sheaths which embrace the stem, and verticillate linear leaves: it attains a height of two feet, and is half an inch in diameter. In the fossil state there are many plants allied to the Equisetum, but only a few that are generically the same.



LIGN. 12. EQUISETUM LYELLII.
Wealden. Pounceford. nat.

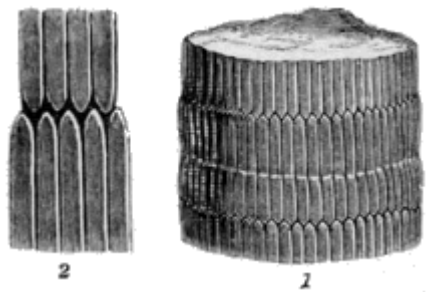
Fig. 1.— A stem, having two sheaths, and a bud at the lowermost joint.
2.— Stem of a young plant, with sheaths, preserved in pyrites.
3.— Stem, with the cryptogamous head or upper end.

EQUISETITES.

EQUISETUM LYELLII, *Lign. 12*.—A species which I discovered in Wealden limestone, at Pounceford (*Geol. S. E.* p. 245), must have closely resembled the *Equisetum fluviatile*: it has an articulated cylindrical stem, and regularly dentated sheaths, embracing the stem at the joints.

A transverse slice of the stem exhibits under the microscope a cellular structure filled with calc-spar, and forms a beautiful object when viewed with the polarizing apparatus. This plant occurs in many

localities of the Wealden in Sussex and Kent; from the railway cuttings near Tonbridge, I collected several fine specimens; it is met with also in the cliffs near Hastings.



LIGN. 13. EQUISETITES COLUMNARIS.
(Ad. Brongn. Pl. 13.)
Lower Oolite. Whitby.

Fig. 1. Portion of a stem, showing two articulations, and an intermediate constriction. $^1/_3$ *nat.*
2. A few of the denticulations produced by the sheath, *nat.*

EQUISETITES COLUMNARIS. *Lign. 13.*—A gigantic species of Equisetum abounds in the strata of the lower division of the Oolitic or Jurassic formation of Yorkshire, and many fine specimens have been collected, especially from the vicinity of Whitby. In the sandstone of the Inferior Oolite of the Cleveland Hills, Yorkshire, numerous stems of this colossal marestail have been observed standing erect, as if occupying the position in which they grew; the same fact was also discovered at Carlton Bank, near Stokesly, forty miles from the coast. In both localities fossil shells of fresh-water mussels (*Uniones*) were associated with the vegetable remains.

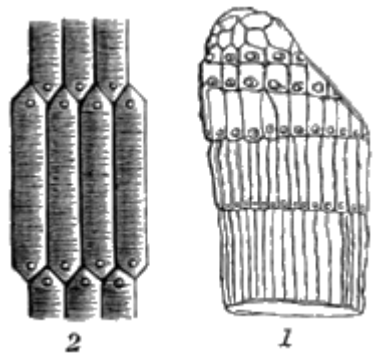
This plant is a true equisetum, differing chiefly

from existing species in its gigantic size and arborescent character. The sheaths surrounding the stem, and the verticillate linear leaves, are preserved in some examples: and in all, the furrows left by the imprints of the sheaths are more or less strongly impressed. The stem is not channelled throughout, as in *Calamites*, the carboniferous plant whose stems at first sight might be mistaken for those of Equisetites, but which are entirely distinct, as will be explained hereafter. The Equisetites columnaris is peculiar to the Oolite; it does not occur in the coal-measures. Specimens have been discovered which indicate a height of twenty feet, and a diameter of several inches.[76]

[76] See Hist. Vég. Fossiles, p. 115.

A small species of Equisetum (*Eq. Brodiei*[77]) occurs in the insectiferous limestone of the lower Lias, at Strensham, Worcestershire, associated with the foliage of fresh-water endogenous plants resembling the *Potamogeton*, or pond-weed, and of supposed dicotyledonous vegetables.

[77] Prof. Buckman, in Geol. Journal, vol. vi. p. 413.



LIGN. 14. CALAMITES DECORATUS.
$^{1}/_{3}$ *nat.*
(Ad. Brongniart. Pl. 14.)
Coal Formation. Yorkshire.

Fig. 1. Part of a stem, showing the tubercles for the attachment of leaves.
2. A portion of the same on a larger scale.

CALAMITES.

CALAMITES. *Lign.* 14, 15.—Stem articulated, regularly furrowed longitudinally, the articulations naked, or studded with tubercles.

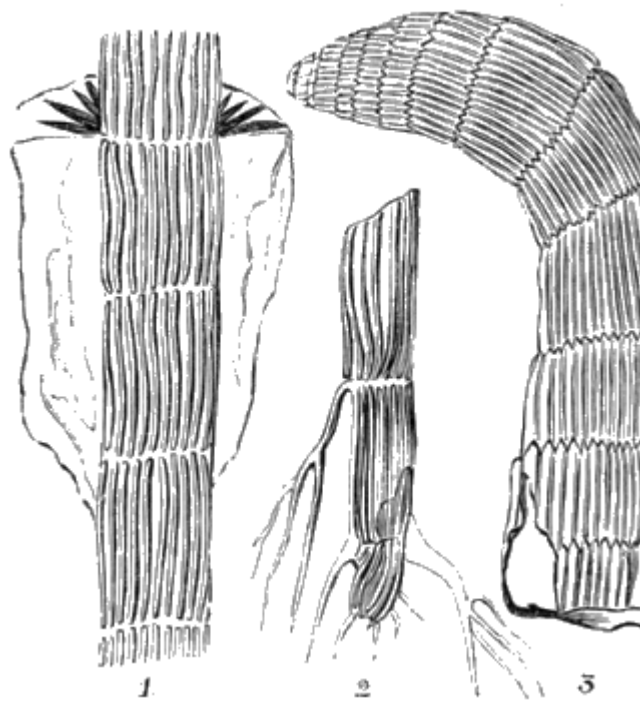
The plants of this genus were supposed to be related to the marestail, but to differ in the absence of the encircling sheaths, and in being uniformly striated; but an examination of specimens in a better state of preservation than those previously known, shows their affinity to the gymnosperms. Some of the species are of a gigantic size, being from one to three feet in diameter, and from thirty to forty feet in height. Calamites abound in the coal formation, and must have constituted an important feature in the forests of the carboniferous period; they occur also in more ancient deposits, and some species belong to the earliest terrestrial Flora of which any vestiges are known. In most instances when specimens are found lying in the same plane with the strata, they are pressed flat, but those occurring in a vertical position retain their natural cylindrical form. An outer crust or cylinder of coal generally invests the stem, but traces of the internal structure are rarely preserved.

The Calamite consists of a large central column of tissue, surrounded by a ligneous cylinder. The central part has in most instances perished after the death of

the plant, and the cavity thus left been filled up with mineral matter. As the hollow ligneous zone is almost always carbonized, and very friable, it is seldom attached to the cast, and consequently the surface of the latter is generally jointed and ribbed.

The true external surface of the cortical investment is marked with longitudinal striæ, without any indications of joints or constrictions; but the position of the original articulations is indicated in some specimens by the *presence of small verticillate scars, to which leaves were appended*[78] as in the example figured by M. Brongniart, of which *Lign. 14, fig. 1*, is a reduced figure.

[78] See Mr. Dawes, "On the Structure of Calamites," Proc. Geol. Soc, 1851, vol. vii. p. 197.



LIGN. 15. CALAMITES, IN COAL SHALE.

Fig. 1. CALAMITES RADIATUS, with the remains of one of the sheaths.

2. Stem, with remains of roots.—$^1/_2$ *nat.*

3. CALAMITES APPROXIMATUS, showing the curved lower end of the stem.—$^1/_5$ *nat.*

[79] This specimen has been inadvertently drawn with the base uppermost.

The stellate appearance on the upper part of the stem figured in *Lign. 15, fig. 1*, is produced by the zone of leaves which surrounded the joint: this character is entirely distinct from the sheath of the Equisetum shown in *Lign. 12*. This specimen points out the importance of carefully examining and preserving the stone around fossil stems; had this

precaution been lost sight of in this instance, no knowledge would have been obtained of this important botanical character. It is rarely that any traces of the roots remain; the fossil figured (*fig. 2*) is from the *Foss. Flor.* A beautiful example of the foliage of a species of Calamites is represented in *Lign. 59, fig. 2*.

Upright stems of Calamites occur in the Coal formation near Pictou, in North America; and in one example a group of ten or twelve stems, covering an area of two square feet, sprung from one root.[80]

[80] Dawson, Geol. Proc. vol. vii. p. 195. See Sir C. Lyell's Travels in North America, vol. ii. p. 195.

FOSSIL FERNS.

Filicites, or Ferns.

We now arrive at the consideration of one of the most interesting families of the vascular cryptogamia that adorned the Flora of the ancient world, and the living species of which impart beauty and elegance to the scenery of the countries where they prevail. The most essential character of these vegetables, is that of developing their fructification on the leaves; a fact familiar to every one who has even but cursorily examined the Polypody growing on our walls, or the Brake of our hedge-rows and commons. The largest species of British ferns scarcely exceed four or five feet in height; but the arborescent or tree-ferns, of warm climates, attain an altitude of from thirty to forty feet. There is too this peculiarity in the arborescent forms, that while in our indigenous species the leaves surround the stem, and incline towards the upper part of the plant, the foliage of the

former bends downwards, and spreads out from the crown, or summit, into an elegant canopy.



LIGN. 16. PECOPTERIS SILLIMANI; *n*
Coal Shale. Ohio.

a. The Stem.
b. Leaf-stalk, or petiole.
c. Leaf, or frond, which is bipinnate.
d. e. Leaflets, or pinnæ; the upper, *d*, are entire; the lower, *e*, are pinnatifid.
f. The pinnules, lobes, or segments.
g. The midrib, or median vein.
h. The veins. The veins are introduced in the leaflets, *d*; but in the lower ones, *e*, the midribs only are marked.

The leaves of our branched ferns are persistent, and when shed, the markings left by their attachment to the stalk are soon obliterated. In the

arborescent ferns, on the contrary, the petioles become detached from their bases, and fall entire, leaving scars or cicatrices on the stem; and these impressions are so regularly and symmetrically disposed, as to afford characters by which the trunks may be distinguished from those of other trees. The stems of the tree-ferns are therefore easily recognized in a fossil state externally, by their cylindrical forms without ramification, and by the regular disposition and peculiar character of the scars left by the separation of the petioles; and, internally by that peculiar zone, formed of bundles of ligneous tissue inclosed in sheaths, which encircles the central axis, as shown in the transverse sections in *Lign.* 2, *ante*, p. 62. The leaves may be identified by the form of their segments, which are disposed with remarkable regularity, and have a peculiar mode of subdivision; and above all, by the delicacy, evenness, and distribution of the veins. There are upwards of two thousand species of living ferns, and in the fossil kingdom the number is considerable; more than two hundred have been collected from the carboniferous formation. The recent tree-ferns are confined almost exclusively to the equinoctial regions; humidity and heat being the conditions most favourable to their development (*Vég. Foss.* p. 141. *Bd.* p. 461. *Wond.* p. 727).

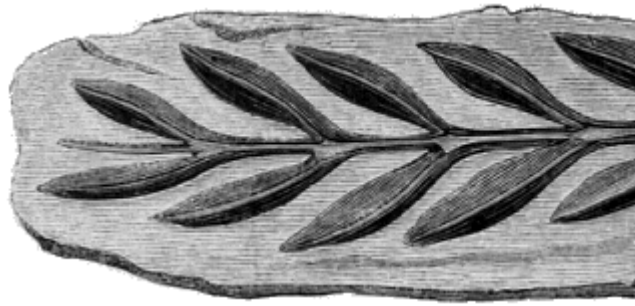
From the elegance and diversity of form of their foliage, fossil ferns are the most remarkable and attractive vegetable remains in the ancient strata. The greater number are from the coal deposits, the fern-leaves generally occurring in the schists or shales that form the roof of the beds of coal. Many of the strata are made up of carbonized fern-leaves and stems closely pressed together. The roof of a coal-mine, when newly exposed, often presents a most

interesting appearance, from the abundance and variety of leaves, branches, and stems, that occur either in relief, or impressed on the dark glossy surface. The specimens selected for illustration exhibit the principal modes of venation on which the genera are founded.

The fossil genera have been established by M. Ad. Brongniart, from the form of the leaves and the characters of their venation; that is, the distribution of the vessels. In the following descriptions some botanical phrases are necessarily employed; a few terms of frequent occurrence are explained in *Lign. 16*.

PACHYPTERIS[81] (*thick-fern*). *Lign. 17.*—In this genus from the lower Oolite, the fronds are pinnated, or bipinnated, the leaflets entire, without visible veins, having but a single midrib, and contracted at the base. The absence of veins, and the leaflets not being lobed, are the essential generic distinctions.

[81] The names of the genera are derived from *pteris*, fern, to which prefixed a term indicative of the peculiar characters.



LIGN. 17. PACHYPTERIS LANCEOLATA.
Inferior Oolite. Whitby.



LIGN. 18. SPHENOPTERIS ELEGANS
Coal-shale, Waldenburg, Silesia.

FOSSIL FERNS. SPHENOPTERIS.

SPHENOPTERIS (*wedge-leaf*). *Lign. 18.*—The leaves are twice or thrice pinnated, the leaflets wedge-shaped, contracted or narrowest at their base, and more or less deeply lobed: the lobes divergent and palmated: the veins radiating from the base.

The ferns of this genus are extremely elegant, and comprise upwards of forty species. A beautiful Sphenopteris (*S. affinis*, *Wond.* p. 716,) occurs abundantly in the fresh-water carboniferous strata at Burdie House, near Edinburgh;[82] another elegant form, in coal-shale, is represented in *Lign. 18*.

[82] See Dr. Hibbert's Memoir on the Strata and Fossils of Burdie House. 4to. 1835.

It is so rarely that the fructification of any species of Sphenopteris is preserved in a fossil state that I am induced to figure a leaflet of a remarkable plant, of this genus from the fluvio-marine oolitic deposits of Scarborough. *Lign. 19* is copied from the lithograph accompanying a notice of some rare plants from that locality, by the eminent botanist, C. J. F. Bunbury, Esq.[83]

[83] Geol. Journal, vol. vii. p. 179, pl. xii.

This fossil fern closely resembles certain species of *Dicksonia* (natives of New Granada). Each segment of the leaflet or pinnate is dilated at the apex into a reniform *indusium*; no capsules are visible, the fructification being, probably, in a young state.





LIGN. 19. SPHENOPTERIS NEPHROCARPA.
Inferior Oolite, Scarborough.
A magnified vein of a leaflet, showing the fructification at the extremities of the lobes, × two diameters.

In the Wealden deposits, both of England and Germany, several species of Sphenopteris abound; one of which (*Foss. Tilg. For.* 1827), often occurs in the calciferous grit of Tilgate Forest, in a beautiful state of preservation: a small branch is figured in *Lign. 20*. This species is characterized by its slender and minutely divided wedge-shaped leaflets. The Sphenopteris Mantelli did not attain a considerable size; the largest stem I have seen indicated a plant of five or six feet in height. This Sphenopteris is sometimes associated with the remains of a beautiful plant of the genus *Alethoptris*,[84] the leaflets of which, in some examples, bear the fructification. (*Wond.* p. 394, *Lign.* 89.)

[84] *Alethoptris elegans* of Dr. Dunker. Mon. Norddeutschen Weald, pl. vii. *fig.* 7.



LIGN. 21. CYCLOPTERIS TRICHOMANOIDES; *a single leaf*
Oolite, near Scarborough.

CYCLOPTERIS (*round-leaf*). *Lign. 21.*—The frond is simple and entire, or but slightly lobed at the margin, and generally orbicular, or kidney-shaped: there is no midrib; the veins are numerous, equal, and dichotomous, or forked, and radiate from the base. The form and disposition of the veins resemble those of some living species of fern; the absence of a median rib, or vein, is the most striking character of this genus. The fructification is supposed to have been marginal.

FOSSIL FERNS. NEUROPTERIS.

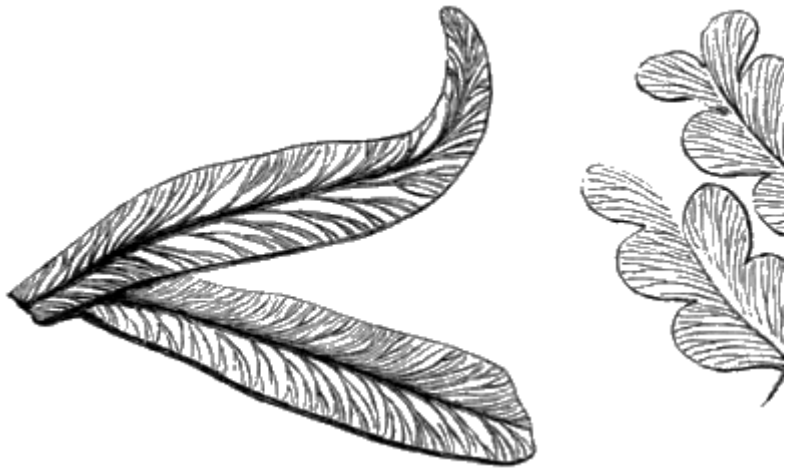
NEUROPTERIS (*nerved-leaf*). *Lign.* 22.—The fronds are pinnate or bipinnate; the leaflets more or less ovate or cordiform and entire, adhering to the rachis by their centre only; veins very fine, arched, rising obliquely from the base of the leaflet; the midrib does not extend' to the apex of the leaflets, but terminates by subdividing into veins.



LIGN. 22. NEUROPTERIS ACUMINATA; *nat.*
In Coal-shale, Yorkshire.

This is a very numerous genus, comprising thirty or more species, which are principally found in the coal-shale. Some of these plants bear a general resemblance to the *Osmunda regalis*, but differ in their essential characters; their leaflets often form the nuclei of ironstone nodules.

GLOSSOPTERIS (*tongue-leaf*). *Lign. 23.*—Leaves simple, sub-lanceolate, gradually contracting towards the base; midrib thick at the base, and vanishing towards the apex of the leaf; veins very fine, curved, oblique, frequently dichotomous, sometimes reticulated, or anastomosing at their base. The plants of this genus resemble the ferns with simple leaves. A few species only are known; of these, two are from the coal-shale, one from the Lias, and one from the oolite.



LIGN. 23. GLOSSOPTERIS PHILLIPSII; *nat. Oolite, Scarborough.*

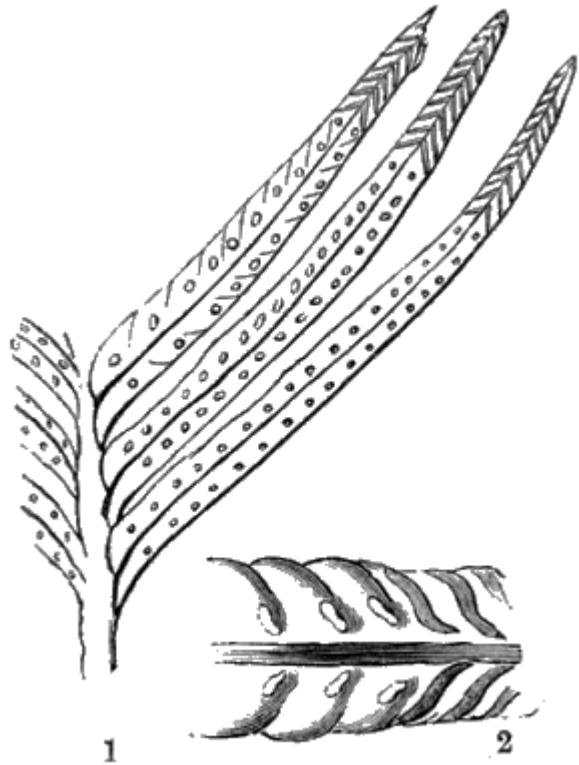
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ODONTOPTERIS (*tooth-leaf*). *Lign. 24.*—Leaf bipinnate, the leaflets adhering to the rachis or stalk by their whole base, which is not contracted; the veins equal, simple, dichotomous, arising side by side from the base of the leaflet; no distinct midrib. In their general aspect these plants resemble some South American species of Osmunda. Five species only are known, all of which belong to the most

ancient coal strata.

ANOMOPTERIS (*anomalous fern*—so named because the plants differ from all recent and fossil ferns). *Lign. 25.*—Leaves deeply pinnated; leaflets very long, entire, linear, traversed by a distinct midrib, equal throughout; secondary veins simple, perpendicular to the median vein, swollen at their free extremities, and not extending to the margin of the leaflet. But one species is known. These leaves are of great size, and doubtless belonged to some arborescent fern; in several examples the fructification is preserved. My collection contained a splendid specimen from near Strasburgh, presented by the late M. Voltz, which is now in the British Museum.[85]

[85] Petrifactions, p. 32.

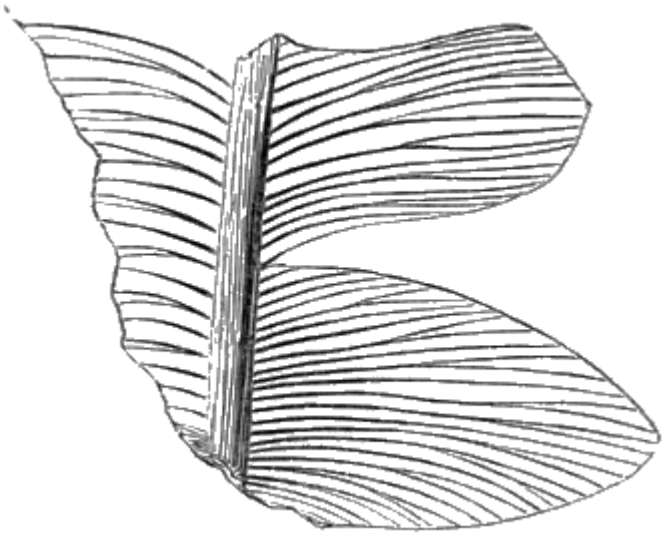


LIGN. 25. ANOMOPTERIS MOUGEOTII; *nat.*
New Red Sandstone; Sultz-les-Bains, near Strasburgh.
Fig. 1.— Three leaflets of a very large frond.
2.— A portion magnified to show the fructification.

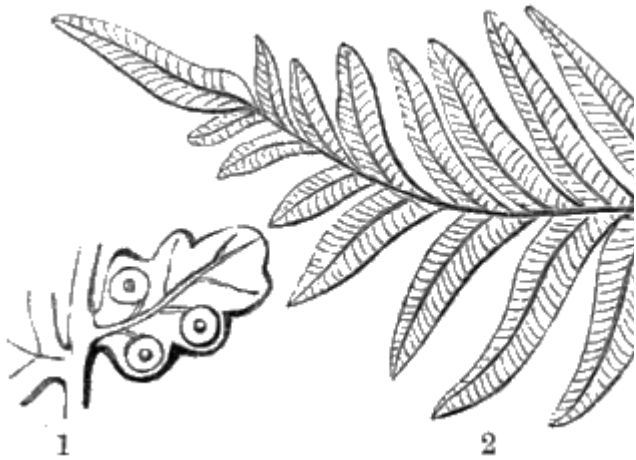
FOSSIL FERNS. TŒNIOPTERIS.

TŒNIOPTERIS (*wreathed fern*). *Lign.* 26.—Leaves simple, entire, straight, with parallel margins, traversed by a strong midrib, which extends to the apex; secondary veins, simple or bifurcated at their base, and almost perpendicular to the median vein. These ferns are related to certain species of Polypodium. Three species are known; two from the Oolite, and one from a tertiary deposit. The specimen

figured is a fragment.



LIGN. 26. TŒNIOPTERIS LATIFOLIA; *fragment of a frond; nat. Stonesfield Slate.*

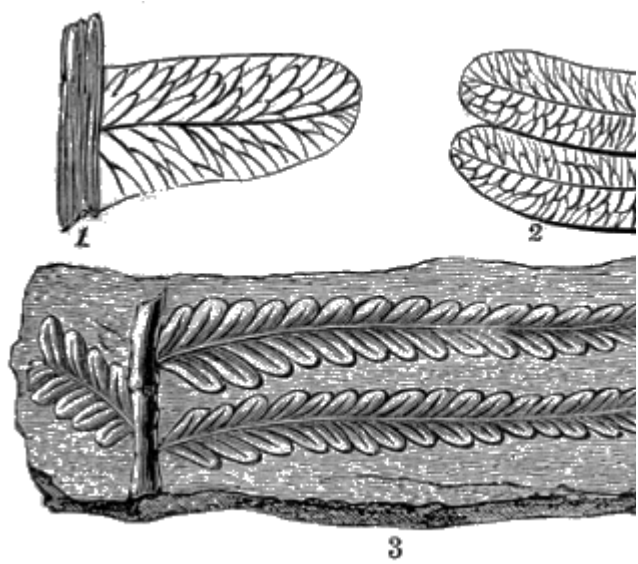


LIGN. 27.

Fig. 1.— PECOPTERIS MURRAYANA; a pinnule with the fructification; *m*
2.— PECOPTERIS LONCHITICA. *Coal-shale, France.*

PECOPTERIS (*embroidered fern*). *Lign. 27.*—Leaves once, twice, or thrice pinnated: leaflets adhering by their whole base to the rachis, rarely by the centre only; traversed by a strong midrib, which extends to the apex; veins simple, or once or twice dichotomous, proceeding almost at right angles from the median vein.

This genus embraces a very large proportion of the ferns which have contributed to the formation of the coal, and whose leaves and stems are preserved in the associated strata. The originals of many species were undoubtedly arborescent, and attained a large size; some leaves four feet wide, and of a proportionate length, have been observed. More than one hundred species are determined. An American species (*Pecopteris Sillimani*) is figured in illustration of certain botanical terms, *Lign.* 16, *ante*, p. 110. Several species of Pecopteris occur in the fluvio-marine oolitic deposits near Scarborough, and leaves in fructification are not uncommon: *fig. 1, Lign.* 27, represents a leaflet slightly magnified.



LIGN. 28. LONCHOPTERIS MANTELLI.
Wealden, Tilgate Forest.

Fig. 1. & 2.— Leaflets magnified, to show the reticulated venation.

3.— A fragment of a frond; *nat.*

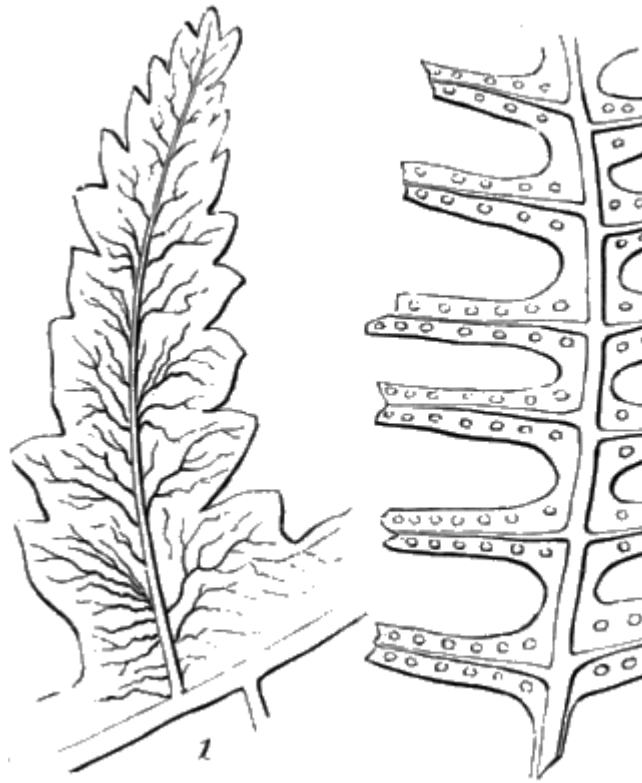
FOSSIL FERNS. LONCHOPTERIS.

LONCHOPTERIS (*spear-leafed.*) *Lign.* *28.*—Leaves many times pinnated; leaflets more or less adherent to each other at their base, traversed by a midrib; secondary veins reticulated.

The three known species which compose this genus resemble the living ferns of the genera Lonchitis, Woodwardia, &c. Two have been found in the coal-measures, and one species in the Wealden formation of England and Germany (*Foss. Tilg. For.* pl. iii.) This last appears to have been a delicate plant; for though fragments are very common in the micaceous grits and clays, any considerable portion of a leaf is of rare occurrence. M. Graves found the

same fern near Beauvais in France, in strata, which, from the presence of the fresh-water limestone called Sussex marble, are supposed to be referable to the Wealden epoch. This Lonchopteris is widely spread through the Wealden; and occurs also in the Greensand. Mr. Morris first observed it in the iron-sandstone of Shanklin Chine.[86]

[86] Geol. I. of W. 2d *Ed.* p. 230.



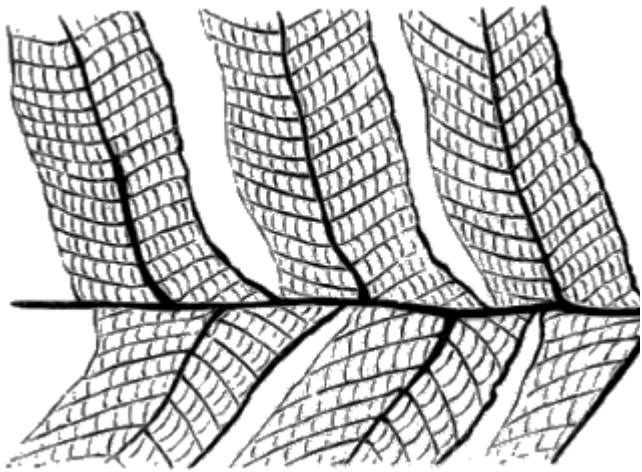
LIGN. 29.

Fig. 1.— PHLEBOPTERIS[87] PHILLIPSII. *Oolite, Scorborough.*
2.— PHLEBOPTERIS PROPINQUA, *showing fructification.*

[87] Comptopteris of M. Ad. Brongniart.

PHLEBOPTERIS (*veined-leaf*). *Lign. 29.*—Leaves pinnated; leaflets with the margin entire, or crenulated, the midrib strong; secondary veins anastomosing by arches, with large angular spaces, often unequally disposed; the finer veins are simple or divided; the apex sometimes free. The fructification is punctiform, and placed at the apices of the veins.

The foliage of these remarkable ferns has been mistaken for the leaves of dicotyledonous plants; but M. Brongniart has demonstrated that they belong to the present family. Six species have been found in the Oolite and Lias.



LIGN. 30. CLATHROPTERIS MENISCOIDES.
Portion of a leaflet: the original $1^1/_2$ ft. long.
Wealden? Scania.

FOSSIL FERNS. CLATHROPTERIS.

CLATHROPTERIS (*latticed-leaf*). *Lign.* 30.—Leaf deeply pinnatifid; leaflets elongated, traversed by a strong midrib extending to the apex; secondary veins

numerous, simple, parallel, almost perpendicular to the midrib, united by transverse branches, which, with the finer veins, produce on the surface of the leaf a net-work of quadrangular meshes.

This genus was instituted by M. Brongniart, for the reception of some very large fern-leaves from the shale of Hoer, in Scania, which resemble in structure the foliage of the recent *Polypodium quercifolium*, a native of the East Indies, and the Moluccas. One leaf was four feet wide, and the leaflets, though imperfect, were eighteen inches long.[88]

> [88] Hoer is a little village, situated nearly in the centre of Scania, a province in the southern extremity of Sweden. The Chalk formation appears in several parts of this district, and Carboniferous strata at Hoeganes. To the west of Hoer, there is a range of hills, composed of ferruginous grits, micaceous sandstones, clays, and beds of quartzose conglomerate. It is in these strata that the ferns and other terrestrial plants occur, and no animal remains whatever have been found in them; their geological position appears to be between the Chalk and the Coal, but on this point nothing positive is known. The general analogy of the plants with the group forming the Flora of the Wealden, led M. Brongniart to suppose that the deposits in question belong to that formation; and M. Nillson, of Lund, who examined my collection at Brighton, recognized, among some undescribed plants from Tilgate Forest, forms that he had collected from Hoer. See "*Observations sur les Végétaux Fossiles renfermés dans les Grès de Hoer en Scanie: par M. Ad. Brongniart.*" *Ann. Sc. Nat.* 1825.

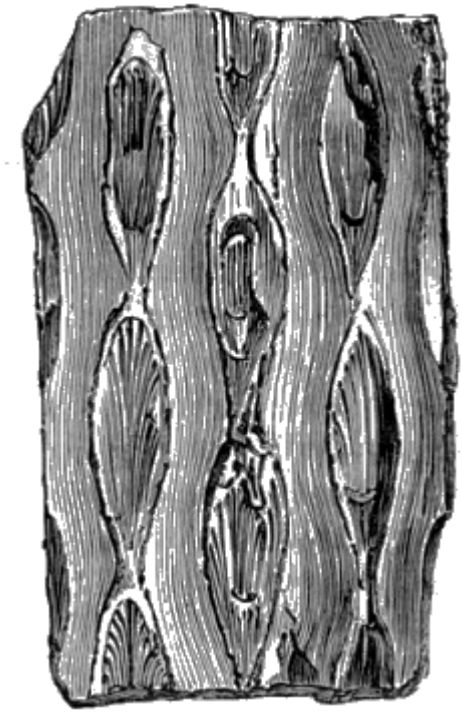
Many other genera of fossil ferns have been

established from the form and venation of the leaves, and are described in *Brit. Foss. Flor.*, and other British and foreign works.

STEMS OF ARBORESCENT FERNS.—Notwithstanding the profusion with which the foliage of many kinds of ferns is distributed throughout the coal formation, the undoubted stems of plants of this family are rarely met with; for the numerous tribe called Sigillariæ is now removed altogether from this class. It may, however, admit of question whether much of the foliage which, from the analogy of structure, has been referred to ferns, may not have belonged to those trees; for as in the animal kingdom, so in the vegetable, distinct types of living organisms are often found blended in the lost races; and as the stems of recent tree-ferns are even more durable than their leaves, it seems impossible to account for their absence in strata, that inclose entire layers of the foliage matted together. A few fossils, supposed to possess the essential characters of recent fern-stems, have been discovered, and arranged under the following genus.

FOSSIL FERN-STEMS.

CAULOPTERIS (*fern-stem*). *Lign.* 31.—Stems not channelled, marked with discoidal, oblong, or ovate scars, arranged longitudinally; vascular cicatrices numerous.



LIGN. 31. CAULOPTERIS MACRODISCUS. *Coal.*

The fragment of stem here figured, resembles the trunks of some recent tree-ferns in its proportions, and in the number, disposition, and size, of the scars of the leaf-stalks; but these markings differ in their more lanceolate form, and pointed terminations, and in their peculiarly striated surface, from those of any known existing species.

PSAROLITES (*Silicified Fern-Stems*).—In the New Red sandstone, near Hillersdorf, in the neighbourhood of Chemnitz, in Saxony, silicified stems, apparently of tree-ferns, occur in great numbers. They are remarkably beautiful, and the organization of the original is so well preserved by

the silex, that slices, examined by the microscope, display the peculiar structure almost as perfectly as if the plants were recent: transverse sections exhibit the arched bundles of vascular fibres which compose the ligneous cylinder, surrounded by the cellular tissue. From the stellated markings produced by sections of the vessels that compose the tissues, and which are visible to the naked eye, these fossils have obtained the popular name of *Staaren-stein*, or Star-stone. The external surface of the specimens I have examined has a ligneous structure, and is of a dark reddish brown colour; internally the stems are of a dull red, mottled with various tints of blue and yellow, from the infiltrated chalcedony with which the vessels are permeated.[89]

> [89] See Pict. Atlas (pl. viii.) for coloured figures; and Org. Rem. vol. L plate viii. *figs.* 1-7. The reader will be amused by the perusal of the ingenious but unsuccessful attempt of the excellent author, Mr. Parkinson, to elucidate their nature. I have still a specimen which he presented to me more than thirty-five years since, as one of the most curious and perplexing fossils that had ever come under his notice.

An excellent work ("*Dendrolithen*") on these fossils, in which thirty species are described, has been published at Dresden by M. Cotta; who arranges them under the genus *Psaronius* or *Psarolites*. The stem is composed of two distinct parts; an outer zone, consisting of a great number of nearly cylindrical bundles of vessels, supposed to have been roots which proceeded from the stem near its base; and an inner part or axis. In the outer portion, the fossil *air-roots* have a vascular tissue, but there is often a delicate cellular tissue interposed. In the axis

the vessels form zigzag or wavy bands, resembling those of ferns.[90] These flexuous and vermiform bands are entirely composed of barred or scalariform vessels, similar to those of ferns and club-mosses. The Psarolites are therefore considered by M. Ad. Brongniart to be the bases of the trunks of lycopodiaceous trees, while M. Cotta and other botanists regard them as true arborescent ferns.[91]

[90] Pict. Atlas, pl. viii.

[91] See M. Brongniart's "*Tableau des Genres de Végét. Foss.*" p. 44.

Dr. Buckland has discovered in the New Bed sandstone formation at Allesley, near Coventry, silicified trunks of coniferous trees, and it is not improbable that further research in that locality may bring to light fern-stems like those of Chemnitz.[92] Dr. Lloyd, of Warwick, has recently obtained leaves of several coniferæ from the same locality.[93]

[92] Vide Geol. Proc. vol. ii. p. 438.

[93] Geol. Society, June 1852. Dr. Lloyd's specimens are probably referable to the genus *Walchia*: see *Lign.* 60.

Sigillarlæ and Stigmariæ.

SIGILLARLÆ AND STIGMARIÆ.

Among the most common and striking objects that arrest the attention of a person who visits a coal-mine for the first time, and examines the numerous vegetable relics that are profusely dispersed among the heaps of slate, coal, and shale, are long flat slabs, from half an inch to an inch thick, having both surfaces longitudinally fluted, and uniformly pitted

with deep symmetrical imprints; these are disposed with such perfect regularity between the grooves, that the specimens are often supposed, by persons not conversant with palæontology, to be engraven stones, and not natural productions. These fossils are the flattened trunks of gigantic trees covered by the bark in the state of coal; the regular imprints on the surface, being the scars left by the separation of the petioles or leaf-stalks, as in the arborescent ferns previously examined. The name *Sigillaria*, commonly applied to these fossils, is derived from *sigillum*, a seal, and alludes to the regular and uniform pattern of the imprints on the surface. These stems are from a few inches to several feet in diameter, and the largest attain a height of sixty feet; they are generally found lying in a horizontal position in the strata, and quite flat, from the pressure produced by the superincumbent rocks; but when the trunks are in an erect position, and at right angles to the plane of the beds, the cylindrical form of the original is preserved.

A remarkable instance, in which five stems of Sigillaria were standing upright, with their roots in the soil below, apparently in the position in which they grew, was brought to light a few years since, in forming the Bolton and Manchester railway.[94] They stand on the same plane, and near to each other. Their roots are branched, and spread out in the bed of impure coal in which they are implanted. The trunks are surrounded by a soft blue shale. The largest tree is eleven feet high, and seven and a half feet in circumference at the base; its trunk is gnarled and knotted, and has many decorticated prominences, like those in barked timber of our old dicotyledonous trees; the roots, too, partake of the same character.[95] The others are respectively from

three to five feet in height. A sketch of one of the short stems is subjoined. All the trees were broken off as if by violence, and no traces of the upper part of the stems or branches were detected.

[94] These trees still remain *in situ*, and, thanks to the scientific zeal of Mr. Hawkshaw, have been carefully preserved. They are situated at Dixon Fold, Clifton, near Manchester. Instructive models of these highly interesting relics of the carboniferous forests may be obtained.

An excellent Memoir on this discovery, with illustrations, by Mr. Hawkshaw, is given in Geol. Trans, vol. vi. pl. xvii. See Pict. Atlas, p. 198; and Petrifactions, p. 36.

[95] See Mr. Bowman's Memoir, Geol. Proc. vol. iii. p. 270.



LIGN. 32. BASE OF A TRUNK OF A SIGILLARIA. WITH ROOT *standing erect with five other stems, in Carboniferous strata.* (*The original is four feet high.*)

In the stratum through which the roots extend, a considerable quantity of the fossil cones, called *Lepidostrobi*, hereafter described, were imbedded (see

Lign. 40). A thin layer of coal which invested the stems, was evidently the carbonized bark. All the stems were filled with blue clay, or shale, a proof that they were hollow when submerged in the mud, which is now consolidated into the shale in which they are imbedded. But it is not probable that they were originally tubular, like a reed: on the contrary, there is evidence to show that they were highly organized. Their internal structure may have decayed, or been destroyed by insects or other depredators; as is often the case in tropical climates, where the trunks of timber trees are speedily excavated after their fall, and afford shelter to innumerable insects and reptiles, as the weary traveller often finds to his surprise and annoyance. [96] The late Mr. Bowman affirmed[97] that these trees were dicotyledonous, and stated that medullary rays and coniferous structure could be detected; an opinion, which the researches of M. Brongniart on the Sigillariæ have fully corroborated.

[96] Mr. Hawkshaw, Geol. Proc. p. 269.

[97] Geol. Proc. vol. iii. p. 270.

ERECT STIGMARIÆ.

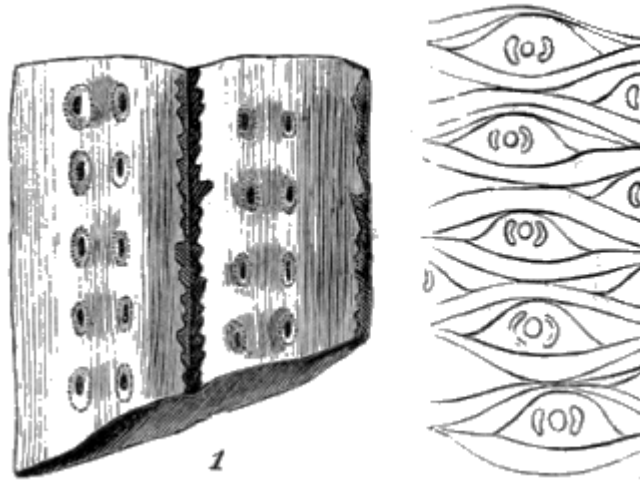
Many other instances have been noticed of Sigillariæ standing more or less erect in the strata. In forming the railway tunnel at Claycross, five miles south of Chesterfield, through the middle portion of the Derbyshire coal-measures, in 1838, a group of nearly forty trees (*Sigillariæ*) was discovered, standing not more than three or four feet apart, at right angles to the plane of the strata.[98] On the coast of Northumberland, within the length of half a mile, twenty trees were observed by Mr. Trevelyan,

in 1816 (*Bd.* p. 470). The coal-pit at St. Etienne, in France, described by M. Alex. Brongniart, is celebrated for affording an example of this phenomenon (*Wond.* p. 673); but the positions of many of those stems are inclined at various angles, and their roots implanted in different beds, so that the perpendicularity of the erect trees is probably accidental (*Bd.* p. 471).

[98] Ibid. p. 272.

The most remarkable instance hitherto observed, is on the southern shore of the Bay of Fundy, in Nova Scotia, where the cliffs, which are about two hundred feet high, are composed of carboniferous strata, consisting of coal, clay, grit, and shale, in which numerous erect trees, probably Sigillariæ, are seen on the face of the cliff; there are ten rows one above another, indicating, in the opinion of Sir C. Lyell, repeated subsidences of the land, so as to allow of the growth often successive forests![99] (*Wond.* p. 674).

[99] "On the Coal Strata of Nova Scotia." Amer. Journ. Oct. 1841 and Travels in America, vol. ii. p. 180.



LIGN. 33. SIGILLARIÆ; *in Coal-shale*.

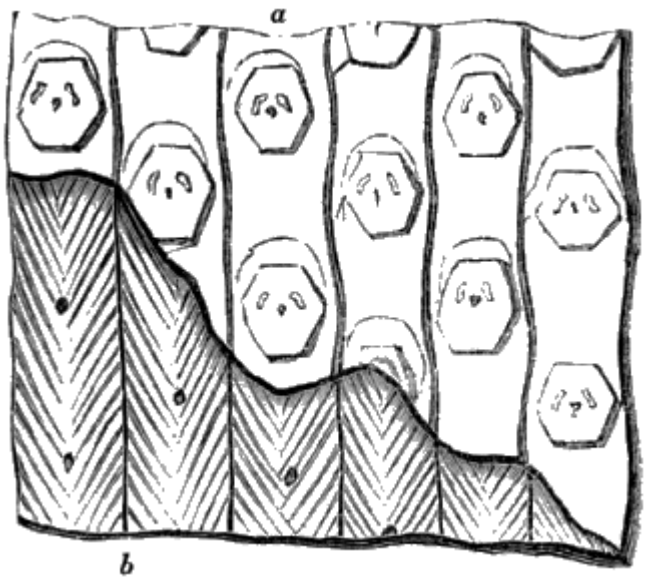
Fig. 1. A specimen deprived of its carbonaceous bark, except in the in — and showing pits left by the external scars.
2. The markings of S. DEFRANCII. (*Vég. Foss. Br.*)
—

SIGILLARLÆ.

The stems of Sigillariæ vary in size from a few inches to five feet in diameter; and in length from five to sixty feet; they gradually taper from the base to the summit. A specimen measured by M. Brongniart was forty feet long, one foot in diameter at the base, and but six inches at the top, where it divided into two equal branches. These stems may be readily distinguished from those of other trees with which they are associated, by the fluted surface produced by the deep longitudinal grooves, and the regularly disposed imprints between the channels. [100] The carbonized bark, in large specimens, is often an inch thick, but in small examples is a mere pellicle, and being extremely brittle, flakes off with the slightest touch, leaving the inner surface

exposed, with the coal remaining in the deep furrows and pits, as in *Lign. 33, fig. 1*. No traces of leaves, or fruit, in connexion with the stems, have been observed. The subjoined sketches (*Lign.* 33, and 34,) illustrate the usual aspect of these fossils. The difference between the imprints on the outside of the bark, and those on the exposed surface of the stem, from the removal of the cortical covering, is well marked in *Lign. 34*.

[100] The stems of some recent dicotyledonous trees from New Zealand, in the possession of Dr. Robert Brown, possess similar longitudinal ribs and furrows, both on the bark and alburnum, or naked wood.



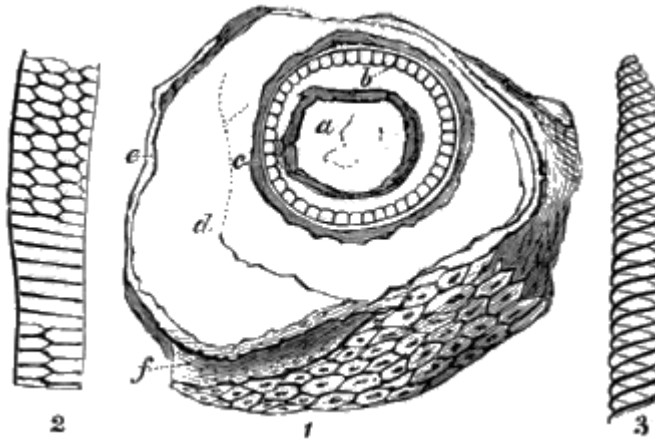
LIGN. 34. SIGILLARIA SAULLII.
Carb. Manchester.

a. The imprints of the petioles on the external surface of the carbonized cortical investment.

b. The inner surface, exposed by the removal of the crust or bark.

INTERNAL STRUCTURE OF SIGILLARIÆ.—Our knowledge of the structure of this numerous tribe of plants, has received an important accession by the discovery of the silicified fragment of a stem, which, fortunately for the advancement of science, was placed at the disposal of M. Adolphe Brongniart. It has been described and illustrated by that eminent botanist, in a memoir which is one of the most valuable contributions to fossil botany that has hitherto appeared.[101]

[101] The reader intending to make fossil botany his particular study, should refer to the original memoir, and become familiar with the facts and inferences so admirably enunciated by the author; not only for the illustration of the structure of the tribe of plants under consideration, but as a valuable exemplification of the manner in which all such inquiries should be conducted. See *Archives du Muséum d'Histoire Naturelle*, tom. i. Paris, 1839.



LIGN. 35. SILICIFIED STEM OF SIGILLARIA ELEGANS.

Autun. France.

(*M. Adolphe Brongniart.*)

Fig. 1. A transverse section of the silicified stem, from Autun; *nat.*
— *a.* Situation of the medullary tissue, occupied by coloured silex
b. Zone composed of bundles of vessels, forming the woody tiss
c. Band of cellular tissue
d. Space between the ligneous cylinder and the bark, with no e
structure, but originally occupied by the external cellular tissue
e. Zone of indistinct cellular substance.
f. External cortical envelopment, or bark.
2. Portion of one of the vessels of the medullary tissue, as seen in
— longitudinal section, (× ×.)
3. Portion of a spiral vessel of the same tissue. (× ×.)
—

The annexed figure (*Lign.* 35) is an outline of the specimen, of the natural size; but this sketch is a mere plan or diagram, for it is impossible without the aid of colour to convey a faithful idea of the original. The student should observe, that when mineral matter has permeated the stems of plants, the vascular tissue is often so well preserved, that one such specimen affords more important information, than hundreds of examples in which the form alone remains.

SIGILLARLA ELEGANS.

The external surface of this specimen possesses the characteristic markings of the insertion of the leaf-stalks of *Sigillaria elegans*. The internal organization, as seen in the transverse section, is as follows:—

a. The centre, filled with silex; it exhibits no traces of structure.

b. The zone which surrounds the interspace on which this letter is placed, is composed of bundles of vascular tissue. A portion of one of these bundles,

highly magnified, is represented in *Plate V. fig. 7.*

The *inner* circle of this zone, indicated by the *convex undulating line*, is made up of medullary vascular tissue; the external circle is divided by rays, and is composed of woody fibre, constituting a ligneous cylinder. One of the spiral vessels (*fig. 3*), and another showing a remarkable difference of structure in a short space (*fig.* 2), as seen in a longitudinal section of the medullary tissue, are figured in *Lign.* 35.

The ligneous cylinder is surrounded by a band of cellular tissue, and the space between this and the cortical integument is occupied by silex, in which there are but obscure traces of structure.

The inner layer of bark, *f*, is composed of elongated cells, disposed in a radiating manner, and traversed by fibro-vascular bundles, which pass towards the leaves.

Upon instituting a comparison between the fossil and the stems of those recent plants which present the closest analogy to it, M. Brongniart was led to conclude that the Sigillariæ constituted a peculiar extinct family, belonging to the great division of gymnospermous dicotyledons.

The Sigillariæ were tall erect trees, with a regular and cylindrical stem, without side branches, but dichotomous towards the summit. Their superficial bark was hard and durable, channelled longitudinally, bearing leaf-scars that are of a rounded form above and below, and angular at the sides, often oblong in relation to the stem, and having three vascular pits, one central and small, and two lateral of a larger size. The internal structure

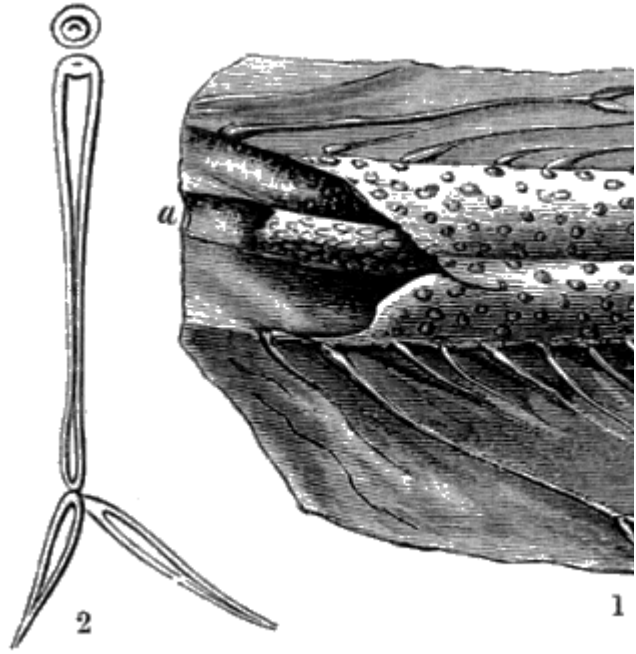
bears most analogy to that of the Cycadeæ, and the foliage consisted of long linear carinated leaves. The Sigillariæ, therefore, differ essentially from the arborescent cryptogamia, which they somewhat approach in having scalariform vascular tissue, symmetrical and regular leaf-scars, and branchless trunks. More than fifty species have been determined.[102]

[102] For figures of Sigillariæ, see Pictorial Atlas, pl. xix. xx, xxiv.

STIGMARIA.

STIGMARIA. *Lign. 36.*—This extended notice of the structure of the Sigillariæ,.will enable us to understand the nature of the fossil vegetables termed Stigmariæ, or spotted-stems, which abound in the beds of under-clay of most coal-fields, as stated in a former part of this work (*ante*, p. 81.). These bodies when uncompressed are of a cylindrical form, from one to six or seven inches in diameter, and of considerable length—sometimes upwards of twenty feet—and gradually diminish in size towards their termination. The surface is marked with distinct pits or areolæ, of a circular or oval form, with a small tubercle in the centre of each, disposed around the stem in a quincunx and somewhat regular order. When broken transversely, a small cylindrical axis is seen to extend in a longitudinal direction through the stem, like a medullary column; it seldom occupies the centre, but lies near to one side, and parallel with a depression on the outer surface of the fossil. This internal body is often loose, and removable; its surface is covered with interrupted, irregular, longitudinal, ridges, which leave corresponding depressions on the walls of the cavity in which it was inclosed. *Lign.* 36, represents a

fragment exhibiting the characters above described.



LIGN. 36. STIGMARIA FICOIDES.
Carboniferous. Derbyshire.—$^1/_4$ *nat.*

Fig. 1. Portion of a stem, with some of the rootlets (formerly considere
— the surrounding clay. The internal axis is seen at *a*; and the cor
portion of external surface that remains.

2. An outline of one of the rootlets, with a tubercle to show the m
— ball and socket joint to the root.

When Stigmariæ are observed in the under-clay, to which stratum they are principally confined, long, tapering, subcylindrical fibres, often several feet in length, are seen affixed to the tubercles with which the surface is covered; their form and mode of attachment are shown in *Lign.* 36. Instances occur in which several Stigmariæ spring from a common

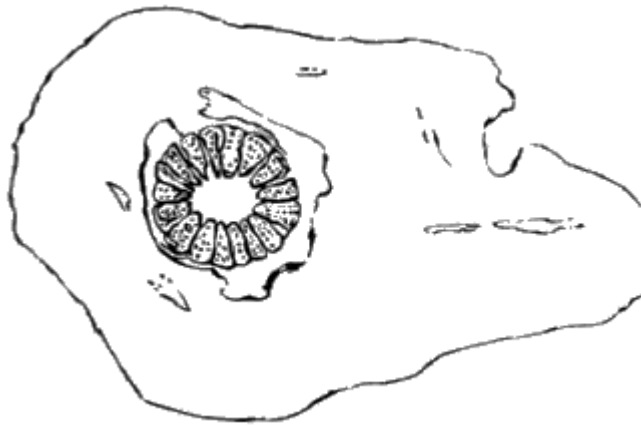
centre, of a dome-like form, whence they radiate in every direction (*Bd.* pl. lvi. *fig.* 8), and the main branches divide and subdivide till they are lost in the surrounding rock.

The nature of these fossil vegetables was long a perplexing question, for no specimens had been found in connexion with any of the stems, branches, or foliage, that abound in the coal deposits. At length, the discovery of a dome-shaped mass, to which were attached numerous Stigmariæ, seemed to afford a clue to the solution of this botanical problem; and it was concluded by the eminent authors of the "Fossil Flora of Great Britain," that the original belonged to a tribe of plants which inhabited swamps, or still and shallow lakes, and were characterized by a low truncated stem, having long horizontal branches beset with cylindrical, and, probably, succulent leaves, that either trailed on the surface of the swamp, or floated in the water.

But within the last few years, the occurrence in various carboniferous deposits of erect stems of Sigillariæ, has shown that the Stigmariæ are nothing more than the roots of these and other congenerous trees; an opinion maintained by the Rev. H. Steinhaur more than thirty years ago, and subsequently affirmed by M. Adolphe Brongniart, who found, on examining microscopically the internal structure of a silicified specimen in which the vascular tissue was preserved, that it bore as close an analogy to that of the Sigillariæ, as exists between the roots and trunks of certain dicotyledonous trees.

The annexed figure, *Lign.* 37, represents the transverse section of a small Stigmaria, with the axis

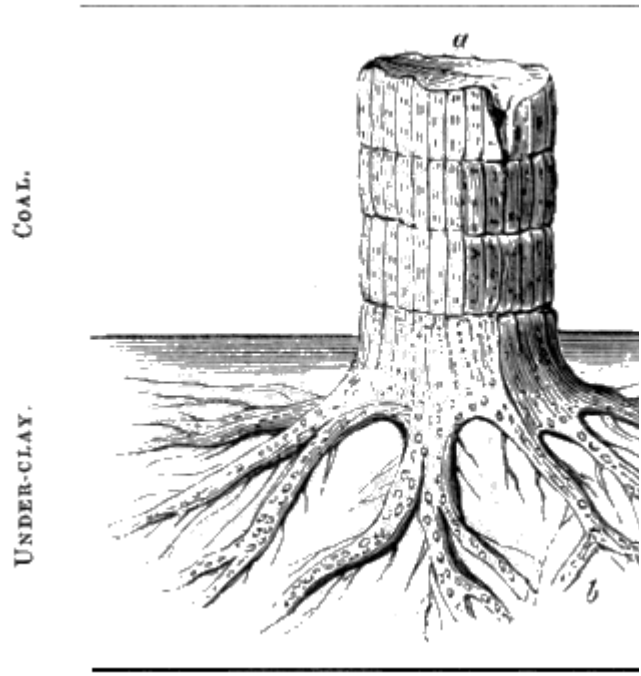
displaced from its natural situation; this circumstance, as well as the corresponding external groove, has arisen from compression, by which the tough cylinder has been forced from its original position in the middle of the soft cellular tissue, to one side.



LIGN. 37. TRANSVERSE SECTION OF STIGMARIA FICOIDES; *n*
(*M. Adolphe Brongniart.*)
This specimen shows that the cylinder (*a* in *Lign.* 36) is formed of l
vascular tissue, disposed in rays.

The central axis is thus shown to be a cylinder composed of bundles of vessels, disposed in a radiating manner, and separated from each other by medullary rays; the whole constituting a ligneous zone resembling that of Sigillaria (see *Lign.* 35); but the inner circle of medullary tissue seen in the latter is altogether wanting. This difference is similar to that observable in the stems or branches of a dicotyledonous tree, in which the woody cylinder is associated internally with bundles of medullary tissue, and the roots of the same tree that are destitute of them. Part of a vascular bundle from the woody tissue of a Stigmaria, seen by a high power

and transmitted light, is figured *Pl. V. fig. 6*; the smooth interspaces are composed of cellular tissue.



LIGN. 38. ERECT STEM OF A SIGILLARIA, WITH
Coal Mine, near Liverpool.

a. The trunk of the tree, traversing a bed of Coal.

b. The roots (*Stigmariæ*) spreading out in the Under-clay.

ERECT SIGILLARIA WITH ROOTS.

This opinion of M. Brongniart was confirmed by the discovery, in 1843, at St. Helen's, near Liverpool, of an upright trunk of a Sigillaria, nine feet high, with ten roots eight or nine feet in length, still attached, and extending in their natural position. *These roots are undoubted Stigmariæ of the usual species, S. ficoides; and the radicles, formerly considered leaves, are spread out in all directions, to the extent of*

several feet.[103] To the sagacity and perseverance of Mr. Binney, of Manchester, science is indebted for this important discovery; the same gentleman laid bare, on the floor of the mine at Dunkinfold, near Manchester, a large erect trunk of a Sigillaria, with numerous Stigmariæ roots.

[103] From a communication to the British Association at Cork, 1843.

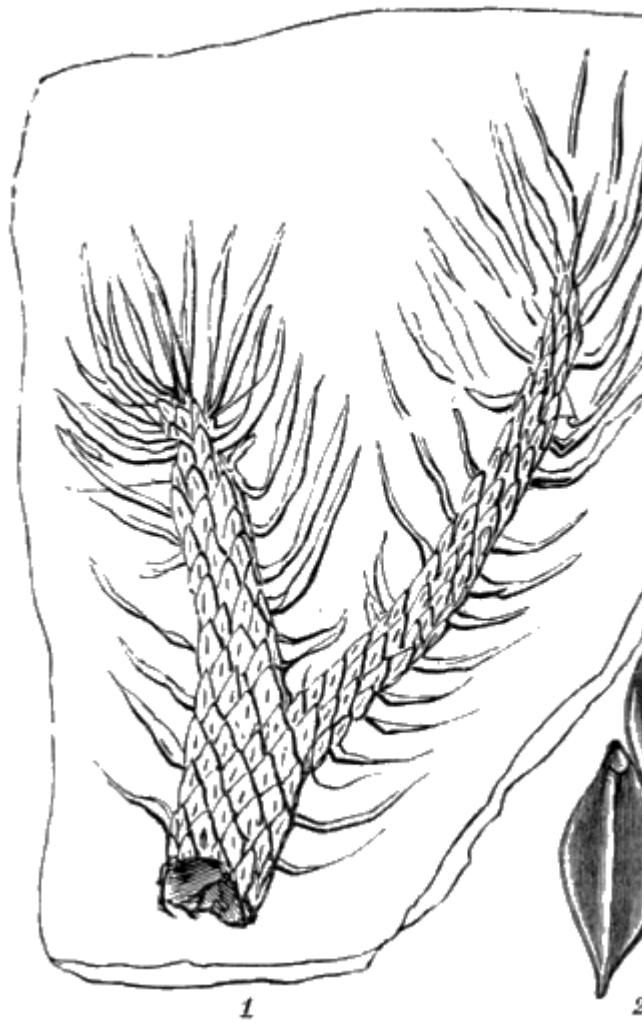
In the Pictou coal-field of Cape Breton, in Nova Scotia, similar facts have been brought to light; the remarkable phenomena existing in that locality, of successive carboniferous deposits containing scores of erect trees with roots spreading into their native soil, presenting peculiar facilities for verifying the observations made in England. In an interesting memoir on the coal-fields of Nova Scotia, Mr. Richard Brown has given a detailed account of numerous examples of stems of Sigillariæ, and of Lepidodendra, (a tribe of gigantic club-mosses of which we shall presently treat,) with the roots attached; these roots, in every instance, had the characters and structure of Stigmariæ. In one instance, the stem of the tree was broken off close to the roots, and the hollow cylinder of bark was bent down and doubled over by the pressure of the surrounding mud, so as effectually to close up the aperture, and leave only a few irregular cicatrices converging near the apex; this fossil explains the true nature of the "dome-shaped" plant figured in the Fossil Flora, and in Dr. Buckland's Essay.[104]

[104] See Pictorial Atlas, p. 200: and Petrifactions, pp. 37, 38.

LEPIDODENDRON.

LEPIDODENDRON (*scaly-tree*). *Lign. 39.*—Stems

cylindrical, covered towards their extremities with simple, linear, or lanceolate leaves, which are attached to elevated rhomboidal spaces, or papillæ; papillæ marked in the upper part with a large transverse triangular scar; lower part of the stem destitute of leaves.



LIGN. 39.

Fig. 1.— A TERMINAL BRANCH OF A LEPIDODENDRON; *nat.*

2.— Leaf-scars on the stem of a Lepidodendron; *nat.*

In Coal-shale, Newcastle.

The remains of this tribe of plants abound in the coal formation, and rival in number and magnitude the Calamites and Sigillariæ previously described. These trees have received the name of *Lepidodendra*, from the scaly character of their stems, occasioned by the angular scars left by the separation of the foliage, as is the case in arborescent ferns: the term, however, simply indicates the appearance, for the surface is not imbricated. Some of these trees have been found almost entire, from the roots to their topmost branches. One specimen, forty feet high, and thirteen feet in diameter at the base, divided towards the summit into fifteen or twenty branches, was discovered in the Jarrow coal-mine.[105] The foliage consists of simple, linear leaves, spirally arranged around the stem, and appears to have been shed from the base of the tree with age. The scars produced by the attachment of the petioles were persistent; and the twigs and branches are generally found covered with foliage, as in *Lign.* 39. The roots are Stigmariæ, like those of the Sigillariæ, as proved by specimens in the Pictou coal-field, discovered by Mr. Brown.[106]

[105] Wond, p. 722. This specimen is figured and described in Foss. Flor.

[106] Petrifactions, p. 39.

The internal organization of the stem of Lepidodendron differs from that of Sigillaria, in the absence of the woody cylinder and medullary rays

which constitute so peculiar and important a character in the latter. The Lepidodendra have only an eccentric, vascular, medullary zone, the interval between which and the bark is filled up by cellular tissue.[107] In their structure, external configuration, mode of ramification, and disposition of the leaves, they accord so closely with the *Lycopodiaceæ*, that, notwithstanding the disparity in size, M. Brongniart, Dr. Joseph Hooker, and other eminent botanists, concur in regarding them as gigantic arborescent club-mosses[108] The living species of Lycopodiaceæ amount to nearly two hundred, the greater number of which, like the arborescent ferns, inhabit the islands of intertropical regions. They are diminutive plants, with delicate foliage, none exceeding three feet in height; most of them trail on the ground, but there are a few erect species, one of which (*Lycopodium densum*) is abundant in New Zealand.

[107] See M. Ad. Brongniart, Archives du Museum d'Hist. Nat. torn. i. (for 1839), pl. XXX.

[108] Figures of Lepidodendra in *Wond.* p. 718. Pict. Atlas, pl. i. iii. ix. xxvi. xxvii. xxxiii.

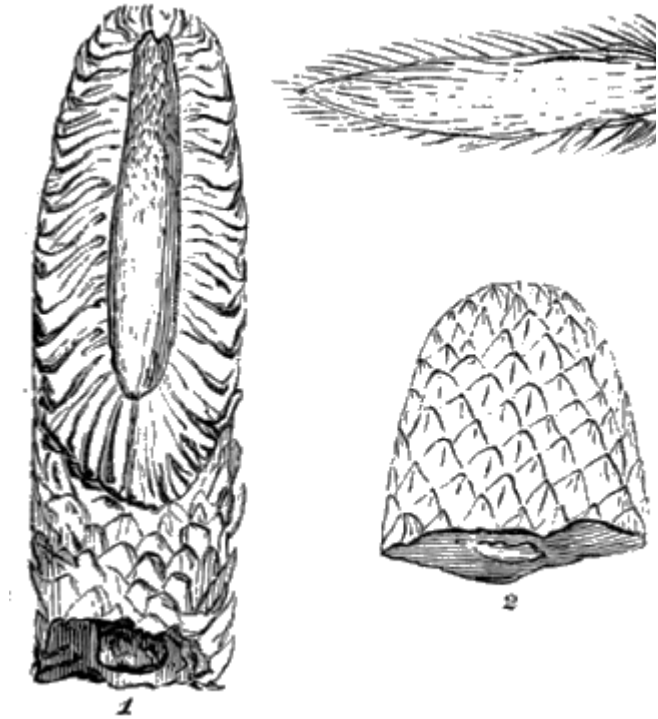
The fruit of the Club-mosses is an oval or cylindrical cone, which in some species is situated at the extremity of the branches, and constitutes an imbricated spike. Now associated with the stems of the Lepidodendra, and very often in masses of their foliage, and in some instances attached to the extremities of the branches, are numerous oblong, or sub-cylindrical, scaly cones, garnished with leaves. These have received the names of *Lepidostrobi* (scaly-cones), and are unquestionably the fruit of the trees with which they are imbedded.

LEPIDOSTROBUS.

LEPIDOSTROBUS. *Lign. 40.*—A cylindrical strobilus or cone, imbricated from above downwards, composed of winged scales, terminating in rhomboidal discs: the axis traversed by a longitudinal cavity or receptacle.

These fossils have long been known to collectors, and are figured by Martin (*Petrif. Derbiensia*), Parkinson (*Org. Rem.* vol. i. pl. ix.), and others. They are cylindrical imbricated bodies, rounded at both extremities, from two to six or seven inches in length, and one or two inches in circumference. When broken asunder, a cylindrical cavity is exposed, which is sometimes hollow, but commonly filled with mineral matter; and when specimens are found imbedded in shale, the cone is fringed with linear-lanceolate bracteæ, as in *Lign. 40, fig. 3*. These fruits, like the fronds of ferns, often form the nuclei of ironstone nodules, and the leaves are frequently replaced either by a white hydrate of alumine, or by the mineral called galena, or sulphuret of lead, and the receptacles filled with the same substances. The specimens from Coalbrook Dale are generally in this state of mineralization, and possess great brilliancy; they are interesting examples of the electro-chemical changes which these fruits of the carboniferous forests have undergone.[109]

[109] These fossil cones are not liable to decompose, like the pyritous fruits from the Isle of Sheppey; they require no preparation for the cabinet; washing injures their lustre; a soft brush will safely remove any extraneous matter. There is a fine collection of Lepidostrobi in the British Museum; see Petrifactions, p. 42.



LIGN. 40. LEPIDOSTROBI, THE FRUIT OF LEPIDODEN
Coalbrook Dale.

Fig. 1.— A portion of a cone, showing the imbricated structure and inte
2.— The upper part of a cone, displaying the imbricated surface.
3.— A young specimen attached to the extremity of a branch.

The figures in *Lign.* 40, represent the usual characters of these fruits. Of the young specimen, (*fig. 3*,) situated at the termination of a branch, M. Brongniart observes, "qu'il est impossible de ne pas reconnaître pour un Lepidostrobus jeune, fixé à l'extrémité d'un rameau."[110] As it is only in their young state that the spikes are found attached to the branches, it is probable they were shed as soon as they arrived at maturity.

[110] Hist. Vég. Foss. tom. ii. p. 47.

Triplosporite.—Additional light has recently been thrown on the structure of the Lepidostrobi, by Dr. Robert Brown's examination of a silicified specimen of the upper part of a strobilus, in which the internal organization is beautifully displayed. The reader specially interested in this department of fossil botany should refer to the original memoir by the illustrious President of the Linnæan Society, with the accompanying plates that admirably exhibit the microscopic analysis of the structure of this remarkable fossil; a slice of which was shown me some years since by the late Marquis of Northampton.[111] The external surface of the specimen is covered with hexagonal areolæ; the transverse sections exhibit the appearance of the bracteæ and sporangia. The strobilus is formed of a central axis of relatively small diameter, from which proceed bracteæ, about thirteen in number, that are densely approximated, and much imbricated; and of an equal number of sporangia, filled with innumerable microscopic sporules, originally connected in threes. This triple composition of sporules (which differs from the constant quadruple union in the tribes of existing plants presumed to be most nearly allied to the fossil, namely the *Ophioglosseæ* and *Lycopodiaceæ*) is expressed by the name *Triplosporite*, adopted by Dr. Brown to indicate this peculiarity of structure, and the class or primary division to which the original plant is supposed to belong.[112]

[111] The specimen brought to England was but two inches of the upper end of the cone; it was purchased conjointly by Lord Northampton, Dr. Brown, and the British Museum, for 30*l.*!

[112] See Trans. Linnæan Society of London, vol. xx. p. 469.

LYCOPODITES.—Species of true Lycopodiaceæ occur in tertiary marls; a beautiful specimen, from Germany, *Lycopodites Benettiæ*, is figured *Wond.* p. 723.

HALONIA. KNORRIA.

HALONIA; KNORRIA. *Lign. 41.*—Associated with the plants already described from the coal-measures, there are trunks and branches of other trees, presenting peculiar and but imperfectly known characters, which it will be convenient to notice in this place. Fragments of these stems are to be seen in most public collections of the carboniferous flora, and should be examined by the student, for figures and descriptions can convey but an imperfect idea of their nature.

Mr. Denny, the intelligent and indefatigable Curator of the Leeds Philosophical Society, has given the following admirable summary of the distinctive characters of the stems of most frequent occurrence in the Coal,[113] which will be found a useful guide to the collector.

[113] On the Fossil Flora of the Carboniferous Epoch, with especial reference to the Yorkshire Coal-field. By Mr. Henry Denny, A.L.S. Proceedings of the Polytechnic Society of Yorkshire; for 1850.

1. *Sigillaria.*—Stem furrowed, not branched, leaf-scars small, round, much narrower than the ridges of the stem.

2. *Favularia.*—Stem furrowed, not branched, leaf-scars small, square, and as broad as the ridges of the stem.

3. *Lepidodendron.*—Stem not furrowed, branched, covered with lozenge-shaped scars in quincuncial order, each having a papilla in the upper part; the upper portion of the stem and branches with simple linear leaves; the lower portion destitute of leaves.

4. *Halonia.*—Stem not furrowed, branched, covered with indistinct rhomboidal marks, and tubercular projections disposed in quincunx.

5. *Knorria.*—Stem not furrowed, branched, marked with projecting scars of petioles disposed spirally.

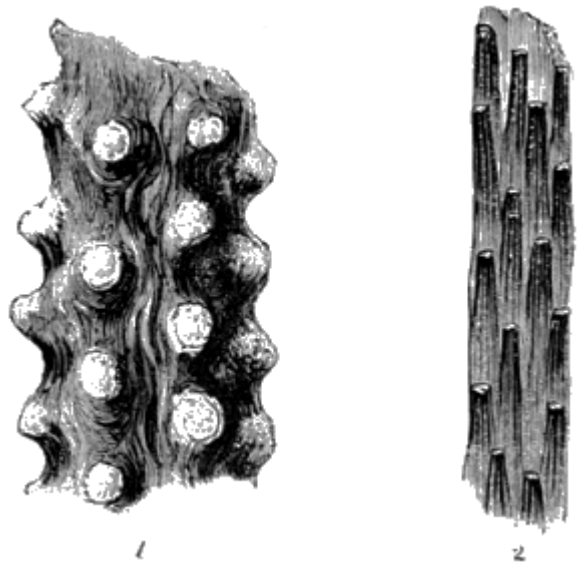
6. *Megaphyton.*—Stem dotted, neither furrowed nor branched, leaf-scars very large, of a horse-shoe figure.[114]

[114] Pictorial Atlas, pl. xxv.

7. *Bothrodendron.*—Stem pitted, neither furrowed nor branched, scars of cones (?) obliquely oval.

8. *Ulodendron.*—Stem neither furrowed nor branched, covered with rhomboidal marks; scars of cones (?) circular.

The characters of the roots called Stigmariæ (*ante*, p. 134.), and of the stems named *Calamities* (ante, p. 107.), and *Equisetites* (*ante*, p. 106.), are sufficiently distinct from the above to be easily recognized, I will briefly notice those not previously described.



LIGN. 41. STEMS FROM THE COAL FORMATION.

Fig. 1. HALONIA REGULARIS. *Coalbrook Dale.*

—

2. KNORRIA TAXINA. *Roof of the High-main Coal seam, Jarrow Coll*

— (*Brit. Foss. Flor.*)

Halonia.—The specimens usually seen are mere sandstone casts having a thin carbonaceous crust; the stem is branched and beset with large elevated knobs, or subcortical protuberances, as shown in *fig. 1, Lign. 41*. These plants appear to be closely related to the Lepidodendra; their mode of branching is shown in a beautiful specimen (in the museum of the Leeds Philos. Soc.) figured and described by Mr. Denny, which is also remarkable because it indicates the probability that the Haloniæ, and the fossil stems, termed Knorriæ, are identical; for the specimen in question, which in its branches is unquestionably of the former type, has the base of the stem impressed with the leaf-scars of the latter.

Knorria.—To this genus the authors of the Fossil Flora of Great Britain referred those stems which have projecting leaf-scars, arranged spirally. The beautiful specimen figured as *Knorria taxina*, *Lign. 41, fig. 2*, closely resembles a young branch of Yew (*Taxus*), and perhaps might be more correctly named *Taxites*.

Bothrodendron and Ulodendron.—These genera, together with *Megaphyton*, are stems of a very remarkable character, and are easily distinguished by the vertical rows of large and distant scars. The two first have two series of very deep oval depressions on opposite sides of the stems, arranged alternately in the specimens I have examined: from the size and form of these obliquely-oval cavities, it is supposed that they were formed by the attachment of cones, and not by petioles; but their real nature is involved in obscurity.[115]

[115] Figured in Bd. pl. lvi.

In *Megaphyton*, the large ovate scars indicate the attachment of deciduous branches or gigantic leaves, which did not grow all round the stem, but in a regular order of superposition on each side.[116]

[116] Figured in Pict. Atlas, pl. xxv.

ASTEROPHYLLITES.

ASTEROPHYLLITES.—I shall conclude this notice of some of the most characteristic trees of the Carboniferous Flora, with an account of a tribe of plants whose remains are so common in the coal-shales and grits, that there are but few large slabs with vegetable remains that do not exhibit examples of the elegant verticillate foliage of one or more species. The term *Asterophyllites*, (expressive of the

star-like form of the leaves,) applied to this family by M. Ad. Brongniart, includes several fossil plants which are known to geologists under different generic names; the following concise account may be useful to the student.[117]

[117] Consult *Tableau des Genres de Végétaux Fossiles*, par M. Ad. Brongniart. Diet. d'Hist. Nat. Paris, 1849.

1. *Calamodendron.*—These are arborescent stems, ligneous internally, and covered with a smooth carbonaceous crust, without regular longitudinal striæ, and not articulated; but the woody axis covered by this bark is deeply striated and articulated, resembling in this respect the true Calamites. These stems have a large central pith, or medullary column, surrounded by a ligneous zone, which is formed of radiated bands, without circles of growth: the structure of the carbonized bark is unknown.

2. *Asterophyllites.*—These are supposed to be the branches and foliage of the stems above described.

3. *Sphenophyllum.*—Plants, differing in the form of the leaves, but analogous in structure and mode of fructification to the Asterophyllites.

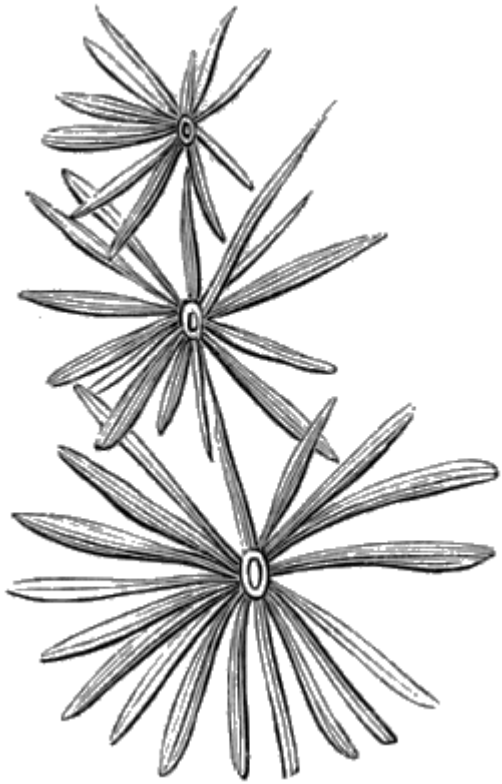
4. *Annularia.*—Herbaceous aquatic plants, distinct from the preceding.

5. *Volkmannia.*—These fossil plants are Asterophyllites in fructification.

The *Asterophyllites* (*Lign.* 42) had branched articulated stems, with verticillate leaves, arranged perpendicularly to the branches which supported them: but as the foliage is in most instances partially

concealed, the natural form is but seldom observable.

The original plants are supposed to have been a tribe of flowering dicotyledons, for small seed-vessels resembling those of the Cypress are often found with the foliage.



LIGN. 42.
ASTEROPHYLLITES EQUISETIFORMIS; *nat. Coal-shale.* (*Foss. Flor.*)

ANNULARIA CARDIOCARPON.

The *Annulariæ* were herbaceous plants with verticillate foliage like the former, but the whorls

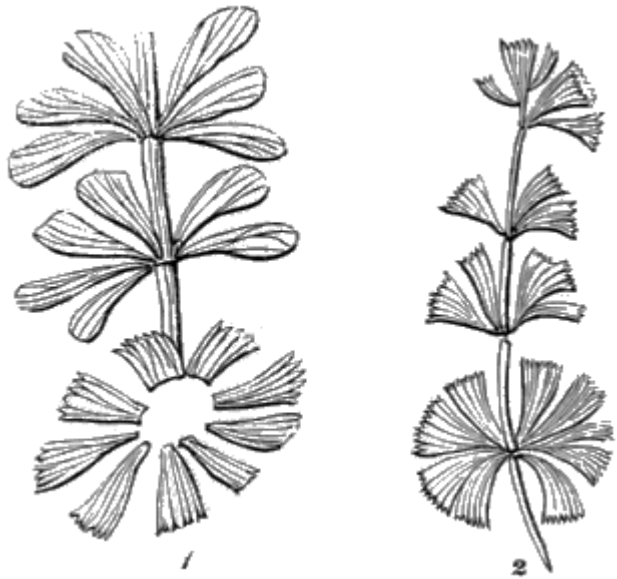
were arranged on the same plane with the stems on which they grew, and their remains have a very elegant appearance when expanded in the coal schists. It is supposed that they were aquatic plants, and that the stems and leaves floated on the surface of the water.[118]

[118] *Wond.* p. 717. Petrifactions, pp. 27, 43, &c. For coloured figures see Pictorial Atlas, pl. v.

SPHENOPHYLLUM (*wedge-shaped leaf*). *Lign. 43.*—The fossil vegetables thus named, though somewhat resembling in their elegant verticillate foliage the Asterophyllites, differ essentially, and are regarded by M. Brongniart as herbaceous plants related to the *Marsiliaceæ*, or Pepper-worts. The leaves are triangular, truncated at the summit, and very deeply lobed and dentated. The fructification consists of sessile axillary or terminal spikes, composed of verticillate bracteæ, covering the receptacles. This mode of fructification resembles that of the Asterophyllites.[119]

[119] For details consult *Tab. des Genres de Vég. Foss.* p. 52.

CARDIOCARPON.—*Lign. 44. fig. 1.*—These are small fossil fruits or seed-vessels, which much resemble those of the Thuja or *Arbor-vitæ*, and are so often found imbedded with masses of the foliage of Asterophyllites, that it is conjectured they belong to those plants. They occur in groups of from five to twenty, and evidently were *didymous*, *i.e.* grew in pairs. *Fig. 1a.* is an enlarged view, to show the surface left by the attachment of the twin-seed.



LIGN. 43.

Fig. 1.— SPHENOPHYLLUM SCHLOTHEIMII; *nat.*

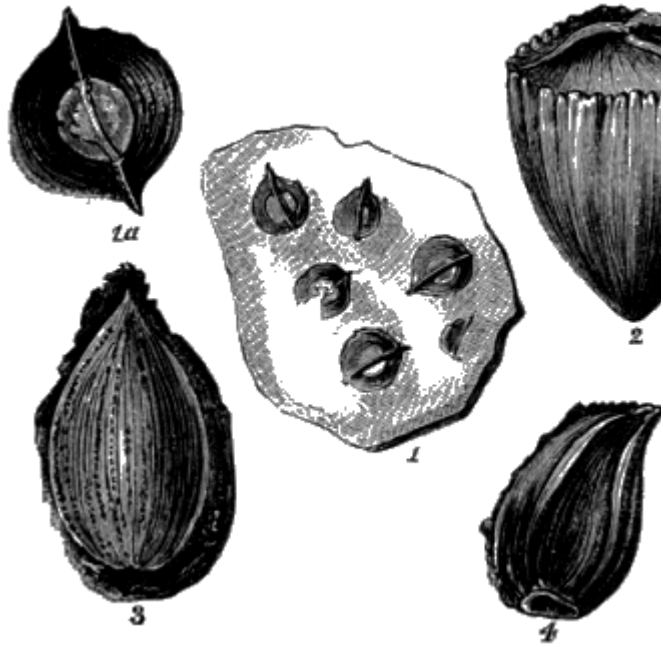
2.— SPHENOPHYLLUM EROSUM.

Coal-Shale.

TRIGONOCARPUM. *Lign. 44. figs. 3. 4.*—These fruits, which resemble those of certain Palms, are often met with in the coal-mines of Leicestershire and Yorkshire; frequently occurring in groups of thirty or forty, as if they were the scattered seeds of a raceme of a Palm: they are referred to the genus Nœggerathia, a tree of the carboniferous formation allied to the Palms.

FOSSIL FRUITS.

A figure of a fossil fruit from the Oolite—Carpolithes Bucklandi, is introduced in *Lign. 44, fig. 2*, and will be described hereafter.



LIGN. 44. FOSSIL FRUITS, OR SEED-VESSELS; *nat.*

Fig. 1.— CARDIOCARPON ACUTUM. *Snibstone Coal-mine, Leicestershire.*

1[a].— 1*a*.—One of the above magnified.

2.— 2.—CARPOLITHES BUCKLANDII. *Coralline Oolite, Malton.*

3.— TRIGONOCARPUM OLIVÆFORME. *Snibstone Colliery.*

4.— TRIGONOCARPUM NÖGGERATHI.

The reader will observe that the fossil vegetables hitherto described belong, with but few exceptions, to the Carboniferous flora; and that the remains of Ferns, Calamites, Sigillariæ, and Lepidodendra, compose in a great measure those prodigious accumulations of mineral fuel, or coal, which supply the luxuries and necessities created by civilization.

Our review of fossil plants will now assume somewhat of a botanical arrangement, and we proceed to notice some of the most characteristic

vegetable forms of the secondary and tertiary formations. We commence our examination with those remarkable tribes of gymnosperms, the Cycadaceæ, which comprise the Zamiæ and Cycadeæ.

Fossil Cycadaceæ.

The plants of this subdivision of the vegetable kingdom, from their singular structure and mode of growth, their simple cylindrical stems, and coronets of pinnated foliage, resembling that of certain palms, their usually gyrate vernation like that of the ferns, and their anomalous inflorescence and fructification, are objects of great interest to the scientific botanist; while the abundance of their fossil remains in the secondary formations renders them of the highest importance to the geologist.



LIGN. 45.
FOLIAGE AND UPPER PART OF THE STEM OF CYCAS REVOLUTA
$^{1}/_{12}$ *nat.*
In Kew Conservatory.

As many kinds of Zamia[120] and Cycas are cultivated in our hot-houses, the general appearance of the plants of this order must be familiar to the reader: the annexed figure of a beautiful living Cycas in the Royal Gardens at Kew, will serve to illustrate the general aspect of these exotics.

[120] The Linnæan genus Zamia is now separated into five or six genera, as Encephalartos, Macrozamia, Dion, &c.

The Zamiæ are short plants, with stout cylindrical stems, beset with thick scales, which are the bases of the petioles that have been shed: towards the summit the stem is garnished with a crown of elegant leaves; the fruit resembles the cones of pines. The leaves are pinnated, and very tough; their venation is either parallel as in endogens, or dichotomous as in ferns, but never reticulated as in exogens: in a young state they are coiled up like a crosier, as in ferns.

The Cycadeæ have the general aspect of the Zamiæ, but differ in their fructification and other characters; and some species have the stem bifurcated towards the top, and attain a height of upwards of twenty feet; for example, *C. circinalis*.

The stem in its internal structure[121] bears a close analogy to that of the Coniferæ; it has a central medullary column surrounded by a ligneous cylinder, divided by cellular medullary rays, each composed of bundles of vessels, and a thick cellular cortical investment or false-bark,[122] composed of the persistent scales that formed the bases of the petioles. (See *Pl. V. fig. 5.*)

[121] See *Bd.* pl. lxii.

[122] See *Bd.* vol. i. pp. 494-498, for

detailed description of structure in recent and fossil Zamiæ and Cycadeæ.

The existing species of Cycadaceæ are exclusively natives of hot regions, and chiefly inhabit the West Indies, South Africa, Equinoctial America, Japan, New Holland, &c.; not one species is known in Europe: a fact in striking contrast with the abundance of fossil plants of this order, which occur throughout the secondary formations of England and the continent.[123]

[123] The most interesting collection of living Cycadeæ and Zamiæ near London, is that of JAMES YATES, Esq., of Lauderdale House, Highgate; it comprises choice examples of several of the sub-genera into which these plants are now divided by botanists.

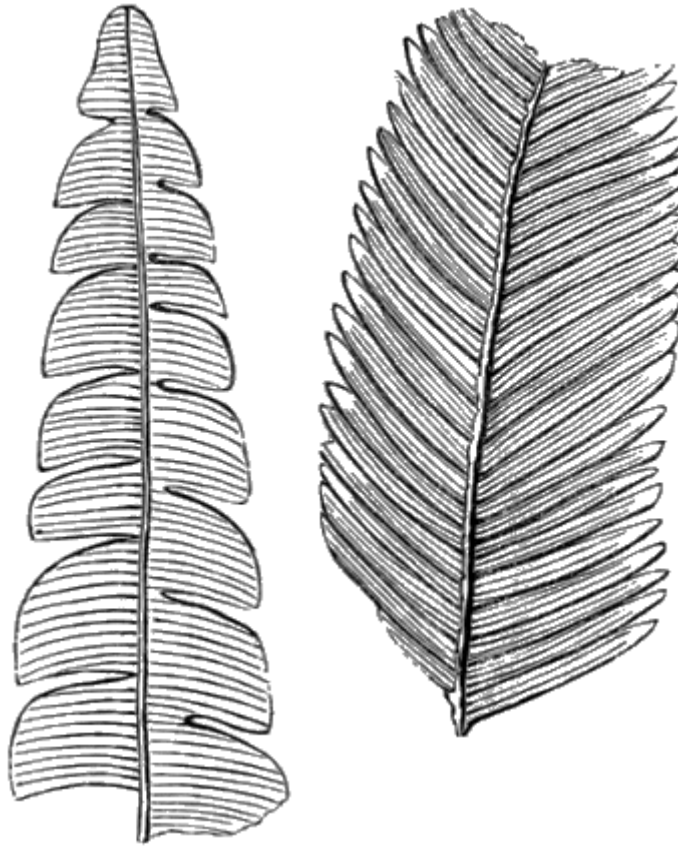
No true cycads have hitherto been discovered in the carboniferous deposits; it is in the floras of the secondary epochs, from the new Red to the Cretaceous inclusive, that this tribe of plants forms an important feature. The foliage, stems, and fruits, occur in a fossil state; and as these organs cannot be referred with certainty to their respective plants, distinct genera are formed for their reception.

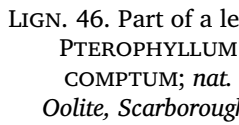
Foliage.—From the tough and durable nature of the leaves, the foliage of the Cycadeæ occurs in a fine state of preservation; and in the fluvio-marine deposits of the Oolite of Yorkshire, many specimens of great beauty have been collected. I know not another locality in England so rich in fossils of this kind, as the cliffs along the coast near Scarborough; Gristhorpe Bay is well known to collectors. Not only the leaves, but also the fruits or cones occur, and of these, examples are to be seen in most public museums.[124] The leaves are carbonized, but the

venation is well preserved.

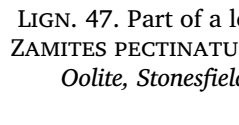
[124] British Museum: see Petrifactions, p. 54, Room 1, Case F.

The leaflet of the recent Cycas is distinguished by a strong nervure, which runs along the middle; that of Zamia has no midrib, but fine parallel veins that pass direct to the margin.





LIGN. 46. Part of a leaf of PTEROPHYLLUM COMPTUM; *nat. Oolite, Scarborough.*



LIGN. 47. Part of a leaf of ZAMITES PECTINATUS; *nat. Oolite, Stonesfield.*

PTEROPHYLLUM COMPTUM. *Lign.* 46.—The general aspect of these fossils is shown in this figure of a leaf, referred to the genus *Pterophyllum*, which is characterized by leaflets, often slightly united at their base, truncated at the summit, of a quadrangular or oblong form, and having fine, straight, parallel veins. The leaves are ten or twelve inches long, and have fine lanceolate leaflets; they are abundant in the same beds, and are often associated with the cones or fruit[125] figured in *Lign.* 48.

[125] Brit. Mus. Petrifactions, p. 55.

ZAMITES PECTINATUS.

ZAMITES PECTINATUS. *Lign. 47.*—In the Stonesfield slate, collocated with remains of reptiles, fishes, insects, and mollusks, leaves and fruits of cycads are occasionally met with. A portion of a leaf nine inches long is here figured. The Lias of Dorsetshire has yielded many beautiful relics of this family[126]

[126] In the carboniferous strata of Eastern Virginia, United States, which are referred by Professor Rogers to the Oolitic epoch, leaves of Cycadeous plants are abundant. See Trans. American Geol p. 298.

But few vestiges of the foliage of Cycads have been observed in the Wealden formation of England; one elegant leaf, however, of an undescribed species, was obtained some years since, from a sandstone

quarry in Surrey, and is figured in my Geology of the South-east of England, p. 238; it is named in honour of my distinguished friend, M. Ad. Brongniart, *Cycadites Brongniarti*. The Wealden of the north of Germany is very rich in fossil Cycadeæ; my friend. Dr. Dunker, has figured and described twelve species in his admirable work on the organic remains of that formation.[127]

[127] Mon. Norddeutschen Weald, tab. i. to vii.

Fruits.—The cones or fruits which occur with the foliage of Zamiæ in the carbonaceous shales and marls of the Oolite of the Yorkshire coast, are very fine, and have been described under the various names of *Zamites Mantelli*, *Z. gigas*, and *Z. lanceolatus*.

An interesting memoir on the structure of these fossils, by James Yates, Esq. (a gentleman distinguished for his knowledge of the recent Cycadaceæ), is published in the Proceedings of the Yorkshire Philosophical Society for 1849, p. 37; and another communication on the same subject by my friend Professor Williamson, of Manchester, in *York. Phil. Trans.* 1819, p. 45; to these papers I must refer for a detailed account of all that is at present known respecting their organization.



LIGN. 48. FRUIT OF ZAMITES MANTELLI, (*Brongniart*
From near Scarborough.
The surface of the cone is concealed by the bract

ZAMITES MANTELLI.[128] *Lign.* 48.—The leaves associated with the fruit here figured, have lanceolate leaflets that insensibly contract at the base, and are inserted obliquely into the rachis; thus resembling the foliage of the recent *Encephalartos*. With these leaves, and the ovate cones (*Lign.* 48), are occasionally found a circle of leaves or elongated

scales, locally termed "*collars*," which Professor Williamson has shown to be a zone formed by a scaly bud in which the germ of the plants was inclosed. In the progress of development, the fruit burst through the upper part of the investing sheath, and, as it grew to maturity, rose above the incurved elongated bracteæ, till the latter formed a zone or "collar" around the pedicle of the cone.[129] These fossils have been mistaken for flowers.[130]

[128] *Podozamites* of Braun.

[129] Proc. Yorkshire Philos. Soc. 1849, p. 45.

[130] Bird's Yorkshire, tab. i. figs. 1 and 7.

It does not appear that the structure of the cone has been preserved in any of the specimens, so as to demonstrate the characters of the original; in all those I have examined, the surface of the fruit is concealed by the elongated bracteæ, which are pressed flat, and adhere so firmly to the inclosed body, as to render it impossible to ascertain its nature.[131] Mr. Williamson is of opinion that the plant resembled the recent *Cycas circinalis*, in its great height, and lax habits; and states, that he had seen portions of leaves that were three feet in length.

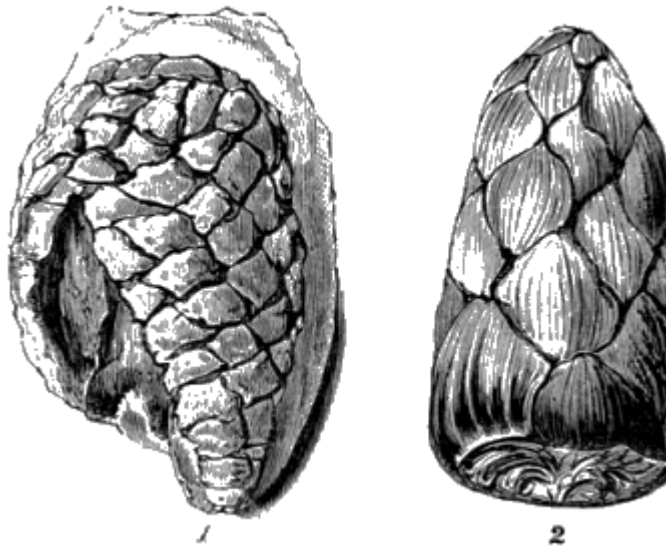
[131] Brit. Mus. Petrif. p. 55.

ZAMITES CRASSUS. *Lign. 49, fig. 1.*—In Sandown Bay, on the south coast of the Isle of Wight, where the Wealden beds rise to the surface from beneath the lowest strata of Greensand on the east and west, several cones have been found, associated with other vegetable remains, and bones of the Iguanodon, &c. A fossil cone from this locality is here figured; it bears considerable resemblance to the fruit of the

recent *Encephalartos*.

ZAMITES OVATUS.

ZAMITES OVATUS. *Lign. 49, fig. 2.*—A few examples of cycadeous fruits have been collected from the Greensand of Kent and Sussex. The beautiful fossil represented, *Lign. 49, fig. 2*, from Foss. Flor. is referred to the Zamiæ, by the eminent authors of that work; but it presents in its imbricated character a greater analogy to a pine cone.



LIGN. 49. FOSSIL FRUITS OF CYCADEOUS PLANTS; $^1/_2$ *nat.*
Fig. 1.— ZAMITES CRASSUS. *Wealden, Isle of Wight.*
2.— ZAMITES OVATUS. *Greensand, Kent.*

ZAMITES SUSSEXIENSIS.—At Willingdon, near Eastbourn, in Sussex, a cone nearly six inches long was discovered in a bed of Greensand, which abounds in fossil coniferous wood: it is of an elongated cylindrical form, and covered with

hexagonal scales. I have provisionally named it *Zamites Sussexiensis* (Geol. Proc. 1843), as it presents a nearer resemblance to the fruit of Zamiæ than to that of Conifers.

TRUNKS AND STEMS OF CYCADACEÆ.—In this section I shall notice the fossil plants which occur so abundantly in the fresh-water deposits that overlie the marine oolitic limestone of the Isle of Portland, and which must be familiar to my readers, from the graphic account of the circumstances under which they occur, by Mr. Webster, and subsequently by Dr. Buckland, and Sir H. De la Beche. In my Wonders of Geology, p. 387, and Geol. Isle of Wight, p. 395, the geological phenomena of that most interesting locality, the Isle of Portland, are so fully described, that it will not be necessary to dwell upon them; the structure and affinities of the fossil vegetables are the especial objects of our present inquiry.

MANTELLIA NIDIFORMIS.



LIGN. 50. SILICIFIED TRUNK OF MANTELLIA NIDIFORMIS (*B*
(*Cycadites megalophyllus. Bd.*) *Wealden. Isle of Por*
a. Central mass of cellular tissue, *b.* Circle of ligneou
c. Zone of cellular tissue, *d.* False-bark.

MANTELLIA. *Lign.* 50, 51.—The fossil Cycadeæ of the Isle of Portland were first described botanically by Dr. Buckland, (Geol. Trans, vol. ii. 2d Series,) under the name of *Cycadeoidea*; of which Memoir the account in *Bd.* p. 404, is an abstract. M. Ad. Brongniart, considering these plants as a peculiar type, referred them to a new genus, which he did me the honour to name *Mantellia* (*Prod. Veg. Foss.*). These stems or trunks are from one to two feet in height; the circumference of the largest not exceeding three feet. The stem is subcylindrical, and

the external surface covered with the rhomboidal scars formed by the attachment of the leaf-stalks, and which are widest in their transverse diameter.

There are two species, which are readily distinguished by the form of the stems, and the difference in the size of the cicatrices left by the petioles.

The most common kind is short, and spheroidal, and the leaf-scars are relatively large; its shape has caused it to be named "*Crows' nest*," by the quarrymen, who believe these plants to be nests that were built by crows in the trees of the petrified forest with which they are imbedded. The specific name (*nidiformis*) adopted by M. Brongniart, expresses this popular notion.

Lign. 50. represents a fine example from the Portland Dirt-bed, which exhibits a structure altogether similar to that which characterizes the stems of recent cycadeous plants; namely, (*a*) a central mass of cellular tissue surrounded by circles of laminated ligneous rays or plates (*b*); then a zone of cellular tissue (*c*), and an external cylinder of false-bark (*d*). The mode of increase by buds, from germs in the axillæ of the petioles, as in the living plants, is also distinctly seen.



LIGN. 51. MANTELLIA CYLINDRICA.
(*Brongn.*); $^{1}/_{8}$ *nat.*
(*Cycadites microphyllus. Bd.*)
Wealden. Petrified Forest of the Isle of Portland.

The other species is subcylindrical, and the leaf-scars are much smaller and more regular than in *M. nidiformis*, indicating a more delicate foliage, as expressed by Buckland's specific name: that of M. Brongniart refers to the cylindrical form of the stem. This plant was higher and more slender than its associate. Numerous buds are seen in the axillæ of the petioles in the specimen figured.

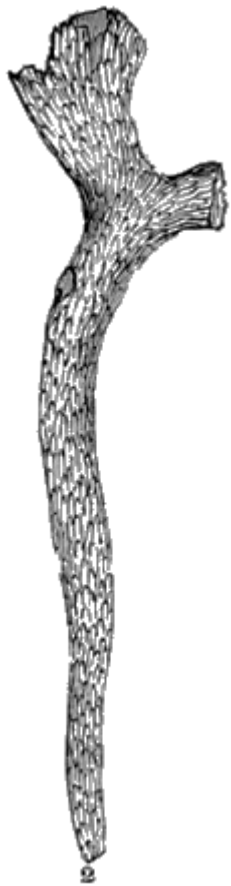
These fossils present, both externally and internally, a close relation to the bulbiform stems of the recent Cycadeæ, named *Encephalartos*, of South Africa.[132]

[132] The fossil Cycads of the Isle of Portland are admirably described and illustrated in Dr. Buckland's Bridgewater Essay, (p. 497, and pl. lx. lxi.), and their internal structure is fully explained.

Neither the leaves nor the fruit are known: a cone found in the Dirt-bed of Portland, and attributed to

these plants, appears to belong to the coniferæ of the petrified forest. Examples of Mantelliæ have been found in the quarry of Portland-stone at Swindon, Wilts.

CLATHRARIA LYELLII.



LIGN. 52. CLATHRARIA LYELLII.
Wealden.
A branched example of the inner axis: the original $3^1/_2$ feet high.

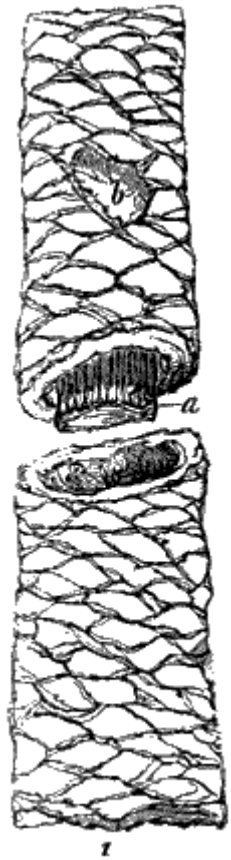
CLATHRARIA[133] LYELLII. *Lign.* 52-57.—The fossil plants to which I would next direct attention were first discovered by me in the Wealden strata of Sussex, in 1820, and were figured and described under the name they still bear, in my Fossils of Tilgate Forest, in 1827. The specimens figured in that work are the most illustrative hitherto discovered, with but one exception.[134]

[133] Clathraria, *i.e. lattice stem*, from the scars left by the petioles.

[134] They are now in the British Museum; see Petrifactions, p. 45. *Room* I. *Case* E.

From the imperfect state of the remains of these plants, the structure and affinities of the originals were very ambiguous, and the fossils have been placed by some eminent botanists with the Liliaceæ, and by others with the Asphodeleæ; their true botanical position is doubtless with the Cycadaceæ; for in some points they resemble the Zamiæ, in others the Cycadeæ.

The stem of the Clathraria is composed of a solid internal axis, the surface of which is covered with reticulated fibres; the large branched specimen of this part, figured in *Lign. 52*, is the finest example hitherto obtained: it was discovered, with bones of the Iguanodon, in a quarry near Cuckfield, Sussex, in 1820. The axis is invested with a very thick false-bark, formed of the consolidated bases of the leaf-stalks, the insertions of which are rhomboidal and transverse. The outer surface of the bark is consequently marked with elevated lozenge-shaped cicatrices (*Lign. 53*), separated from each other by a marginal furrow, which is surrounded by a parallel ridge or band of a fibrous structure.



LIGN. 53. CLATHRARIA LYELLII. $^{1}/_{4}$ *nat.*
A stem, with rhomboidal transverse scars, left by the petioles; broken transversely and separated, to show the internal axis at *a*, which, if the pieces were united, would be received in the cavity below the depression, or cicatrix, on the middle of the upper portion, *b*, was probably the situation of a resinous secretion, like the dragon-blood in the Dracæna.

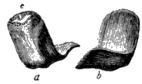
The cortical zone is generally converted into a cylinder of stone, which in some examples separates from the axis. In a beautiful specimen of this kind, *Lign. 54*, the axis projects and is surrounded by the false-bark.

The axis is solid, and has its surface strongly marked with interrupted ridges. This surface has generally patches of vascular tissue adhering to it; and there are here and there deep pits, or lacunæ,

which probably contained a resinous secretion. Thin transverse sections of the axis, prepared with Canada balsam, and examined under the microscope, only give faint traces of cellular tissue.



LIGN. 54. CLATHRARIA LYELLII; $^{1}/_{4}$ *nat.* *Wealden Sandstone.* *Tilgate Forest.* Portion of a stem, scored by the cicatrices of the petioles; showing the Axis *a*, surrounded by the cortical cylinder.



LIGN. 55. PETIOLE OF CLATHRARIA LYELLII;

a. External aspect.

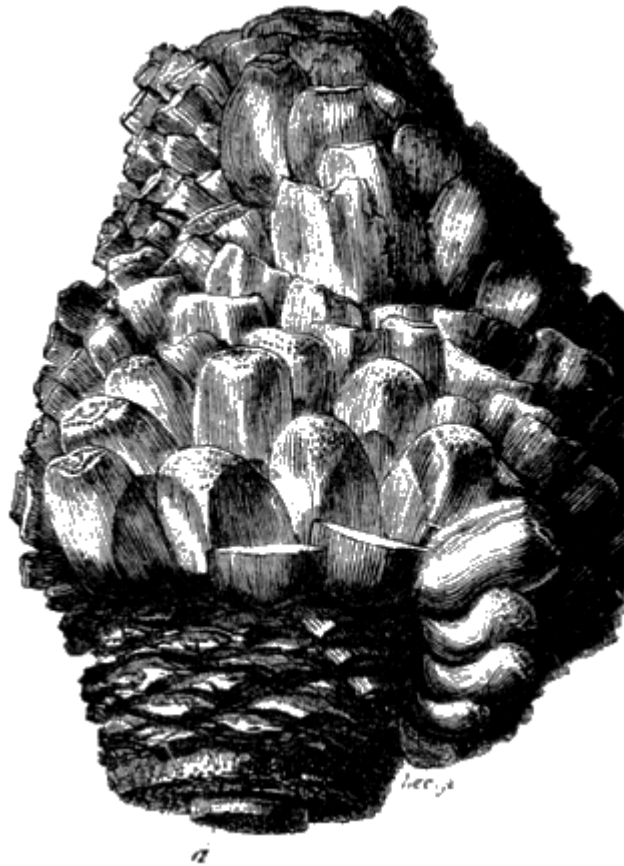
b. Inner surface.

c. Vascular pits left by the separation of the leaf.

I have spared neither trouble nor expense in endeavouring to detect the organization of this plant; numerous sections of stems have been cut, and examined microscopically, but very few exhibit any traces of structure; and in those which retain some vestiges of organization, the siliceous mass which

permeates the vascular tissue, is not sufficiently transparent to yield satisfactory results. It can only be inferred that in their internal organization, as in their external characters, the Clathrariæ were most nearly allied to the Cycadeæ or Zamiæ. A remarkable specimen, (*Lign. 56*,) discovered in a stratum of Chalk-marl, near Bonchurch, confirms this view, and throws much light on the nature and relations of these vegetables.

This fossil is a portion of the summit of a stem garnished with persistent petioles, or leaf-stalks; it is fifteen inches in length, and nearly perfect at the top; and at the lower end, which has been broken off transversely, the inner axis (*Lign. 56 a.*), surrounded by the false-bark formed by the confluence and consolidation of the bases of the petioles, is exposed. The stem has been stript of the leaf-stalks at the lowermost part, and exhibits the characteristic lattice-like scars. The petioles are for the most part entire; some of them are abortive, and others, which have supported leaves, are marked on the summits with vascular pits, indicating that the foliage was shed naturally; as shown in *Lign. 55 a*. These petioles were probably persistent for some years, as in the existing Cycads. The opposite side of the stem to that represented is covered with elongated and flattened petioles.



LIGN. 56.
CLATHRARIA LYELLII; $^{1}/_{4}$ *nat.*
Chalk-marl. Bonchurch, Isle of Wight.
The summit of a stem garnished with petioles; the lower part shows th
the removal of some of the petioles: *a*, the internal ax

On the sea-shore bounded by cliffs of Wealden rocks, in the Isle of Wight, water-worn portions of stems of Clathrariæ are occasionally met with; and these are impressed with the lozenge-shaped areas left by the petioles, as in the specimen, *Lign. 57*. Mr. Saxby, of Bonchurch, has favoured me with the loan

of a thin section of a stem of Clathraria in which the bundles of vascular tissue in the petioles appear to be made up of spiral vessels. From what has been advanced, it is obvious that these remarkable plants of the Wealden flora were gymnosperms, closely related to the Cycadeæ.

Vestiges of roots, seed-vessels, and panicles, have been found in the Wealden, which may possibly belong to the Clathraria; but the evidence as to their presumed relationship is at present too vague to require further notice.



LIGN. 57.
CLATHRARIA LYELLII; $^1/_2$ *nat.*
Specimen, showing the water-worn external surface.

ENDOGENITES.

ENDOGENITES EROSA.—(*Geol S. E.* pl. i.; Tilg. Foss. pl. iii.; and by Dr. Fitton in *Geol. Trans.* vol. iv.) —The genus *Endogenites* was established by M. Ad. Brongniart for the reception of those fossil stems and

woods, whose internal structure is endogenous, but which are too imperfect to be referred to any particular family. In this category must be placed certain silicified stems having a carbonaceous cortical investment, which I discovered in the strata of Tilgate Forest, in 1820.

These fossils often occur in the layers of lignite which traverse the clay-beds in some parts of the Weald of Sussex. They are from one to eight inches in diameter, and five or six feet in length, and of very irregular shapes; I have not observed any indications of branches. Some specimens are subcylindrical in the middle, and gradually taper to a point at each end; others are of a depressed clavated form, like some of the Cacteæ or Euphorbiaceæ. They are generally silicified, and, when *in situ*, are invested with a friable carbonaceous crust, of a glossy lustre, which soon falls to pieces on exposure to the atmosphere, so that cabinet specimens seldom retain any vestiges of it. When this coaly matter is removed, the surface of the silicified stem is seen to be traversed by numerous fine meandering grooves, and deep, tortuous channels, disposed in an irregular manner, in a longitudinal direction. These channels or vessels, which are generally lined with quartz crystals, give the surface that eroded appearance which suggested the specific name, erosa; but this term is inapplicable, for the perforations and sinuosities are not the effect of erosion, but result from the structure of the original. Polished sections, seen by transmitted light, are represented in Dr. Fitton's memoir (*Geol. Trans.* vol. iv.); and I have had many slices ground as thin as possible, in the hope of detecting the characters of the vascular tissue. In one example there are indications of a cycadeous structure, which favour the conclusion, that the

originals belonged to an extinct tribe of gymnosperms; but in other specimens, bundles of vascular tissue, resembling those of palms, are apparent.

Large water-worn stems of *Endogenites* are occasionally washed out of the Wealden cliffs at Hastings, and in Sandown and Brook Bays, in the Isle of Wight.

Fossil coniferæ.

FOSSIL CONIFERÆ.

The other great natural order of Gymnospermous phanerogamiæ,[135] the *Coniferæ*, or cone-bearing—so named from the form of their fruit, of which the fir-cones and larch-juli are familiar examples,—comprise the extensive tribes of Firs and Pines, and the Cypresses, Yews, Junipers, Cedars, &c., among which are the loftiest trees on the face of the globe.

[135] Signifying, flowering plants with naked seeds.

The Conifers are all arborescent, having numerous branches, which are in general disposed with much regularity. The leaves are commonly acicular or needle-shaped, narrow, and linear: in two or three genera, however, (*Dammara*, *Podocarpus*,) the foliage departs remarkably from the ordinary type, the leaves being broad and flat. The structure of the stem, though in its general characters essentially exogenous (see *Plate IV. fig. 4*),—that is, having a central pith, medullary rays, zones of vascular tissue, and concentric circles of growth,—differs in the almost entire absence of spiral vessels, and in the peculiar modification of the radiating

bands of woody fibre, which are made up of uniform longitudinal vessels, and run parallel with the medullary rays. The lateral walls of these vessels have longitudinal rows of areolæ, which are generally circular or elliptical, but when in contact are angular and polygonal: each areola has a small pore or punctation in the centre. These discs, glands, or ducts, as they are called, are variously arranged in different genera; they are generally confined to the contiguous and corresponding lateral surfaces of the fibres; and occur rarely, if ever, on the inner and outer aspects of the vessels. In the recent genus Pinus the rows of ducts are single in some species; in others both single and double series occur, but never more than two, and in the latter case the ducts are always parallel to each other (see pl. v. 3*b*. *Wond.* pp. 696, 725). But in the *Araucariæ*, or Norfolk Island Pines, the vessels have double, triple, and sometimes quadruple, rows of discs, of smaller size than in the common pines; and in the double series, these bodies are always arranged alternately (*Wond.* p. 696. *Bd.* 56 *a.*); Mr. Nicol states that there are about 50 discs in the length of $^{1}/_{20}$ inch, the diameter of each not exceeding $^{1}/_{1000}$ inch.

The form and arrangement of these ducts, and the structure of the medullary rays, are the characters on which the scientific botanist relies for the detection of the affinities of the coniferous trees, whose mineralized trunks and branches, in a fragmentary state, are, for the most part, the only relics of these important tribes of the lost floras of the earlier ages of our planet.[136]

[136] I know not a more delightful and instructive branch of science for the young and inquiring of both sexes, than this department

> of Fossil Botany, which the recent improvements in the microscope have rendered so accessible; and yet there are but few cultivators of fossil botany in England!

The great value of these data will be shown in the sequel.

The stems, fruit, and foliage, of Coniferæ, occur in the various fossiliferous deposits, from those containing the earliest traces of terrestrial vegetation to the newest tertiary strata; and a large proportion of the petrified wood found in the British formations belongs to trees of this order. The presence of rows of ducts on the ligneous fibres, which is peculiar to this division of gymnosperms, as we have already explained (*ante*, p. 58.), is so easily detected by microscopic examination, that the merest fragment of fossil coniferous wood retaining internal structure, may without difficulty be recognized. The number of rows, and the opposite or alternate arrangement of the areolæ, are characters which, in the living pines and firs, enable us to refer the respective trees to European or exotic forms; but in the fossil coniferous wood, much diversity exists in other not less important points of structure, and for the successful cultivation of this department of fossil botany, works especially devoted to the subject must be consulted. To the English student, Mr. Witham's beautiful volume, "Observations on the Structure of Fossil Vegetables, Edinburgh, 1831," will be found a valuable guide.

FOSSIL CONIFEROUS WOOD.

FOSSIL CONIFEROUS WOOD.—The coniferous

wood of the secondary formations of England, belongs for the most part to the Araucarian type: that is, the glands, when in double rows, are placed alternately, as in the Norfolk Island Pines (*Wond.* p. 696), and not side by side, as in the common European species of firs and pines (*Bd.* p. 486). Numerous sections of this kind of fossil wood are figured by Mr. Witham, from specimens obtained from Lennel Braes, on the banks of the Tweed, near Coldstream; and from near Allanbank Mill, in Berwickshire (*Obs. Foss. Veg.* p. 14); a fossil trunk, 40 feet long, discovered in Craigleith Quarry, near Edinburgh, at a depth of 136 feet, possessed the same structure.

PALÆOXYLON (*coniferous wood of the Coal Measures*).—The existence of coniferous trees in the Carboniferous flora, and the fact that their trunks and branches had contributed to the formation of coal, was first discovered and clearly demonstrated by Mr. Witham in the work to which reference has been made. Figures of the peculiar structure observable in thin slices of coal, are given in *Obs. Foss. Veg.* pl. iii. iv. v. This carbonized wood resembles that of the Araucariæ in the multiple series of ducts, and their alternate arrangement; but the presence of thick compound medullary rays in these stems,—a character unknown in any living conifers,—led M. Brongniart to place them in a separate genus—*Palæoxylon* (ancient wood); characterized by the presence of medullary rays formed of numerous layers of cells, which are not arranged in superimposed series, and that present a lanceolate or oval form, in a section perpendicular to their direction.[137]

[137] The *Pinites Withami*, and *P. medullaris*,

of Lindley and Hutton, figured in Mr. Witham's work, belong to this genus. It may interest the reader to know that slices of these woods prepared for the microscope by Mr. Nicol, (presented to me by the late Dr. Henry, of Manchester,) not only expose the vegetable organization in an admirable manner, but also form beautiful objects for the exhibition of polarization.

PEUCE.—Another species of coniferous wood from the coal is thus named; it differs from the former in the medullary rays being composed but of one layer of superposed cells.

ARAUCARITES (*Dadoxylon of Endlechen*).—This term is employed to designate the fossil wood whose structure is apparently identical with that of the living species of Araucariæ, having the same kind of medullary rays, and the ligneous fibres studded with discs or areolæ, which are polygonal, often hexagonal, and disposed in several alternating series. This wood is common in the Lias, Oolite, Wealden, and Chalk.

Drifted fragments of coniferous wood of this type occur in the Stonesfield slate, associated with leaves and fruits of cycadeæ, and with marine shells, bones of reptiles, fishes, and mammalia; at Scarborough, with the ferns and zamiæ previously described; at Swindon, in the Portland oolite, with belemnites, ammonites, trigoniæ, &c.

STERNBERGIA.

STERNBERGIA.—To the Araucarian tribe, according to the recent investigations of Professor Williamson, must be referred certain fossil stems

found in the coal-measures, and named *Sternbergiæ*.[138] These are long solid cylindrical casts of sandstone or clay, with annular constrictions, which are generally invested with a thin film of carbonaceous matter; when this crust is removed the surface is found to be marked with longitudinal ridges. These fossils were once supposed to be the stems of plants allied to Yucca or Dracæna; but, as was first shown by Mr. Dawson and Mr. Dawes,[139] they are merely sandstone casts of the medullary axis or cylinder of an extinct genus of coniferæ, allied to the Araucariæ: a specimen in which the cast was surrounded by a thick ligneous cylinder, heaving enabled that acute observer to detect the structure of the original.[140] The Sternbergiæ are sandstone casts of central cavities existing within the true pith; which cavities, under some favourable conditions, were filled with inorganic materials. Mr. Williamson is inclined to believe that all the coniferous wood from the coal-measures, belonging to the genus *Dadoxylon*, is referable to the trees of whose piths the *Sternbergiæ approximatæ* are internal casts; and that some of the foliaceous appendages of these trees have been confounded with Lepidodendra.[141]

[138] See Pictorial Atlas, pl. xviii. p. 53.

[139] On the Coal formation of Nova Scotia, Geol. Proc. 1846.

[140] See Prof. Williamson's Memoir on Sternbergia, Manchester Philos. Trans. 1851.

[141] Ibid. p. 355.

PETRIFIED FORESTS OF CONIFERS.—The most remarkable assemblage of fossil conifers is that presented in the well-known quarries in the Island of Portland, to which allusion was made when

describing the Mantelliæ obtained from that locality (*ante*, p. 157.). Referring to *Wond.* p. 385,[142] for an account of the geological circumstances under which the phenomena occur, it will suffice to state that a forest of pines appears to have been submerged, and the trunks to have become petrified, whilst standing erect on the spot where they grew; the Cycads still shoot up as it were between the stems, and the roots of the trees, though changed into flint, extend into the bed of mould whence they originally derived support, and which is so little altered in appearance, as to be called the *Dirt-bed*, by the quarrymen; thus realizing the fable of the petrified city in Arabian story, whose inhabitants were turned into stone, in the varied attitudes of life.

[142] Geol. I. of Wight, p. 394. Petrifactions, p. 56.

No foliage has been observed in connexion with these trees; not a leaf has been found in the rocks: a cone, nearly related to the fruit of Araucaria excelsa, was discovered in the Dirt-bed.

At Brook-point, in the Isle of Wight, an equally interesting fact may be observed. At the base of the cliff, which is entirely composed of Wealden clays, shales, and sandstones, there is a vast accumulation of petrified firs and pines, imbedded in the indurated grit that forms the lowermost strata on the sea-shore, and of which the reefs and rocks, produced by the encroachments of the sea, and that extend far from land, are composed. These can be examined at low-water, and the observer, upon lifting up the fuci and algæ which cover them, will find the rocks and masses of stone to consist of petrified trunks of coniferæ. There are no erect trees as in Portland; on the contrary, the stems are prostrate, and lie

confusedly intermingled, and associated with bones of Iguanodons and other reptiles, and large mussel-shells; the whole presenting the characters of a raft of forest trees which had drifted down the stream of a vast river, and entangled in its course the limbs and carcasses of animals that were floating in the water, and the shells that inhabited the river, and at length became submerged in the bed of the delta or estuary. Both foliage and fruit have been found in the Wealden deposits at Brook, and will be described hereafter.[143]

[143] See Geol. I. of Wight, chap. x. and xi.

In the sands of the Desert of Sahara, in Egypt,—among the mammalian bones of the Sub-Himalayas,—and in the tertiary deposits of Virginia associated with cycads,—drifted trunks of conifers have been discovered.

Fossil trees of this family also occur in various localities in Australia and Van Diemen's Land, the wood of which is in some parts calcified, and in others silicified. The same trunk often has externally a white friable calcareous zone, several inches thick, traversed by veins of silex, or opaline chalcedony, while the centre is a silicified mass; in both states the internal structure may be detected. This kind of fossil wood is to be seen in most cabinets, a large quantity having been sent to England by emigrants.[144] These fossil trees appear to have been subjected to the same mutations as those of the Isle of Portland, for they are described as standing erect to the height of several feet in a bed of arid sand, apparently in the places where they grew; their petrified branches being scattered around them. They so entirely preserve their natural appearance, that one of the

colonists mentions among the extraordinary sights he witnessed on his first arrival in New Holland, the burning of trees into lime to manure the ground.

[144] My late friend, Sir Francis Chantrey, had a magnificent specimen, which, is now in the British Museum. See Petrifactions, p, 59.

FOSSIL CONIFERÆ OF AUSTRALIA.

A fossil pine forest, on the eastern coast of Australia, in the inlet called Lake Macquarrie, is described by the Rev. B. Clarke, as occurring at the base of a mountain range, composed of conglomerate and sandstone, with subordinate beds of lignite; an alluvial plain extends to the water's edge, covering the sandstone rock which is seen *in situ* beneath. Throughout this plain, stumps of fossil trees project from the ground, and present the appearance of a forest in which the trees have all been broken off at the same level. At the distance of some yards from the shore, a reef is formed by vertical rows of the petrified stems, which project out of the water. Many of the fossil stems on the strand have the remains of roots extending into the sandstone below the alluvial deposit, and, like those in the Island of Portland, are in some instances surrounded by an accumulation of rock, which forms a mound of a higher level than the surface of the stratum. The trunks are, generally, three or four feet high, and from two to six feet in diameter. The wood is silicified, and veins of chalcedony traverse its substance between the concentric rings and medullary rays; in several examples, from 60 to 120 annual circles of growth were observable. Beds of lignite occur in the neighbouring hills, both above and below the fossil trees; many localities along the eastern coast of Australia are mentioned, as presenting similar phenomena. I may add that the only fragment of petrified wood found by Mr. Walter Mantell in New Zealand is coniferous.

In the valley of the Derwent, in Australia, opalized coniferous trees of a similar character were observed under very extraordinary circumstances, by the distinguished traveller, Count Strzelecki. Truncated stems were found standing erect in a bed of scoriaceous basalt (lava) and trachytic conglomerate: but in some instances only basaltic casts of the trunks remain. This curious phenomenon can only be explained by supposing the silicified stems to have resisted the intense heat of the incandescent lava, while trees placed in circumstances unfavourable to their petrifaction were consumed: but the latter, being either saturated with water, or fresh and green, were burnt slowly, and left cylindrical moulds in the cooled basaltic scoriæ, with impressions of the external surface of the bark; these moulds were filled Tip by a subsequent eruption, and thus basaltic casts of the consumed trees were formed.[145]

[145] Physical Description of New South Wales, by Count Strzelecki.

CONIFEROUS WOOD IN OXFORD CLAY.—It would occupy too much space to notice the numerous localities in which fossil remains of conifers occur in the Liassic and Oolitic formations of England.

In the Oxford and Kimmeridge Clays water-worn trunks and branches of large pine-trees are often met with. An interesting deposit of these remains was brought to light by my youngest son (Mr. Reginald Mantell), when constructing the branch line of railway from the Great Western to Trowbridge, in Wilts. In the progress of the work, extensive sections were cut through the Oxford Clay, and laid bare a large quantity of drifted wood, much of which was not petrified, but in the state of bog-wood, and was

used for fuel by the workmen. Trunks ten or twelve feet long were met with, to which serpulæ, oysters (*Ostrea delta*), and other shells were adherent. These vegetable remains were associated with Belemnites, Belemnoteuthides, Ammonites, &c.; and had evidently been drifted far out to sea by currents.[146]

[146] See *Wond.* p. 502. Geol. Journal, vol. vi. p. 311.

FOSSIL CONIFEROUS WOOD.

CONIFEROUS WOOD IN THE CHALK FORMATION.—The arenaceous limestones of the Greensand of Kent and Sussex abound, in some localities, in water-worn masses of coniferous wood, which are often perforated by boring mollusks, as *Teredo*, *Fistulana*, *Gastrochæna*, &c. In the Iguanodon quarry of Kentish rag, near Maidstone, large quantities of these remains occur, and Mr. Bensted has collected several cones belonging to different kinds of conifers; one of these appears to be a species of *Abies*, or Fir:[147] it was associated with fragments of trunks and branches, whose internal structure proved their relation to the fruit. *Plate V. fig. 2*, are microscopic views of transverse and longitudinal sections of this wood; 2^a shows the cellular tissue in a transverse slice, seen by reflected light; 2^b a vertical section in the direction of the medullary rays, exhibiting the vessels studded with single rows of glands. This wood occurs both in a calcareous and siliceous state; in some examples the external zones are calcareous, and the inner siliceous; in others the entire branch is changed into black flint, in which the coniferous structure is beautifully preserved.

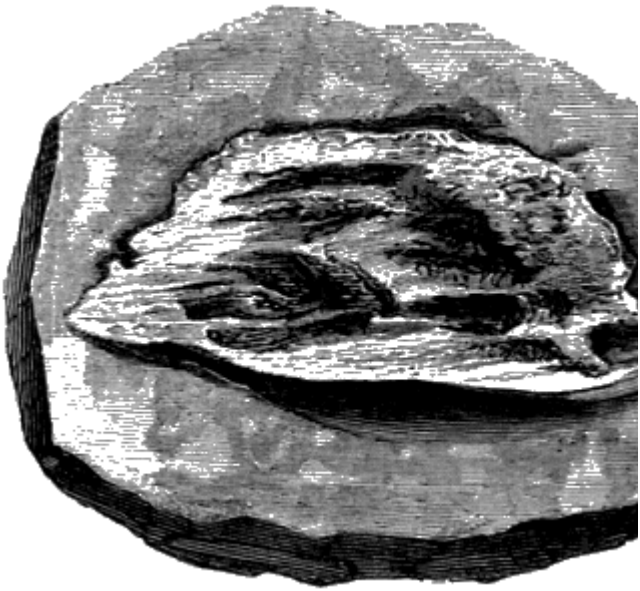
[147] It is figured and described as *Abies Benstedi*, by the Author. Geol. Proc. January,

1843.

Near Willingdon, in Sussex (*Geol. S. E.* p. 172), a bed of sand, immediately beneath the Galt, contains a layer of water-worn fragments of stems and branches, of small size; they are generally perforated by *Gastrochœnce*, and the cavities formed by these depredators are filled with particles of green chlorite sand. The structure of this wood is represented in *Plate V. fig. 3*[a] a transverse, and 3[b] a vertical section, viewed by reflected light; in 3[b] the vessels are dotted with two parallel longitudinal rows of very minute glands, arranged alternately, as in the Araucariæ; a fragment of one of the medullary rays is seen near the middle of the specimen.

In this deposit of coniferous wood, two or more fruits apparently referable to *Zamiæ* have been discovered; one specimen, five and a half inches long, and of an elongated cylindrical form, covered with rhomboidal eminences, I have figured and described as *Zamites Sussexiensis*.[148]

[148] Geol. Proc. 1843.



LIGN. 58. FRAGMENT OF CONIFEROUS WOOD IN FI
From a wall in Lewes Priory,

The White Chalk of England has afforded but few traces of plants of this family. Fragments of coniferous wood are, however, occasionally found in the state of carbonaceous, or reddish brown friable masses, and when this substance is removed, the surface of the chalk is seen to be marked with impressions of ligneous fibres; sometimes the surface is studded over with little pyriform eminences, which are cretaceous casts of perforations made by insects in the wood. These specimens, when all traces of the wood are absent, are very puzzling to those who are not aware of their origin.

Occasionally silicified fragments of wood are found imbedded in flint. I have an interesting specimen of this kind obtained from a wall in Lewes Priory (*Lign. 58*), and though it must have been

exposed to the influence of the weather for nearly eight centuries, its surface still exhibits coniferous structure.

WOOD IN FLINT.

TERTIARY CONIFEROUS WOOD.—The Tertiary formations in some localities abound in coniferous plants and trees, which, in the Paris basin, are associated with bones of mammalia; several species of pine (*Pinus*) and of yew (*Taxus*) from those deposits are described by M. Brongniart. I have collected fossils of this kind from the London Clay of the Isle of Sheppey, Bracklesham Bay, and Bognor in Sussex, and Alum Bay, in the Isle of Wight; and from the plastic clay at Newhaven.

FOSSIL FOLIAGE AND FRUIT OF CONIFERS.—From this digression on the pine-forests and drift-wood of the secondary formations, we return to the examination of the foliage and fruits of this order of vegetables that are preserved in the mineral kingdom.

ARAUCARIA PEREGRINA (*Lindley and Hutton*). *Lign. 59, fig. 1.*—With the trunks and branches of conifers of the Lias, cones and foliage are occasionally found: a beautiful example of a branch with the leaves preserved, is figured, *Lign.* 59. This fossil has been so admirably cleared from the shale which invested it (by Miss Philpot) that even the surface of the leaves is exposed. It so closely resembles a twig of *Altingia excelsa*, that the eminent authors of Foss. Flor. have named it as above. But M. Brongniart states that the foliage differs from that of the two living groups of Araucariæ: in *Araucaria Brasiliensis*, the leaves are flat, in *Altingia excelsa*, quadrangular; in the fossil the leaves are short,

fleshy, arranged spirally, and inserted.



LIGN. 59.

Fig. 1.— PART OF A BRANCH OF ARAUCARIA PEREGRINA; *nat. Lias, Lym*
2.— CALAMITES NODOSUS with foliage; *nat. Coal-shale*, (see *ante*, p

PINITES; a name applied to those fossil leaves and fruits which agree in their general character with the

recent genus Pinus; upwards of thirty species are known.[149] In the Pines, as botanically distinguished from the Firs (*Abies*), the leaves arise in bundles of from two to five; and the scales of the cones are thickened, and terminate in discs more or less defined. In Firs, (Larch, Cedar, &c.) the scales have thin edges, and the leaves are solitary.

[149] See Endlechen's Synopsis Coniferarum.

PINITES FITTONI. *Geol. Isle of Wight*; 2d edit, p. 457.—Several cones with the above characters have been found in the Wealden formation. A cone figured and described by Dr Fitton, is remarkable for a double prominence on each scale: It was supposed to resemble the fruit of *Dammara*, but the strobilus of the latter is like that of the Cedar of Lebanon, in which the edges of the scales are thin. The Wealden fossil appears to be a genuine pine, and may be distinguished by the name of its discoverer, *Pinites Fittoni*; a small figure of the only known specimen is given, *Wond.* p. 399, *fig.* 4.

I have collected from the Wealden strata of the Isle of Wight three or four small cones, which resemble those of a species of Araucaria; they are ovate, imbricated, with acuminated scales, which are recurved at the apex. The fossils figured in *Wond.* p. 399, *figs.* 2 and 3, are, I believe, water-worn specimens of the same species.[150]

[150] I subjoin a definition of the genera Pinus and Abies, for the use of the student.

PINUS.—*Fruit*-catkins ovate, roundish, or cylindrical closely set with thick two-flowered scales; forming an imbricated cone, composed of numerous ligneous angular, or flat, rigid

scales, having attached to the inside of each two seeds crowned with a thin membraneous, falcate, oblong, or roundish wing; the scales are composed of a thick woody substance, forming an angular surface, with a recurved point. The Pines are evergreen trees, with from two to five narrow, angular leaves springing from each sheath. Cotyledons four to twelve.

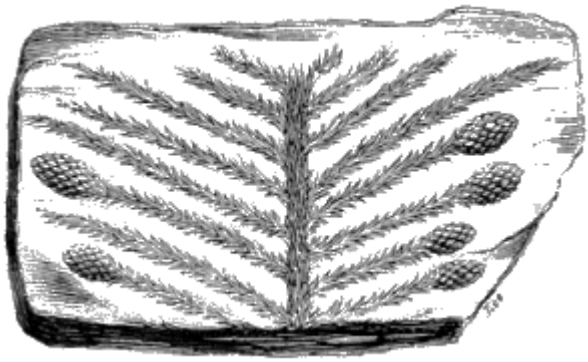
ABIES.—Cones with thin flat scales, which are more membranous at the extremities than in Pines: the leaves are emarginate, short solitary, needle-shaped, angular or flat.

WALCHIA.

WALCHIA. *Lign. 60.*—The fossil coniferæ thus named by Sternberg, have numerous closely set, regularly pinnated branches, resembling those of *Araucaria excelsa*, and which are thickly beset with foliage. The leaves are sessile, compact, enlarged at the base, tetragonal or falciform, and slightly decurrent; they often vary considerably in form and length on the same bough. The branches are in some examples terminated by oblong cones, composed of imbricated, oval or lanceolate, pointed scales, the summits of which are not recurved, as in the Araucariæ. The trees of this genus are closely related to the *Araucaria excelsa*, and *A. Cunninghami*. Some species occur in the Coal formation at St. Etienne and Autun;[151] others (as *Walchia hypnoides*) in the schists of Lodève, and in the copper slates of the Zechstein in Mansfeld.[152]

[151] "Mines de Houille de Vettin, &c." See "Tableau des Vég. Foss." p. 70, par M. Brongniart.

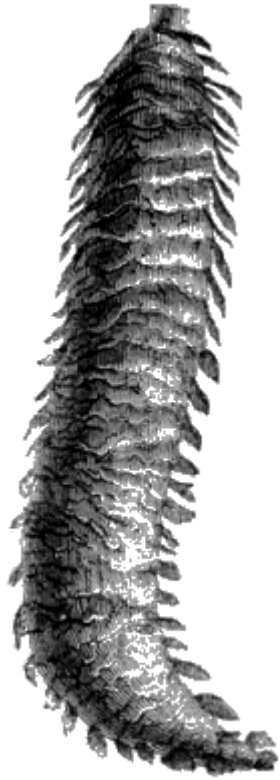
[152] Missing!



LIGN. 60. WALCHIA HYPNOIDES; $^{1}/_{3}$ *nat.*
Permian, Lodève.
Part of a bough with six of the branches bearing terminal cones.

ABIETITES.—To the Abies, or Fir, several cones found in the Wealden deposits of Sussex and Hants closely approximate in the form and structure of their scales. The most remarkable is the very elongated coniferous fruit, first discovered by me in the Wealden at Brook Point, and described and figured in my Geology of the Isle of Wight (*2d edit.* p. 452), under the name of *Abietites Dunkeri*, in honour of the eminent geologist who has so successfully and diligently explored the Wealden of the North of Germany.

I have been so fortunate as to collect from thirty to forty specimens of these fruits of the conifers of the country of the Iguanodon, associated with trunks and branches, and imperfect vestiges of single lanceolate leaves.



LIGN. 61.
ABIETITES DUNKERI.
Wealden; Isle of Wight;
$^{1}/_{3}$ *nat.*
Fir-cone, showing the imbricated scales, and many bracteæ.

ABIETITES DUNKERI.

ABIETITES DUNKERI. *Lign. 61.*—These cones are of a cylindrical form, and greatly elongated: the largest specimen is thirteen inches in length, and but three inches in circumference. The scales are broad, slightly convex without and concave within, obovate or subrotund, with a prominent midrib, edges thin

and entire. Leaves solitary, slender, slightly curved, from 1 inch to $1^{1}/_{2}$ inch in length. The cones were garnished with bracteæ, which are seen on the margins of the fossil when imbedded in the rock. Whether the foliage that forms the constituent substance of a large proportion of the bituminous coal of Hanover (*ante*, p. 74.), and which has been figured and of the named by Dr. Dunker *Abietites Linkii*, belongs to the same species of Fir as these cones, I am unable to determine. The seeds are of an ovate form: the pericarp is in the state of carbon, and filled or lined with pyrites or calc-spar.

These cones are generally found more or less pyritified, and are extremely beautiful objects when first collected; but like the fruits from the Isle of Sheppey, similarly mineralized, often decompose, in spite of every precaution, after exposure to the air but for a few weeks.

A small sub-ovate fir-cone found with coniferous wood in the Kentish-rag of Mr. Bensted's quarry, near Maidstone, (*ante*, p. 173.), and figured and described by me as *Abies Benstedi*, probably belongs to the coniferæ of the Wealden, since it was associated with drifted bones of the Iguanodon.

FOSSIL CYPRESSES.—The tribe of conifers called *Cupressus* or Cypress, (distinguished from the firs and pines by the leaves being mere scales, and the cones consisting of small wooded peltate bracteæ, and by other botanical characters,) including the Juniper and Arbor-vitæ, appears to have flourished during the whole of the secondary epochs; for fossil leaves and stems referable to this family, but whose generic affinities cannot be determined with precision, have been found in the Trias, Lias, Oolite, and Wealden

deposits.



LIGN. 62.
THUITES KURRIANUS *nat.*
Wealden. Hastings.

THUITES KURRIANUS. *Lign. 62.*—The *Thuja* or Arbor-vitæ, a plant too well known to require description, is the type of the fossil plants distinguished by the name of *Thuites*. Many years since I discovered vestiges of branches and leaves of some species of this genus, in the ironstone of the Wealden beds, at Heathfield in Sussex (*Geol. S. E.* p. 228); and of late, many specimens have been found in strata of the same formation in England and Germany. The branch here figured, from the cabinet of S. H. Beckles, Esq. will serve to illustrate the appearance of these fossil plants. Some small fruits found in the ironstone of Heathfield may possibly belong to Cypresses. The foliage and fruit of five or six distinct species of Thuites have been discovered in Tertiary strata.

VOLTZIA.[153] (*Wond.* p. 547).—This extinct genus of plants is peculiar to the Trias (*Grès bigarré*) or New Red deposits, and is one of the most characteristic of the fossil coniferæ. The specimens first found were from *Sultz-les-Bains*, near Strasburgh. The leaves are alternate, arranged spirally, sessile, and decurrent, and have much analogy with those of certain Araucariæ. The fruits are oblong cones, with cuneiform scales, slightly imbricated, not contiguous, and generally with from three to five lobes.

[153] Named in honour of the late M. Voltz, of Strasburgh, by whom they were first discovered. The specimens in the British Museum, from my collection, were presented to me by M. Voltz.

TAXITES. NŒGGERATHIA. FOSSIL RESINS.

TAXITES.—Some branches found in the Stonesfield slate, and bearing a general resemblance to twigs of Yew (*Taxus*), are described under the above name, but their analogies are doubtful. (See *ante*, p. 145.)

NŒGGERATHIA.[154]—I must briefly notice the coal-plants which M. Brongniart has placed under this genus, because the foliage of some species appears to have entered largely into the formation of certain seams of coal, although the perfect form of the leaves is unknown. The foliage referred to Nœggerathia consist of pinnated, or deeply pinnatifid, simple leaves. These leaves, or leaflets, are either elongated, linear, lanceolate, wedge-shaped or flabelliform, and entire, or deeply lobed at their extremity, and are traversed by numerous, fine, equal nerves, slightly diverging from the base, but almost parallel. The affinities of these plants are not

satisfactorily made out: M. Brongniart considers them to approach nearest to the Cycads or Conifers; perhaps forming a connecting tribe between those two great groups of gymnosperms.[155]

[154] A leaf of *N. flabellata* is figured in Foss. Flor.

[155] Tab. Veg. Foss. p. 64.

FOSSIL RESINS.—AMBER.—The resinous secretions of Conifers are occasionally found in a fossil state. When the tunnel was carried through Highgate Hill, in 1811, concretionary lumps of a brittle substance were discovered, which proved, upon analysis, to be the resin of a coniferous tree changed by mineralization. In a bed of fossil wood, near Hythe, in Kent, a resin was found that partook of the properties of amber and retinasphalt; it was of a clear red colour, very infusible, and acted upon with difficulty by many chemical solvents.[156]

[156] Geological Proceedings, 1843.

The pollen of pines or firs occurs in a tertiary deposit at Egra, in Bohemia; this bed is entirely composed of pollen and the frustules of many kinds of diatomaceæ.[157]

[157] Described by M. Ehrenberg.

AMBER. FOSSIL PALMS.

Amber, so remarkable for its electrical properties, and so largely used for ornamental purposes, is a fossil resin, the product of an extinct species of pine (*Pinus succinifer*), which, though nearly allied to *Pinus abies*, and *P. picea*, is essentially distinct. The Amber in the European markets is principally collected from the shores of the Baltic, between

Memel and Konigsberg, being washed out of submerged beds of lignite, and thrown up on the strand by the waves. Amber is occasionally found on the eastern and northern shores of England. The forests of Amber-pines appear to have been situated in the south-eastern part of what is now the bed of the Baltic, in about 55° north latitude, and 37° to 38° east longitude, and were probably destroyed at the commencement of the Drift period.

Insects, spiders, small crustaceans, leaves, and fragments of vegetable tissue, are often imbedded in amber; and a few hairs and feathers of mammalia and birds have been detected. These organic bodies must have become immersed in this substance when it exuded from the trees in a viscid state, for they are often preserved as fresh and beautiful as if recently embalmed in the liquid resin. Upwards of 800 species of insects have been discovered, chiefly referable to Aptera, Diptera, Neuroptera, Coleoptera, Libellula, &c.: by far the greater number belong to extinct forms.

The vegetable remains comprise four species of pine, and species of cedar, cypress, juniper, yew; and of oak, poplar, beech, ash, &c.; and a few ferns, mosses, liverworts, confervæ, and fungi. The Amber appears to have exuded from the bark and wood, but chiefly from the root-stock, as is the case with the *Copal* and *Animé*, which are resinous substances obtained from certain trees in India and America, and largely employed for varnish: these resins are often substituted for true amber, especially when they contain insects, &c.; but the latter are always of the existing indigenous species of the country. The difference observable in the colour of the various species of amber, is attributable to accidental

chemical admixtures.[158]

[158] Petrifactions, p. 23.

FOSSIL PALMS (*Palmacites*).—Reserving an account of the fossil plants belonging to the other grand division of Dicotyledons, the *Angiosperms* (*ante*, p. 61.), for the last section of the present chapter, I proceed to notice the most important family of the *Endogens*, or *Monocotyledons*, whose remains occur abundantly in many tertiary deposits —the PALMS.

The Palms are, for the most part, lofty trees, having a single cylindrical stem, which, like that of the arborescent ferns, rises to a great height, and is crowned with a canopy of foliage. The trunks are solid, most dense on the outer part, and in some species (as the Cane-palms) are coated with a thin siliceous epidermis. At a little distance above the surface of the ground, strong, simple, rope-like roots are sent off from the stem, appearing like clusters of stays or braces to support the trunk; and the base of the petrified palm-trees often exhibits vestiges of these organs.[159] The leaves are supported by petioles, and are in most species very large;[160] they are either pinnated or flabellated (fan-shaped), and sometimes nearly split in half: the veins or nervures are parallel, and the interspaces plaited like the folds of a fan. The surface of the stem is scored by transverse scars formed by the separation of the petioles, and these markings assist in the identification of the fossil trunks of palm-trees. The fruit is in some kinds a single drupe, as the Cocoa-nut; in others a cluster of soft pericarps, as the Date.

[159] Specimens in the Brit. Mus. Petrifactions, p. 12.

[160] In the Fan-palm (*Corypha*), the leaf is sometimes twenty feet broad.

The Palm family is divided into upwards of sixty genera, comprising more than a thousand species: the greater number are inhabitants of tropical countries. Stems, with the external surface and internal structure preserved, and the foliage, and fruit, of several kinds of Palms, have been found in a fossil state, and chiefly in the Tertiary formations. Examples of the large silicified palm-stems from the West India Islands, where they occur imbedded with corals petrified in the same manner, are to be seen in the British Museum,[161] and most public collections: and sliced polished sections, exhibiting the monocotyledonous structure, are common in private cabinets. The endogenous organization of the stems is so obvious as to leave no doubt as to the class to which the trees belong, but M. Brongniart states, that, in the absence of the foliage and fruit, it is seldom possible to pronounce with certainty that a fossil monocotyledonous stem belongs to a Palm; for the internal structure alone does not enable the botanist to fix upon any characters which will distinguish the stems of Palms from those of Pandanus, Agave, Yucca, Aloes, Dracæna, &c. Fossil monocotyledons known by their stems only, are therefore arranged by M. Brongniart under the general name of *Endogenites*.

[161] Petrifactions, p. 52.

The *Palmacites carbonigenus* of Corda, and other supposed palm-trees of the Coal formation, are regarded by the same eminent botanist as essentially differing in structure from this family, and belonging to an extinct tribe of exogens.

That a large proportion of the exogenous stems found in the Tertiary deposits are true palms, there can, however, be no doubt, for the foliage and fruit, which are occasionally associated with them, confirm the inference drawn from the characters of the trunks.

FOSSIL PALM LEAVES.

Stems, leaves, and fruits of Palms have been discovered in the Paris basin, by M. Ad. Brongniart (*Bd.* pl. lxiv. p. 515); and silicified trunks in many other places on the Continent; but no fossils of this kind surpass in beauty and interest those which are found in the West Indies. A slice of a silicified stem from Antigua is represented, as seen by reflected light, in *Plate V. fig. 1*; it admirably displays bundles of vessels imbedded in cellular tissue.

Silicified stems of monocotyledons, related to the Palms, are very widely distributed, and have been collected among mammalian remains in Ava, and in the Sub-Himalaya mountains.

FOSSIL PALM-LEAVES.—The pinnated and fan-shaped leaves of the Palms are so peculiar as to be easily recognized in a fossil state. Though many specimens have been found in the tertiary strata of the Continent, but two or three examples have been met with in England. The first discovered British specimen is in my cabinet, and was obtained by Mr. Fowlstone, of Ryde, from the fresh-water limestone of Whitecliff Bay, in the Isle of Wight. It is thirteen inches in length, and eleven in width: fresh-water shells and plants are imbedded with it. It is figured in Geol. I. of Wight, *2d edit.* p. 431. This species (*Palmacites Lamanonis*) occurs also at Aix in Provence, in great perfection, associated with Insects,

Fishes, fresh-water shells, &c. (*Wond.* p. 260. *Petrif.* p. 62).

Twelve species of palm-leaves are enumerated by M. Unger, from the Tertiary deposits of the Continent. One species has been found in the Chalk formation of Silesia; the most ancient strata in which the remains of undoubted palms have as yet been observed.

The fossil palm-leaves of the pinnated form are named *Phœnicites*,[162] and examples occur in the Tertiary grits of Puy en Velais, I am not aware that leaves of this type have been found in England: diligent research in our tertiary leaf-beds (at Whitecliff Bay, Alum Bay, Bournemouth, Wareham) will probably sooner or later discover them. The leaflets have a well-marked median nerve, with fine nervures running parallel with it; a character by which the foliage of *Phœnicites* may be distinguished from that of the Cycadeæ.

[162] From *Phœnix dactylifera*: the Date-Palm.

FOSSIL FRUITS OF PALMS.—Although certain fruits found in the coal-measures have been referred to the palm-tribe by M. Unger, Dr. Lindley, and other botanists, M. Brongniart is of opinion that no such identification can be established; the same remark applies to the Carpolithes from the Oolite; in fine, the Tertiary deposits have alone yielded fruits that can be unquestionably referred to plants of this order. The most productive British locality of fossil fruits of Palms, and of many other vegetables, is the Island of Sheppey; and I purpose describing in this place, not only the remains of this family, but also of

the other plants associated with them.

FOSSIL FRUITS OF THE ISLE OF SHEPPEY.

FOSSIL FRUITS OF THE ISLE OF SHEPPEY.—This little island, which is situated in the mouth of the Thames, is entirely composed of the London Clay, with bands of septaria. On the north, there is a range of cliffs, about two hundred feet high, which is being continually undermined by the waves, and large masses of the clay are thrown down, and innumerable fruits, seeds, branches and stems of trees, and other fossils, are exposed on the strand at low-water. The vegetables are strongly impregnated with iron pyrites, and as this mineral speedily decomposes when exposed to the atmosphere, the choicest examples often fall to pieces, even when preserved in the cabinet.[163] The nodular masses of indurated clay, termed septaria, contain the best preserved and most durable fossils. The fossil fruits, or carpolithes, occur in such profusion, that a large collection can easily be made; they comprise several hundred species, few of which have been scientifically investigated.[164]

[163] Mr. Bowerbank, who possesses an unrivalled collection of these fruits, keeps them in stopper-bottles filled with water, placing the different species separately, and labelling the phials. I have successfully employed mastic varnish, first wiping the specimens dry, and removing any saline efflorescence by means of raw cotton, and then brushing in the varnish with a stiff hair-pencil.

[164] See vol. ii. Excursion to the Isle of Sheppey.

Mr. Parkinson has given admirable figures of

several of the Sheppey fruits, particularly of the large palm-like nuts, called "*petrified figs*" (*Org. Rem.* vol. i. pl. vi. vii. *Pict. Atlas*, pl. vi. vii.) M. Ad. Brongniart has named several in his *Prodrome*; but without figures the descriptions are useless to the student. Mr. Bowerbank has published two numbers of a work entitled, "*History of the Fossil Fruits of the London Clay*," with seventeen plates; from which I have selected a few subjects for illustration. The fruits described are the following:

1. Fruits having a downy structure, like the Cotton plant.

2. *Cucumites.* Seeds of plants of the cucumber family. *Lign.* 63, *fig.* 1 and 3. These fossil fruits so closely resemble the seeds of various members of the recent genus *Cucumis*, or Cucumber, comprising the Gourd, Water-melon, &c., both in outward form and internal structure, that there is no reasonable doubt of their belonging to plants of the same family; hence the name *Cucumites* or fossil cucumbers.

3. Cones of a tree allied to the genus *Petrophila*, of New Holland. *Lign.* 63, *figs.* 2 and 8.

4. Seeds of the Bean family, some of which resemble those of the common Scarlet-runner. *Lign.* 63. *figs.* 5, 6, 7.



LIGN. 63. FOSSIL FRUITS FROM THE ISLE OF
London Clay.

Fig. 1. and 3. *Cucumites variabilis*: *fig.* 3, is a vertical section, showing
—

2 and 8. *Petrophiloides Richardsoni*: $^1/_3$ *nat.* Fig. 8, is a vertical se
— seeds in the cells formed by the confluent scales—$^1/_2$ *na*

4.— *Wetherellia variabilis*: a section of the fruit, in which stat
collectors—$^1/_3$ *nat.*

5 and 6. *Faboidea semicurvilinearis*: fig. 5, side view—$^1/_4$ *nat.*
—

6.— Is the face of a similar seed—$^1/_3$ *nat.*

7.— *Faboidea bifalcis*: side view—$^1/_3$ *nat.*

9.— *Nipadites lanceolatus*: *a*, the seed; *b*, the shell, or pericar

10.— *Nipadites cordiformis*: *a*, the extremity of the seed, imbe

5. *Wetherellia*; pulpy fruits divided into two lobes by the expansion of the ripe seeds. As the section thus exposed bears some resemblance to a coffee-berry, these fossils are popularly called petrified coffee-berries. This genus has no known living representative. *Lign. 63, fig. 4*.

6. Fruits allied to the Palm tribe. (*Nipadites*). *Lign.* 63, *fig.* 9, and 10.

7. Fruits of leguminous plants, differing from any known recent. *Lign.* 64, *figs.* 1, 2, 3, 4.

8. Seeds, allied to the *Amomum*, or Cardamom tribe. *Lign.* 64, *fig.* 5.

9. Seeds of *Cupressinites*, or plants related to the Cypress.

10. Seeds resembling those of the *Laburnum*.

11. Seed-pod of a species of *Acacia*, or *Mimosa*. *Lign.* 64, *fig.* 7.—$^{2}/_{3}$ *nat.*



LIGN. 64. FOSSIL FRUITS FROM THE ISLE OF SHEPP

Fig. 1 and 2. *Zulinosprionites latus*. 2. A section, showing the receptacl —

3.— *Leguminosites dimidiatus*; side view.—$^1/_2$ *nat.*

4.— *Leguminosites subquadrangularis*; side view.—$^1/_2$ *nat.*

5.— *Cupanoides lobatus.*—$^1/_2$ *nat.*

6.— *Cucumites variabilis.*—$^1/_2$ *nat.*

7.— *Mimosites Browniana*; from Ossington, Suffolk. A seed-po *Mimosa* family.—$^2/_3$ *nat.*

NIPADITES. *Lign. 63*. (*Pict. Atlas*, pl. vi. vii.)—The most remarkable fruits in the above catalogue are those which, from their appearance when compressed, are known to collectors by the name of "*petrified figs*" (*Lign. 63, fig. 9, 10*). Some specimens attain a considerable size, and are from five to seven

inches long. The nut, and the pericarp or shell, are often well preserved. These fossils were referred to the *Cocos* by Mr. Parkinson, but they have not a ligneous endocarp with three pores as in the Cocoa-nut.

Mr. Bowerbank has shown that they are nearly related to the fruit of the NIPA, or Molucca-Palm, a tree which abounds in Bengal, and in the Molucca and Philippine Islands. The Nipæ are low, shrub-like plants, having the general aspect of palms; they grow in marshy tracts, at the mouths of great rivers, particularly where the waters are brackish. They are allied to the Cocoa-nut tribe, on the one hand, and to the *Pandanus*, or Screw-pine, on the other.

The *Nipadites*, according to Mr. Bowerbank, have the epicarp and endocarp thin and membranous, and the sarcocarp thick and pulpy, and composed of cellular tissue, through which run numerous bundles of vessels. Nearly in the centre of the pericarp is situated a large seed which, when broken, is more or less hollow. This seed consists of regular layers of cells, radiating from a spot situated near the middle, and apparently inclosing a central embryo.

The same author remarks, that "if the habits of the plants to which the fossil fruits belonged were similar to those of the recent *Nipa*, it will account for their abundance in the London Clay in the Isle of Sheppey; which formation, from the great variety of stems and branches, mixed up with star-fishes, shells of mollusks, and bones of fishes, crustaceans, and reptiles of numerous marine and fresh-water genera, is strikingly characteristic of the delta of a river, which probably flowed from near the Equator towards the spot where these interesting relics are

deposited." The fact that the seed-vessels of several species of Nipadites abound in the Isle of Sheppey, and have not been observed in any other locality in England, tends to support this opinion.

Carpolithes of this kind occur in great perfection in the Eocene strata of Belgium, and were figured and described, nearly seventy years since, in Burton's "*Oryctographie de Bruxelles*," as petrified cocoa-nuts; the uncompressed state in which these fossils occur makes the resemblance to the recent fruit more striking than in the flattened pyritous specimens from the clay of Sheppey.

NIPADITES OF BELGIUM.

The *Nipadites* of Brussels have recently been brought under the more immediate notice of English geologists, in a memoir "On the Tertiary Strata of Belgium and French Flanders," by Sir Charles Lyell, in which several specimens are figured and described.[165] These fossils are found in sands and sandstone, presumed to be of the age of the Bracklesham beds of Sussex. They are procured from Schaerbeek, in the northern suburbs of Brussels, where extensive quarries are worked for paving-stones, and have long been celebrated for remains of turtles, trunks of palms, and dicotyledonous trees, and the fruits, now called Nipadites. The vegetable remains often occur silicified; Sir C. Lyell was shown by the workmen "the trunk of a petrified exogenous tree, with forty rings of annual growth; it had lain in a horizontal position, and was bored by teredinæ. The silicified base of the trunk of a Palm-tree, apparently broken off short at about the level of the soil, had numerous air-roots, or rootlets, attached."[166]

[165] Quarterly Journal of the Geological Society of London, vol. viii. August 1852.

[166] "On the Belgian Tertiary Formations," Geol. Journal, vol. viii, p. 344.

Of the thirteen species of Nipadites enumerated by Mr. Bowerbank, some of which are, however, only accidental varieties, four have been identified among those obtained from Schaerbeek: two of them belong to but one species—the *Nipadites Burtoni*: the others are *N. lanceolata* (*Lign. 63, fig. 9*), and *N. Parkinsoni* (*Pictorial Atlas*, plate vii.). These fossil nuts closely resemble the fruit of *Nipas fruticans*, a palm which abounds in the delta of the Ganges, and other parts of Bengal, and is the only living species of the genus known.[167] In an immature or abortive specimen of *Nipadites giganteus* (of Bowerbank), figured in *Geol. Journ.* pl. xix. fig. 2, the angularity of the pericarp observable in the ripe fruit (*Lign. 63. fig. 9*) is well marked. The largest specimen of Nipadites from Schaerbeek, is above seven inches long and four wide. The arenaceous strata containing these fruits, and stems of palms and dicotyledonous trees, are supposed to have been formed in the sea near the mouth of a river, as in the case of the clay-beds at Sheppey: the vegetable remains are associated with bones of fresh-water Turtles, teeth of Sharks, cases and spines of Echinoderms, and shells of the genera Ostrea, Pinna, &c.[168]

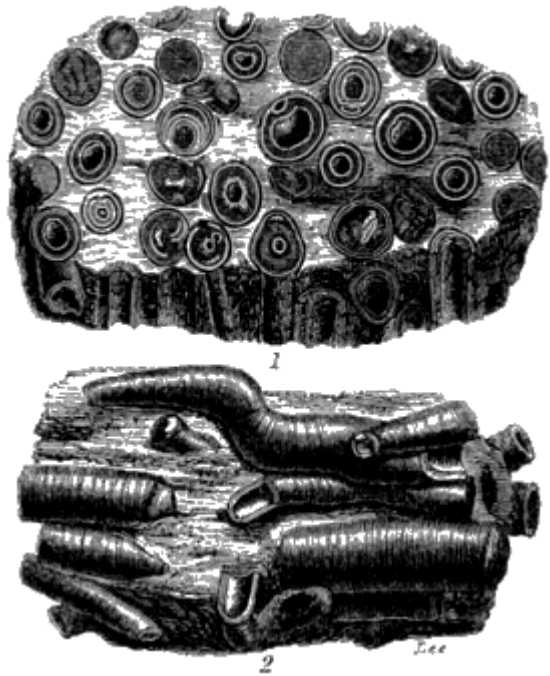
[167] "On the Belgian Tertiary Formations," Geol. Journal, vol. viii. p. 344.

[168] Geol. Journal, vol. viii. p. 347.

FOSSIL PANDANUS.

FOSSIL FRUIT OF PANDANUS. (*Popocarya. Bd.* pl. lxii. p. 503.)—The *Pandanaceæ* are monocotyledonous trees, named Screw Pines from the spiral insertion of their long, rigid, sword-like leaves, along the stem; they are natives of hot climates, and abound in the groups of islands in the Pacific; being generally the first important vegetable tenants of the newly-formed Atols or coral-islands. As in the palms, the stem is supported near the base by long side-roots, which enable these trees to maintain an erect position, and flourish on the newly-elevated coral-reefs, where but little soil has accumulated.

The existence of this tribe of plants during the secondary ages is known only by a single example of a fossil fruit, which was discovered by Mr. Page, of Bishport, in the Inferior Oolite, to the east of Charmouth, Dorsetshire, and is preserved in the museum at Oxford; no vestiges of the stems or foliage have been observed.



LIGN. 65. FOSSIL WOOD WITH TEREDINES; *nat. London Clay, Regent's Park.*

Fig. 1. A polished transverse section, showing the tubes lined with spar.

2. Portions of mineralized Teredines, seen in relief on the wood.

This carpolithe, (for a detailed account and figures see *Bd.* p. 504, pl. lxiii.) is of the size of a large orange; the surface is covered with a stellated epicarpium, composed of hexagonal tubercles forming the summits of cells which occupy the entire circumference of the fruit. Each cell contains a single seed, usually hexagonal, resembling a small grain of rice, and is supported by a foot-stalk, formed of dense fibres; a character exhibited only by the seed-vessels of Pandanus. The fossil fruit differs from that of the recent Screw-pines in the seeds being neither

inclosed in a hard nut, nor collected into drupes, but dispersed uniformly over the entire mass; this forms the essential generic distinction between them. Dr. Buckland has named this unique carpolithe *Podocarya*. (*Bd.* p. 505.)

WOOD PERFORATED BY TEREDINÆ. *Lign. 65.*—The drifted trunks and masses of wood found in the London Clay, at Sheppey, Bognor, Bracklesham, &c., some of which belong to Palms, others to Conifers, and Dicotyledons, are commonly more or less perforated by the boring mollusks called *Teredo*, or *Teredina*; and remains of their testaceous tubes are often well preserved. The tortuous channels excavated in the wood by these borers, are lined or filled up with calcareous spar, indurated clay, or other mineral matter, of various shades of grey, blue, yellow, &c.; and the polished slabs of this fossil wood are beautifully diversified by the sections of the sparry tubes, crossed at right angles by the ligneous structure; as in the specimen *fig. 1, Lign. 65*, from the Canal in the Regent's Park.[169]

[169] Slabs of this kind are generally kept by the lapidaries at Bognor, Worthing, &c. and sold at 2*s.* or 2*s.* 6*d.* each.

In the fossil, *fig. 2. Lign. 65*, from the Isle of Sheppey, the tubes of the teredinæ are seen in relief, in consequence of the surface of the block of wood having decayed and been removed.

FOSSIL LILIACEÆ.—The family of endogens, termed *Liliaceæ*, comprises many beautiful plants; those with annual stems, as the Lily, Hyacinth, Tulip, &c. are well known for the variety and splendour of their blossoms; some of the arborescent forms, as the Tulip-tree, attain a large size, but the flowers of this

division are relatively small. In tertiary strata, the stems, leaves, fruits, and even the imprints of flowers, have been discovered, of plants related to *Sagittaria* (Arrow-head), *Smilax* (Bind-weed), *Convallaria* (Lily of the valley), &c.

The Dracæna (*Dragon-blood tree*), a tall, slender, elegant tree with amplexicaul leaves (common in our hot-houses), belongs to this family; and certain stems found with Clathrariæ, and bones of the Iguanodon, in the Kentish-rag at Maidstone (*ante*, p. 173.), so closely resemble the trunk of this plant, that they have been named by Mr. König,[170] *Dracæna Benstedi*; the specimens are in the British Museum. Until the internal structure of these fossils has been examined, the correctness of this identification is, however, uncertain: the external resemblance to the stem of the Dracæna consists in the interrupted annular ridges, denoting amplexicaul leaves: no vestiges of the foliage have been observed.

[170] Petrifactions, p. 49.

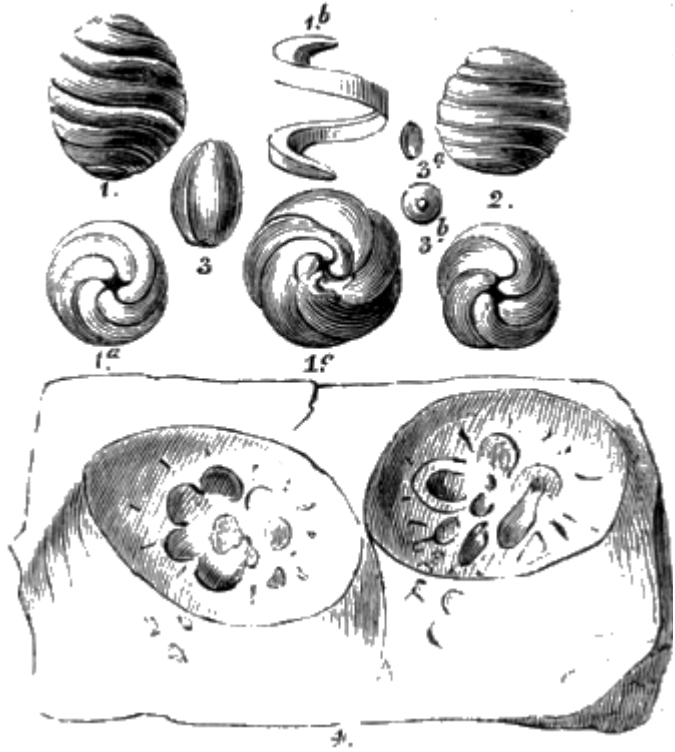
FRESH-WATER PLANTS. FOSSIL CHARÆ.

FOSSIL FRESH-WATER PLANTS.—The tertiary fresh-water strata often contain abundance of the remains of the aquatic vegetables that inhabited the lakes and rivers in which those deposits were formed. The remains of several species of the common lacustrine plant, the *Chara*, are found in immense quantities in the fresh-water limestones and marls of the Isle of Wight, of the coast of Hampshire, and of the Paris Basin. The shell-marls, still in progress of formation in the lakes of Scotland, and the travertine precipitated from thermal springs, in like manner envelop and preserve the leaves and fruits of recent species.

FOSSIL FRUITS OF CHARA. (*Gyrogonites.*) *Lign.* 66. —The Chara is a well-known inhabitant of almost every stream and rivulet. The stems are hollow, and composed of tubes filled with a fluid in which green globules circulate; they form beautiful microscopic objects for exhibiting the circulation in vegetables. The fruit consists of very small nuclei, contained in a calcareous pericarp, composed of five spirally twisted plates, that unite at the summit. These seed-vessels, when first discovered in a fossil state, were supposed to be the shells of mollusks, and a genus was formed for their reception with the name of *Gyrogonites* (*twisted-stones*); a term still employed, though the vegetable nature of these bodies is well known. In *Plate III. fig. 5*, a branch of the common Chara with seeds is represented: and figures of the seed-vessels, of two fossil species are given in *Lign. 66, figs. 1, 2*.

Specimens of the fossil fruits and stems of Charæ, may be collected in abundance in the fresh-water limestone at East Cliff Bay, Isle of Wight.[171]

[171] See my Geology of the Isle of Wight, *Lign. 5*, p. 109.



LIGN. 66. FOSSIL FRESH-WATER PLANTS.
Eocene, Paris.

Fig. 1. Seed-vessel of *Chara helicteres* × 10; side view.
— 1[a].—View of the base of the same.
1[b].—One of the spiral valves separated.
1[c].—View from above.
2. Seed-vessel of *Chara medicaginula* × 10. The upper figure is a s
— the lower, a view of the base.
3. *Carpolithes ovulum*, magnified side view.
— 3[a].—The same, natural size.
3[b].—Magnified view of the base of the same.
4. A piece of fresh-water limestone, with impressions of two stem
— *Nymphea arethusa* ×.

The *Purbeck beds* at Durlstone Bay, near Swanage, also contain numerous Gyrogonites associated with

fresh-water shells. The bands of siliceous sinter, which occur in the lowermost deposits, are especially rich in these remains.[172]

[172] I am indebted to the Rev. Osmond Fisher, of Dorchester, for a fine suite of these and other interesting fossils from the Purbeck beds of Ridgway and Osmington, near Weymouth; and to William Shipp, Esq., of Blandford, and Edward Woodhouse, Esq., of Ansty, for many specimens from Durlstone Bay, and Ridgway.

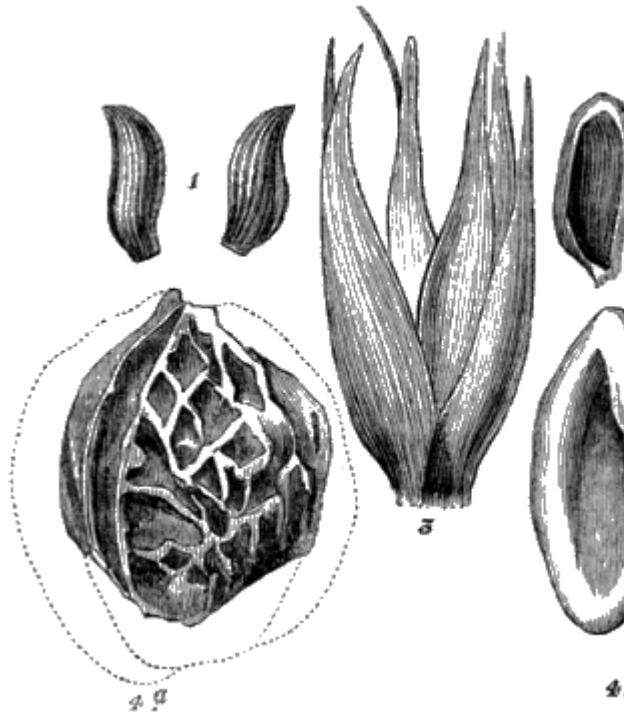
Fossil Nympheæ. *Lign. 66, fig. 4.*—Those magnificent aquatic plants, the Water-Lilies (*Nympheæ*), that adorn our rivers and lakes with flowers and foliage which partake more of the characters of an exotic flora than any other of our indigenous plants, are also found fossil in the lacustrine marls and limestones of the tertiary formations of France; but the nature of these remains could only be recognized by a profound botanist, for they consist of impressions of the internal structure of the stems, which, however, is so peculiar, that no reasonable doubt of their origin can be entertained. Two imprints on a piece of limestone from Lonjumeau, presented to me by the late M. Alex. Brongniart, are figured in *Lign. 66, fig. 4*; some minute seed-vessels (*Lign. 66, fig. 3*), found with them, closely resemble those of *Nympheæ*, and are supposed to belong to the same plants (*Class. Vég. Foss.* p. 72).

FOSSIL FLOWERS.—The tertiary limestones of Monte Bolca (*Wond.* p. 565), so rich in ichthyolites, and other fossil remains of great interest, contain leaves, and even flowers, of liliaceous plants. The specimen figured (*Lign. 67, fig. 3*) is in the Museum

at Paris, and described by M. Brongniart under the name of *Antholithes* (stone-flower) *liliaceus*; it consists of the corolla and calyx: the anthers and pistils have not been observed in any example. The discovery of this fossil should excite the young collector to search diligently for such objects in the tertiary strata of England.

FOSSIL ANGIOSPERMS.

FOSSIL ANGIOSPERMS.—The fossil remains of the class which constitutes the grand features of the existing floras of most countries, the *Exogenous Angiosperms*, are now to be considered; and though our survey of fossil botany has partaken but little of a geological arrangement, yet the reader may have observed, that a large proportion of the vegetables composing the floras of the ancient secondary formations, belonged to the Cryptogamous and Gymnospermous classes. A striking contrast is presented in the geological position of the mineralized dicotyledonous plants, of existing genera. These abound in the tertiary strata, and generally in an inverse ratio to the antiquity of the deposit, while their remains are almost wholly absent in the older rocks; neither have there been discovered in the Tertiary, any beds of vascular cryptogamia, at all approaching the immense accumulations in the Carboniferous formations.



LIGN. 67. FOSSIL NUTS, AND FLOWER.

Fig. 1.— THALICTROIDES PARISENSIS; Tertiary strata, Paris.
2.— THALICTROIDES WEBSTERI. Isle of Wight.
3.— ANTHOLITHES LILIACEUS. Monte Bolca.
4.— JUGLANS NUX-TAURINENSIS: fossil Walnut, Turin.
4^a.—-Portion of the husk of the shell.
4^b.—The kernel, formed of calcareous spar.

The most remarkable exception, is the single instance of a large leaf of a dicotyledonous plant in the Trias, or New Red sandstone, near Liverpool, described by Sir Roderick Murchison, which much resembles the foliage of a thick-ribbed Cabbage.[173]

[173] This fossil is named *Dictyophyllum crassinervium*, by Dr. Lindley, Foss. Flor. pl. cci. and is figured, Sil. Syst. p. 43.

It would be impossible, within the limits necessarily assigned to these volumes, to offer even a general view of the fossil remains of this grand class of vegetables; our remarks must be limited to a few interesting examples and localities.

When stems of dicotyledonous trees only are found, but little certainty can be obtained as to the family to which they belonged; the foliage of many well-known genera offer more positive characters; the flowers are rarely in a state of preservation to afford any valuable data; but the fruits, or seed-vessels, are frequently well preserved, and these may enable the botanist to arrive at precise determinations as to generic, and, perhaps, specific relations.

The tertiary marls of Aix, in Provence, which abound in insects, crustaceans, and lacustrine shells, contain many kinds of dicotyledonous leaves, associated with those of palms. (*Wond.* p. 260.)

The Lignite, or Brown-coal deposits, are almost entirely composed of dicotyledonous trees, belonging to many genera, which are inhabitants of Europe; namely, the Poplar, Willow, Elm, Chestnut, Walnut, Sycamore, Maple, Linden, Buckthorn, Vine, &c. (*Bd.* vol. i. pp. 508-514.)

The beds of brown coal, on the banks of the Rhine, are literally carbonized submerged forests, which in some remote period were drifted from the interior of the Continent into a vast lake or gulf; for the trees bear evident marks of transport, and are destitute of roots and branches. These masses resemble the rafts of forest trees, which are daily floated down the Mississippi into the Atlantic, where they become engulfed in the profound depths of the

ocean, and probably will be converted into coal or lignite; and in future ages, may be elevated above the waters, become dry land, and present to the then existing communities of mankind an inexhaustible supply of mineral fuel, composed of species and genera of plants, which possibly may then be extinct, and replaced by peculiar types of vegetation.

FOSSIL FLORA OF ŒNINGEN. (*Bd.* pp. 511-514).—The celebrated lacustrine tertiary formation of Œningen, whose fossil reptiles and mammalia we shall have to notice hereafter, contains a rich assemblage of dicotyledonous and gymnospermous ligneous vegetables, with a few ferns and grasses. Not only branches and leaves of a species of Vine[174] occur, but even the fruit; fossil grapes being found in these deposits;[175] there are also many aquatic plants. A descriptive list of these fossils, by Professor Braun, of Carlsruhe, is given by Dr. Buckland. The brown-coal of this basin is in thin beds of but little economical importance, but so rich in the vegetation of the miocene tertiary period, that a few days spent in collecting those treasures will amply reward the intelligent tourist who may visit Constance. (See *Wond.* p. 263.)

[174] See Knorr, Mon. des Catastrophes, pl. xxxviii. tom. i.

[175] Fossil grapes from the lignite of Œningen were exhibited by Dr. Daubeny at a late meeting of the Geological Society.

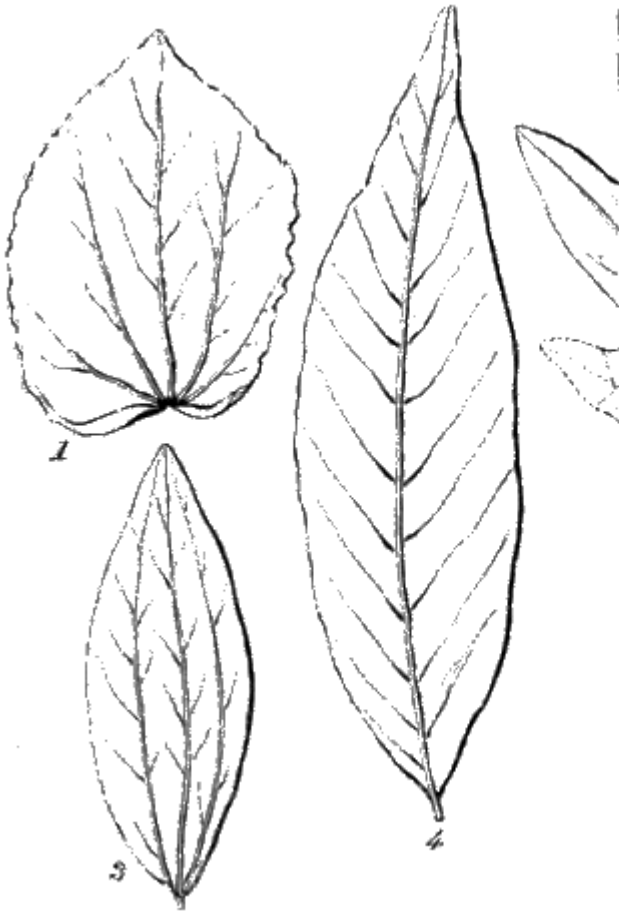
FOSSIL DICOTYLEDONOUS LEAVES.

The foliage of dicotyledonous trees frequently occurs in the Eocene marls and limestones, and in some localities in considerable abundance, and in beautiful preservation. Near Bournemouth, on the

Hampshire coast, the leaves of many species are met with in a bed of sandy marl, between three and four feet thick: the vegetable substance is carbonized; some of the leaves are referable to the *Lauraceæ* and *Amentaceæ*, others to the *Characeæ*;[176] a similar deposit of tertiary plants has been discovered near Wareham. These beds belong to the lower group of the Hampshire Basin.[177]

[176] Geol. Proc. vol. iii. p. 592.

[177] As the seed-vessels and other vegetable remains in the Isle of Sheppey are all of a tropical character, while those found in the Eocene strata of Alum Bay, Bournemouth, and Newhaven, are of a temperate climate, as Nerium, Platanus, &c., Prof. E. Forbes infers that the former were transported from distant lands by currents, and that the latter belong to the true flora of the country inhabited by the Palæotheria and other associated mammalia.



LIGN. 68. IMPRINTS OF DICOTYLEDONOUS LEAVES
Tertiary. Stradella, near Pavia.

Fig. 1.— Leaf of Poplar (*Populus græca*).
2.— ———— Maple (*Acer*).
3.— ———— Water-spike (*Potamogeton*).
4.— ———— Willow (*Salix*).
5.— ———— Chestnut (*Æsculvs*).

The red marlstone associated with lignite in the plastic clay beds at Castle Hill, Newhaven (*Geol. S. E.*

p. 54), contains leaves of a similar kind; a seed-vessel of a coniferous tree has also been found in it.

Some of the most interesting examples of dicotyledonous leaves that have come under my notice, are from the Sub-Apennine tertiary strata, at Stradella, near Pavia. They belong to several genera of arborescent, or at least ligneous plants, and most of them to species which still grow in Italy. In some examples the substance of the leaves is changed into carbon, and the structure well preserved; but, in general, sharp imprints on the stone are the only traces of the originals. They are found in a gypseous marl, of a cream colour; and, from their perfect state, it is inferred that they were enveloped in the soft matrix immediately after their fall, and preserved by the rapid crystallization of the gypsum. Two specimens from my cabinet are figured in *Plate III. figs.* 4 and 8; and outlines of a few other examples, in *Lign. 68*.

CARPOLITHES (*Fossil Fruits*).—In the description of the fossil fruits from the Isle of Sheppey, several kinds of dicotyledons were included. Many species also abound in the lignites of Germany, France, and Italy; in those near Frankfort, seed-vessels of the Maple, Elm, Hornbeam, Birch, Willow, and Walnut, &c. In the environs of Turin, fruits of a species of Walnut (*Juglans*, *Lign. 67*), occur in the newer tertiary deposits, and are called Turin-nuts; the ligneous envelope has perished, but the form of its surface, and of the inclosed kernel, is preserved in calcareous spar. These nuts differ, both in the pericarp and kernel, from the living species: the lobes are simple (*Lign. 67, fig. 4b*), and not subdivided as in the common walnut; a species has been discovered at Lons-le-Saulnier, in which the lobes are

mamillated.

Two kinds of fruits belonging to plants of the order *Ranunculaceæ*, and related to *Thalictrum* (*Meadow-rue*), have been found in the eocene deposits of France and England; one in the Paris basin, (*meulière du terrain d'eau douce supérieur*,) by M. Alexandre Brongniart, and the other in the Isle of Wight, by Mr. Webster. In the specimen from the last-named locality the pericarp is carbonized, and its cavity filled with clay. Figures of these seed-vessels are given in *Lign.* 67, *figs.* 1, 2.

CARPOLITHES SMITHIÆ.—I would notice in this place some very remarkable fossil fruits that are occasionally met with in the White Chalk of Sussex and Kent, and appear to belong to dicotyledonous trees. The first specimen was discovered by me in a chalk-pit near Lewes, and is described in my "Fossils of the South Downs:" some illustrative examples collected by Mrs Smith, of Tunbridge Wells, tending to elucidate the nature of the original more satisfactorily than those in my collection, are figured and described by me in the Journal of the Geological Society, 1843, under the above name. These fruits are of an oval form, about one and a half inch long, and one inch wide, and are pressed almost flat. They are of a rich burnt-sienna colour, mottled with white, from the chalk having permeated their substance, and are studded over with slight eminences, which are the exposed summits of oblong flattened seeds. Although the internal structure is not preserved, there can be no doubt that the originals were spurious compound berries, having, like the Mulberry, the seeds imbedded in a soft pulpy mass.

FOSSIL DICOTYLEDONOUS TREES.

FOSSIL DICOTYLEDONOUS TREES.—The occurrence of trunks and branches of angiospermous trees in a carbonized state has already been described; like the monocotyledons and conifers, they also occur silicified.

The most beautiful specimens I have seen are from the Lybian and Egyptian deserts, and were collected by my friend, the late Colonel Head. In these the most delicate vascular tissue is permeated by chalcedony and jasper, and the vessels are filled with silex of a bright vermilion and blue colour, while the cellular structure is of a rich yellow. Fragments of these fossil trees are scattered everywhere among the sands of the desert; the most interesting locality is an irregular plateau, which reposes on marine limestone, considerably above the level of the Nile, about seven miles east by south from Cairo. This district is called the *petrified forest*, from the immense quantities of silicified trees with which it is covered. It is thus graphically described by a late traveller:—

"Having passed the tombs of the Caliphs, just beyond the gates of Cairo, we proceed to the southward nearly at right angles to the road, across the Desert to Suez: and after travelling some ten miles up a low barren valley covered with sand, gravel, and sea-shells, fresh as if the tide had retired but yesterday, we cross a low range of sand-hills, which has for some distance run parallel to our path. The scene now presented is beyond conception singular and desolate. Heaps of fragments of large trees converted into stone everywhere meet the eye, and when struck by our horses' hoofs rang like cast iron; they extend for miles in the form of a decayed

and prostrate forest; and the appearance is so natural, that were it in Scotland or Ireland, it would pass without remark as a drained bog, on which the exhumed trees lay rotting in the sun. The roots, and rudiments of the branches, are in many cases nearly perfect, and in some the worm-holes eaten under the bark are distinctly recognizable."[178]

[178] Bombay Times.

Many of the trunks are scattered over the surface, among rolled and angular fragments of dark grit, and pebbles of jasper,[179] chert, and quartz. The large trunks occur in great numbers on dark-coloured knolls, where they lie, like the broken stems of a prostrate forest, crossing each other at various angles. Two of the largest measured respectively forty-eight, and sixty feet in length, and two and a half, and three feet in diameter, at the base. With but two or three exceptions, all the specimens examined microscopically, are dicotyledons. No traces of seed-vessels or leaves have been detected.

[179] The jaspers are known to lapidaries as *Egyptian Pebbles*.

The situation and condition of these petrified forests, indicate great changes in the relative position of the land and sea in that part of Egypt; for the trees must have grown on the dry land formed by the elevated bottom of a former ocean; which must have subsided, and been covered by beds of sand and pebbles; another elevatory movement must have raised the entire series of deposits to their present situation, and the retiring waters have removed the loose portions of the last formed strata, and dispersed them, with fragments of the silicified trees, over the surface of the Egyptian and Lybian deserts.

[180]

[180] See a Memoir on the Geology of Egypt, Geol. Proc. vol. iii. p. 782; and on the Petrified Forest near Cairo, vol. iv. p. 349, by Lieut. Newbold, F.R.S.

DICOTYLEDONOUS OF THE CRETACEOUS EPOCH.

DICOTYLEDONS OF THE CRETACEOUS EPOCH.—Among the crowd of interesting facts relating to the botanical character of the earlier periods of geology which recent observations have brought to light, one discovery demands especial notice, and I have reserved it for this place, rather than introduce it in an earlier section.

In the neighbourhood of Aix-la-Chapelle the lower members of the Cretaceous formation, viz. the Greensand, Galt, and Chalk-marl, are well developed, and comprise a series of littoral deposits of the great Chalk ocean that extended westwardly between France and England, on both sides of the existing Channel, and eastwardly over North and Central Germany, Sweden, Poland, and Russia, far into Asia. The series of strata at Aix-la-Chapelle is several hundred feet in thickness, and the lowermost beds lie immediately on the Carboniferous rocks of the country.

Dr. M. H. Debey,[181] to whose scientific labours we are indebted for an accurate knowledge of these interesting facts, divides these cretaceous deposits into four groups, the lowermost of which appears to be the equivalent of our Greensand; it consists of beds of clay and sand, the middle portion abounding in stems, leaves, and fruit, and the resin of coniferous trees.

[181] See Geol. Journal, vol. vii. p. 109.

The epidermis of the leaves often occurs in a carbonized state, and is recognizable by its microscopic structure. Xylophagous mollusks are found in the petrified and carbonized wood. Fresh-water Desmidiaceæ, and a few marine remains, are associated with this fossil flora, which is distinguished by the abundance of Ferns and dicotyledonous leaves, and the scarcity of Cycads; among them are undoubted *Proteaceæ*.

The specimens collected by M. Debey from the lower cretaceous beds are the following:

Algæ, 15. Filices, 28. Hydropteridæ, 2. Cycadeæ, 5. Naiadeæ, 5. Palmæ, 1. Coniferæ, 20. Julifloræ, 5. Credneriæ, 3. Leaves of Dicotyledons, undetermined, 26. Fruits undetermined, 8. Woods.[182]

[182] Geol. Journal, vol. vii. p. 111.

This assemblage of angiosperms, with gymnosperms, and cryptogamia, at the commencement of the Cretaceous epoch, when the Iguanodon and other reptilian forms of the Oolite and Wealden still inhabited the land and water, proves, as Sir Charles Lyell has remarked,[183] that the meteorological phenomena of that remote period differed in no essential particular from those which now prevail.

[183] Supplement to the New Edition of Elements of Geology, 1852, p. XV.

RETROSPECT OF FOSSIL BOTANY.

RETROSPECT OF FOSSIL BOTANY.

IF we pass from the consideration of details of structure, and of botanical affinities, to a general survey of the mineralized remains of the vegetable kingdom, we perceive that from the palæozoic deposits, to those which are contemporaneous with the human race,—from the coal-measures to the peat-bogs of modern times,—vast accumulations of vegetable matter, in various states of carbonization, have been produced from the imbedded relics of the terrestrial floras that flourished during the respective periods of their formation; petrifaction, or the transmutation of vegetable tissues into stone, from the infiltration of siliceous, calcareous, or metallic solutions, being an accidental process, dependent on the physical conditions under which the trees and plants were submerged, and entombed in the strata.

Although the entire system of vegetable life which prevailed during the earlier ages of the world is but partially revealed by the fossil remains which geological researches have brought under the examination of the naturalist,—for numerous tribes of plants may have existed of which no traces have been detected, while of species of delicate tissues all vestiges may have perished,—yet a review of the facts hitherto obtained, presents some highly important and unexpected results, as to the characters of the successive floras which prevailed during the palæozoic, secondary, and tertiary epochs. And though deductions of this nature must, in the present state of our knowledge, be regarded in the light of shifting hypotheses to be modified or abandoned with the progress of discovery,—yet the predominating types which characterize the flora of one system of formations, differ so essentially from those of another, that it may be reasonably inferred such apparent distinctions are the effect of organic

laws, and not illusions arising from our misinterpretation of the natural records of former conditions of the vegetable world.

The absence in the most ancient deposits of the entire class of Angiosperms, or flowering plants, which constitutes the leading features of the floras with which we are familiar,—the abundance of unknown types of Cryptogamia, and the extinction or disappearance of those tribes in the succeeding formations, and the prevalence of new species and genera belonging to another class;—the predominance in one flora, both in number and variety, of certain tribes, and their decadence in the next period; while a family subordinate in the antecedent epoch, and known but by a small number of species, suddenly acquires a pre-eminence both in numbers and variety;—are phenomena, which the facts brought before us in the course of this argument, present in a striking point of view.

Assuming these data as the basis of a philosophical generalization, M. Brongniart arranges the known species of fossil plants into three grand systems, which correspond with the great geological periods, comprehended in the palæozoic, secondary, and tertiary formations.

The first or most ancient flora is characterized by the predominance of *Cryptogamic Acrogens*—the *Ferns* and *Club-mosses*; the second by the large development of the *Dicotyledonous Gymnosperms*—the *Cycads* and *Conifers*: the third by the appearance and prevalence of the *Angiosperms*, both dicotyledonous and monocotyledonous. The following table presents a concise view of the results of M. Brongniart's investigation.[184]

[184] For details, and a masterly review of the subject, the original Memoir must be consulted. See Tableau des Genres de Végétaux Fossiles, considérés sur le point de vue de leur Classification Botanique et de leur Distribution Géologique, par M. Adolphe Brongniart. Paris, 1849.

CHARACTER OF THE FLORAS.		GEOLOGICAL EPOCHS.
I. RÈGNE DES ACROGÈNES; the Flora of Vascular Cryptogamia.	}	The *Devonian*, *Carboniferous*, and *Permian*, Formations.
II. RÈGNE DES GYMNOSPERMES; the Flora of Cycadaceæ and Coniferæ.	}	The *Triassic*, *Jurassic* (or *Lias* and *Oolite*), and *Wealden*, Formations.
III. RÈGNE DES ANGIOSPERMES. Flora of Dicotyledonous and Monocotyledonous flowering plants, or Angiosperms.	}	The *Cretaceous*, and *Tertiary* (*Eocene*, *Miocene*, and *Pliocene*), Formations.

It must be observed that this table is only designed to indicate the successive *predominance* of each of the three classes of the vegetable kingdom, in the respective epochs, and not the entire exclusion of the others. Thus, in the two first, both Acrogens and Gymnosperms existed; but in the first period the former greatly exceeded the latter, both in number and magnitude; while in the next the Gymnosperms acquired the ascendancy; but in both these epochs, from the Devonian to the Wealden inclusive, very few if any Angiosperms, or flowering dicotyledons, existed. With the Cretaceous period the Angiosperms appear in great numbers, and in the Tertiary epochs

acquire the importance they possess in the existing floras.

The following analysis of the flora of the Carboniferous epoch, by M. Brongniart, will exemplify these remarks.[185]

[185] See Wonders of Geology, vol. ii. pp. 726-733, for an account of the Carboniferous floras and deposits.

ANALYSIS OF THE CARBONIFEROUS FLORA

CRYPTOGAMIA (*Amphigens*).		Algæ	4	
		Champignons	6	
			——	6
	(*Acrogens*).	Ferns	250	
	Lycopodiaceæ (Club-mosses)		83	
		Equisetaceæ	13	
			——	346
DICOTYLEDONOUS GYMNOSPERMS.		Asterophyllites	44	
		Sigillariæ	60	
		Nœggerathiæ	12	
		Cycadeæ?	3	
		Coniferæ	16	
			——	135
Dicotyledonous Angiosperms				0
Monocotyledons? (very doubtful)				15
				——
				502
				——

Thus out of five hundred species, 352 are

Cryptogamia; and with the exception of six, belong to the Acrogens.[186]

[186] Bronn gives the annexed numerical summary of the fossil and recent species of plants:—

Plants. —	Cellular	188 Fossil.	9,100 Living.
	Vascular	1,867	60,303
		2,055	69,403 (80,000, Lindley.)

In conclusion, I must direct attention to a remarkable character of the palæozoic and secondary floras, namely, the almost entire absence of the *Gramineæ* or Grasses, which constitute so large a proportion of the existing vegetation.

Above six hundred species of plants have been discovered in the British strata;[187] and yet two species of *Poa* (a tribe of grasses), from Coalbrook Dale, are the only known examples of Gramineæ. It has been suggested that the greater or lesser durability of the foliage of certain vegetables, may have occasioned their presence or absence in the carboniferous deposits, and experiments were instituted by Dr. Lindley with the view of determining this question. But though it was found that, when the foliage of various families was subjected to long maceration, the leaves of dicotyledons and grasses disappeared, while those of ferns and cycads remained, this fact does not meet the exigencies of the case, for we have no evidence to show that the fossil leaves were ever placed in similar conditions; on the contrary, there is reason to

conclude that they were imbedded under circumstances that arrested the usual progress of decomposition, prevented the escape of the hydrogen and other gaseous elements, and gave rise to the bituminous fermentation by which they were converted into lignite and coal; and we have no proof that, had grasses been associated with the ferns, they would not have undergone a similar change. Moreover, there are countries in which the ferns now assume the numerical proportion of the grasses of other latitudes; for example. New Zealand, which also presents in its fauna a striking analogy to that of the carboniferous deposits, in the almost entire absence of indigenous mammalia; one species of Rat being the only known living quadruped.

[187] See Mr. Morris's Catalogue of British Fossils.

On this subject Dr. Dieffenbach remarks, that "although in its flora New Zealand has some relationship with the two large continents between which it is situated, America and Australia, and even possesses some species identical with those of Europe, without the Latter being referable to an introduction by Europeans, yet the greater number of species, and even genera, are peculiar to it. New Zealand, with the adjacent islands, Chatham, Auckland, and Macquarrie, forms a botanical centre. It is sufficiently distant from both continents to preserve its botanical peculiarities, and it offers the most striking instance of an acknowledged fact in all branches of natural history, viz. that the different regions of the globe are endowed with peculiar forms of animal and vegetable life. The number of species of plants at present known is 632, of which 314 are dicotyledonous, and the rest, or 318, are

monocotyledonous and cellular. The monocotyledons are few in comparison with the cellular plants, for there are but seventy-six species. The grasses have given way to ferns, for the ferns and fern-like plants are by far the most abundant in New Zealand, and cover immense districts. They *replace the Gramineæ* of other countries, and give a character to all the open land of the hills and plains. Some of the arborescent kinds grow to thirty feet and more in height, and the variety and elegance of their forms, from the minutest species to the most gigantic, are very remarkable."[188] In the accumulations of vegetable matter now in the progress of formation in the morasses, bays, and creeks of New Zealand, the remains of ferns largely predominate; and I am informed by my son,[189] that in the estuaries they are associated with numerous shells of brachiopodous mollusca.

[188] Dr. Dieffenbach's New Zealand.

[189] Mr. Walter Mantell, of Wellington, New Zealand.

ON COLLECTING BRITISH FOSSIL VEGETABLES.

ON COLLECTING FOSSIL VEGETABLES.

From what has been advanced, the student will perceive that to obtain an illustrative collection of the fossil plants of Great Britain, many different localities must be visited.

The fruits and stems of Palms, Conifers, and many dicotyledons, may be collected in the Isle of Sheppey,

and other places where the London Clay is exposed. (See *Excursion to the Isle of Sheppey*, Part IV.) Cycadeous stems and coniferous wood may be procured in the Isle of Portland; from the Wealden Cliffs along the southern shore of the Isle of Wight; and on the Sussex coast, from Bexhill, by St. Leonard's, to the east of Hastings. The foliage of several species of Zamiæ and ferns, occur abundantly in the lower Oolite, along the Yorkshire coast, near Scarborough, and at Gristhorpe Bay. The Lias of Lyme Regis, Charmouth, and their vicinity, affords stems and branches of coniferous trees, and leaves of cycads.

Ferns, Sigillariæ, Calamites, and the usual plants of the carboniferous flora, may be found in every coal-mine; and the Devonian limestones of the South of Ireland yield ferns and Lepidodendra. In Forfarshire the lower Devonian shales abound in the foliage of aquatic, apparently fluviatile, plants.[190]

[190] See Memoir on the TELERPETON; Geol. Journ. vol. viii. p. 106.

A list of some of the most productive British localities is subjoined.

In addition to the suggestions already given as to the mode of collecting specimens, it may be necessary to state that the leaves in the tertiary marls and clays are generally very delicate and friable, and liable to flake off in the state of a carbonaceous film. This may, in a great measure, be prevented by carefully covering them with a thin coating either of mastic varnish, or gum-water, before they are placed in the cabinet. In extracting these specimens, a broad chisel will be found the most convenient instrument. In searching for fossils in coal-mines, the collector

should remember that the ironstone nodules often contain beautiful examples of the leaves of ferns, and fruits of Lepidodendra. These nodules, when of an oblong shape, should be split open in a longitudinal direction, by a smart blow of a hammer, and the inclosed leaf will thus be exposed, as shown in *Lign.* 3, *figs.* 2, 3, *ante*, p. 69.

BRITISH LOCALITIES OF FOSSIL VEGETABLES.

Allenbank, Berwickshire	*Carb.*	Stems of Conifers, &c.
Alum Bay, Isle of Wight	*Tert.*	Fruit, dicotyledonous leaves, lignite; Charge, stems and seed-vessels.
Ashby-de-la-Zouch, Leicestershire	*Carb.*	Coal plants in great abundance.
Bignor, Sussex	*Cret. Firestone*	Fucoids.
Binstead Quarries, near Ryde, Isle of Wight	*Tert.*	Charæ, stems and seed-vessels.
Blackdown, Devonshire	*Gr. Sand.*	Silicified wood—coniferous.
Bognor, Sussex	*Tert.*	Coniferous and monocotyledonous wood; washed up on the shore.
Bolton, Lancashire	*Carb.*	Lepidodendra, Sigillariæ, &c.

Bournemouth, Hants	*Tert.*	Dicotyledonous leaves. [191]
Brook-point, Isle of Wight	*Wealden*	Cycads, and coniferous wood.
Burdie House, near Edinburgh	*Carb.*	Ferns, wood, &c.
Calbourn, Isle of Wight	*Tert.*	Charæ, stems and fruits.
Camerton, near Bath	*Carb.*	Usual plants of the coal.
Charmouth, Dorset	*Oolite*	Coniferous wood; Cycads; fruit of Pandanus.
Clifton, near Manchester	*Carb.*	Coal plants in great perfection.
Coalbrook Dale, Shropshire	*Carb.*	Usual plants of the coal, in abundance. The ironstone nodules are rich in fern-leaves, fruits of lepidodendrons, &c.
Cuckfield, Sussex	*Wealden*	Clathraria, Endogenites, Ferns, and Lignite.
Durlstone Bay, near Swanage	*Wealden*	Charæ; Gyrogonites in abundance.
Folkstone, Kent	*Galt*	Coniferous wood—bituminous, and pyritified.
Glasgow	*Carb.*	Coal plants, and large trunks of Coniferæ.
Hastings, Sussex	*Wealden*	Clathrariæ, Cycads, Endogenites, Ferns, Thuites, &c.
Herne Bay, Kent	*London Clay*	Fruits of Conifers, and Palms: wood.

Kilkenny, Ireland	*Carb.*	Calamites, ferns, &c.
Knocktopher, nr. Kilkenny, Ireland	*Devonian*	Ferns, Lepidodendrons, &c.
Leeds	*Carb.*	Beautiful coal-plants from the pits in the vicinity.
Liverpool	*New Red*	Fuci.
Lyme Regis, Dorset	*Lias*	Cycads; Conifers; wood.
Maidstone, Kent	*Greensand*	Fruits and wood of Abies, Pinus, Dracæna; Fuci.
Malton	*Oolite*	Fruits, and Cycads.
Newcastle (Jarrow Colliery)	*Carb.*	Coal plants in great variety.[192]
Newhaven (Castle Hill), Sussex	*Tert.*	Dicotyledonous leaves and fruit—*rarely*.
Portishead (on the shore)	*Millstone Grit*	Sigillariæ, Stigmariæ, &c.
Portland, Isle of	*Wealden*	Petrified forest of Conifers, with Cycads.
Pounceford, Sussex	*Wealden*	Equiseta, Ferns, Lignite.
Runswick, Yorkshire Coast	*Lower Oolite*	Cycads, Ferns, &c.
Saltwick, near Whitby	*Lower Oolite*	Foliage of Cycads, Ferns, &c.
Sandown Bay, Isle of Wight	*Wealden*	Conifers, Cycads, wood.
Scarborough	*Oolite*	Ferns, Cycads, Equiseta, &c.

Selmeston, Sussex	*Greensand*	Coniferous wood.
Sheppey, Isle of	*London Clay*	Fruits innumerable, wood, &c. (*ante*, p. 186.)
Stonesfield, Oxfordshire	*Oolite*	Fuci, Cycads, Thuites, &c.
Swindon, Wilts	*Oolite*	Coniferous wood, & Cycads.
Tunbridge Wells (vicinity)	*Wealden*	Ferns, several species.
Ventnor, Isle of Wight	*Firestone*	Clathraria, Conifers.
Wareham, Dorset	*Tert.*	Dicotyledonous foliage, and Palm-leaves.
Whitecliff Bay, I. of Wight	*Tert.*	Palm-leaves, Charæ, &c.
Whitwick, Leicestershire	*Carb.*	The usual coal-plants.

[191] Fruits and Fern-leaves have been collected here by Mr. Beckles and stems of a species of *Arundo*, by Mr. Alfred Woodhouse.

[192] In collecting *Stigmariæ*, the student should particularly attend to the relation existing between these fossils and their supposed stems; for it is probable that roots of this type will be found to belong to other genera, besides Sigillaria, and Lepidodendron (*ante*, p. 136.).

The above list must, of course, be considered as merely suggestive: many other localities are mentioned in the previous notices of the fossil genera.

PART III.

FOSSIL ZOOLOGY.

"THE very ground on which we tread, and the mountains that surround us, are vast tumuli in which the Organic Remains of a Former World are enshrined."—PARKINSON.

THE existing species of animals scientifically determined by naturalists amount to upwards of one hundred thousand, while those known in a fossil state scarcely exceed twenty-five thousand; yet the latter comprise examples of all the classes, and most of the families and genera, which still inhabit our planet. Although our notice of these remains must necessarily be very general, we shall endeavour to describe all that are of peculiar interest, either in a geological or zoological point of view; or which from their prevalence, or wide distribution, will frequently be met with by the collector in the course of his researches.

Our examination will commence with animal organisms of the simplest structure, and proceed in an ascending order, in accordance with the usual zoological classifications; but, as in the botanical department, it will be convenient occasionally to include the consideration of the fossil remains of more than one family in the same section, when

associated in a particular locality or deposit.

In the preliminary remarks on the nature of Organic Remains (*ante*, p. 43.), the various conditions in which the durable structures of animals are preserved in the mineral kingdom, were fully explained; we may therefore at once enter upon the investigation of this most important division of our subject; that to which the term *Palæontology*, is, indeed, restricted by some authors.

The fossil remains of the animal kingdom will be treated of under the following heads:—

I. ZOOPHYTES: including—
   1. PORIFERA, or AMORPHOZOA: the most simple animal structures; as the *Sponges*.
   2. POLYPIFERA, or POLYPIARIA; *Coral-animals*.
   3. BRYOZOA, or *Molluscan Zoophytes*; as the *Flustræ*.

II. ECHINODERMATA, or ECHINODERMS; Comprising—
   1. CRINOIDEA; or Lily-shaped animals.
   2. ASTERIADÆ; *Star-fishes*.
   3. ECHINIDÆ; *Sea-urchins*.

III. MOLLUSCA, or MOLLUSKS. Under this head not only the fossil shells of testaceous mollusca, but also those of a lower order of animals, the *Rhizopodes*, or *Foraminifera*, will be treated of.
   1. FORAMINIFERA.
   2. BIVALVES: the LAMELLIBRANCHIA, and BRACHIOPODA.
   3. UNIVALVES: the GASTEROPODA and PTEROPODA.

4. CEPHALOPODA; those with chambered shells, as the *Nautilus* and *Ammonite*; and the naked tribes, the SEPIADÆ, or *Cuttle-fish*.

IV. ARTICULATA. (Animals protected by a hard jointed envelope or case.)
1. CIRRIPEDIA: as the *Balanus*, or Barnacle.
2. ANNELIDA: red-blooded worms, as the *Serpulidæ*.
3. INSECTA, and ARACHNIDA or *Spiders*.
4. CRUSTACEA; including *Crabs*, *Lobsters*, *Trilobites*, &c.

V. PISCES; or FISHES.

VI. REPTILIA; or REPTILES.

VII. AVES; or BIRDS.

VIII. MAMMALIA.

IX. MAN.

CHAPTER VII.

FOSSIL ZOOPHYTES.—PORIFERA OR AMORPHOZOA—POLYPIFERA OR CORALS—BRYOZOA OR MOLLUSCAN ZOOPHYTES.

Many tribes of the extraordinary beings whose mineralized relics are the immediate subject of our investigation, have largely contributed to the solid materials of which the sedimentary strata are composed. In the most ancient rocks in which vestiges of organic structures have been detected, those of *Zoophytes* hold a conspicuous place; and in

the seas of tropical climates, the agency of the Coral-animalcules, or Polypifera, is producing enormous deposits, and laying the foundations of new islands and continents, and forming reefs of rocks hundreds of miles in extent, which, if elevated above the level of the sea, would rival in magnitude the mountain-chains of modern Europe.

The reader unacquainted with the natural history of these marvellous creatures will find an account of their nature and economy, and of the physical effects produced on the earth's surface by their agency, in the sixth lecture of *Wond.* vol. ii. p. 588.

The term Zoophytes, or animal-plants, comprises two very distinct classes of living beings, namely, the PORIFERA, or Sponges, which (if not vegetables) are wanting in many attributes regarded as essential characteristics of the members of the animal kingdom; and the POLYPIFERA, or polype-bearing-animals,—the Corals; which are generally associated groups or aggregations of individuals, united by a common organized mass or axis, each polype having an independent existence, and exhibiting volition and perception, in a greater or lesser degree.

Fossil Porifera.

FOSSIL PORIFERA.

The terms *Amorphozoa* (signifying animals of variable shapes), and *Porifera* (structures traversed by pores or channels), are employed by naturalists to designate the Sponges and analogous organisms, which appear to occupy the boundary line that separates the animal from the vegetable kingdom. The true position of the Sponges in the great system of Creation is still a disputed point; for while many

distinguished naturalists regard them as *Protozoa*, or the lowest type of animal organization, others of equal eminence affirm that neither in structure nor functions do they differ from vegetables in any essential particular; and that if a line be drawn between the two kingdoms the Porifera must be placed on the vegetable side of the boundary. On the other hand, Dr. George Johnston, in his delightful work on the British Zoophytes,[193] expresses his opinion that there is nothing to discountenance the belief that these bodies hold an intermediate place; that they are, in fact, the true *Zoophytes*, or animal-plants; in some forms, as the green *Spongillæ* of our lakes, the vegetable nature prevails; while in others, as the horny or keratose sponges filled with mucilaginous slime, and the fleshy *Tethya* whose oscula, or pores, are said to exhibit signs of irritability, the animal character predominates.

[193] A History of British Sponges, &c. by Dr. George Johnston, Edinburgh. 1843. One vol. 8vo. with twenty-five plates. A previous work, "A History of British Zoophytes," with forty-four plates, from drawings by the accomplished lady of the Author, cannot be too highly commended.

Without committing ourselves to either opinion, and simply remarking that the large proportion of silex that enters into the tissues of a considerable number of the porifera, is more characteristic of vegetable than of animal structures, we proceed to consider the fossil sponges and allied forms, as the mineralized remains of the lowest types of the animal kingdom: if the vegetable nature of the originals were generally admitted, this section should have followed that which treats of the Diatomaceæ (*ante*, p. 100.).

Sponge consists of a reticulated fibrous mass, covered with numerous pores of various sizes, which are connected internally by anastomosing channels, and this tissue is surrounded by a cellular gelatinous matter, by which the entire structure was secreted, and is, in fact, the vital part of the zoophyte. The tough framework or skeleton is in some kinds fibrous, horny, flexible, or rigid, and strengthened by calcareous or siliceous spicula (*spines*);[194] while in other species its substance is calcareous, and in some siliceous, constituting a web of transparent rock crystal, resembling spun glass,[195] The gelatinous matter lines all the cavities, and forms the margins of the openings; it presents no signs of irritability, and may be easily pressed out of the porous mass with the hand, so slight is the connexion between the skeleton and the investing tissue. Currents of water constantly enter the small pores, traverse the inosculating canals, and issue from the larger orifices, which often project above the surface in perforated papillæ. By the circulation of the water through the porous structure, the nutrition of the organized mass is effected; and the modifications observable in the number, size, form, and disposition of the pores, channels, and orifices, in different species, appear to be subservient to this especial purpose; the imbibition and expulsion of water being the only function the sponges perform. In its earliest stage the sponge gemmule is of a spheroidal shape, and covered with vibratile cilia, and after expulsion from the canals in which it is formed, moves rapidly through the water till it becomes attached to some body, and is then immovably fixed during life; exhibiting no signs of vitality save the aqueous circulation through the pores and canals.

[194] The Mediterranean and American sponges of commerce are devoid of spicules, and are deprived of their soft animal matter simply by washing freely in fresh water.

[195] I particularly allude to a siliceous Sponge from Barbadoes, named, by Mr. Samuel Stutchbury, formerly of the Bristol Institution, (now of Australia.) *Dictyochalix pumicea*. This specimen is of a fungiform shape, and appears to the naked eye as if formed of pumice stone, but under the microscope is literally a tissue of transparent silex.

There is much confusion in the arrangement and nomenclature of the fossil species of this class of zoophytes; and this has originated, in part, from the varied forms assumed by the same species, having been described under different names; and from the reprehensible practice of changing, without sufficient reason, the name assigned to a species by the original discoverer; an evil, unfortunately, not restricted to this department of natural history.

The recent Sponges are arranged in four groups according to their structure, viz.—

Fresh-water Sponges.

SPONGILLA: siliceous spicula in a translucent jelly-like mass.

Marine Sponges.

TETHEA: having a tough outer skin; siliceous spicula in bundles, and radiating from the compact nucleus to the periphery.

HALICHONDRIA: (from *silex* and *cartilago*) siliceous spicula in a cartilaginous mass.

GRANTIA: calcareous spicula in a gelatinous mass.

FOSSIL SPONGES.

M. D'Orbigny seems to believe that with the exception of the horny *Cliona*, all the fossil sponges had originally calcareous skeletons,—"qu'ils n'ont jamais été cornés, mais que leur tissu a toujours été calcaire et pierreuse;"[196] which is certainly not the case, for abundant examples of fossil keratose sponges occur.

[196] Cours Elémentaire de Paléontologie, torn. ii. p. 208.

I have selected a few genera for the illustration of the subject, and shall describe them under the names that are most familiar to the British scientific collector: doubtless sooner or later some competent naturalist will undertake the elucidation of this department of palæontology, and construct a classification and nomenclature based on natural characters; till then the student will find it hopeless to attempt to learn the ever-varying names of genera and species applied to fossil Porifera and Polypifera, by different observers.[197]

[197] It has happened most unfortunately, that but recently Mr. Lonsdale, in the late Mr. Dixon's beautiful work on Chalk and Tertiary Fossils, and Mr. Milne Edwards in his able Monograph in the Palæontological Society's Memoirs, have described many of our chalk Corals under different specific and generic names.

SPONGITES IN CHALK AND FLINT.

ON THE SPONGES IN CHALK AND FLINT.—From

the durability of the tissue of the flexible sponges, and the imperishable nature of those which have a siliceous or calcareous endo-skeleton or framework, their fossil remains generally occur in a fine state of preservation, and in immense quantities, in the sediments that were deposited in those parts of the ancient sea-bottoms, originally inhabited by these zoophytes. Even the relics of the keratose species, the *Halichondria*, whose structure consists of siliceous spines imbedded in a cartilaginous mass, are equally abundant. Sponge-spicula are everywhere met with in the chalk, flint, and greensand, and many layers in the cretaceous strata are almost entirely composed of them.

Sponges so commonly form the nuclei of the nodular flints, that some naturalists have ascribed the formation of the layers and nodules of silex in the cretaceous rocks to these zoophytes: a supposition altogether groundless,[198] The various states of mineralization in which sponges occur in the chalk give rise to many beautiful and highly instructive fossils, as we shall point out in the course of this notice. In general the zoophyte is simply invested by the flint, the pores and tubes being filled with silex, the original tissue appearing as a brown reticulated calcareous mass. In other examples the sponge has been permeated by the liquid flint, and subsequently perished; and in this manner have been formed those hollow nodules which on being broken are found to contain only a powder, consisting of siliceous spicules and fragments of silicified sponge. But in numerous instances the substance of the zoophyte is completely silicified, and the intimate structure of the original exquisitely preserved; such are many of the flint-pebbles, and moss-agates, that are mounted as brooches and other ornaments.

[198] See Wonders of Geology, p. 300. This question is fully considered in a Memoir entitled Notes of a Microscopical Examination of the Chalk and Flint of the South-East of England, &c. by the Author, in 1845.

SPONGITES.[199]—This name I would apply generically to those fossils which appear to be identical in structure with the ordinary marine sponges that consist of a fibro-reticulated porous mass, destitute of regular tubes or canals: the form exceedingly various.

[199] *Achilleum* of Schweigger.

The fossil sponges of the chalk may be divided into two groups; the cyathiforms, or cup-shaped, and the ramose, or branched. Flints inclosing the first kind, generally exhibit externally the form of the original; those containing the branched species are of irregular shapes, and except by an experienced observer, the nature of the enclosed body would not be suspected. On breaking them, the sponge is often well displayed, as in the specimen figured in *Lign.* 69, *fig.* 2: the surface of this fossil was covered with a white gritty powder, made up of minute needle-shaped siliceous spicula.

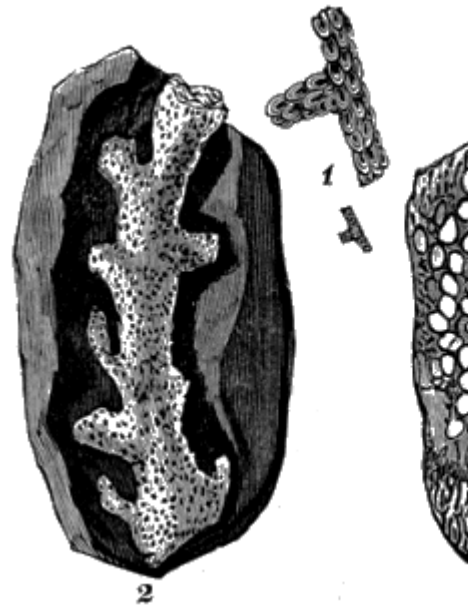
SPONGITES IN FLINTS.

SPONGITES RAMOSUS.—A branched sponge, sometimes from twelve to fifteen inches long, is not uncommon in the flints of the Lewes and Brighton chalk; the stems and branches are cylindrical, and the terminations of the latter are rounded and full of large pores. When completely silicified the structure can only be detected by fracture, but occasionally the sponge appears to have been saturated with liquid chalk before it was enveloped in the flint; and as it is

coated with calcareous matter, it may be detached from the nodule entire.[200]

[200] In this manner I obtained the beautiful specimen (now in the British Museum) figured in my Foss. South Downs, tab, xv. fig. 11. A branch of this species is represented Pict. Atlas, pl. xxxix. fig. 12.

Spongites lobatus (sp. Fleming) is figured Pict. Atlas, pl. xxxix. fig. 6.



LIGN. 69. CORAL, AND SPON
Chalk. Sussex.

Fig. 1.— PETALOPORA PULCHELLA. Upper figure × ×: lower figure, *na*
Chalk near Chichester. (*Mr. Walter Mantell.*)

2.— SPONGITES CLAVELLATUS. a branch in the cavity of a flint.
South Downs.

3.— SIPHONIA MORRISIANA. (G. A. M.) A transverse polished secti

A smaller ramose spongite, with numerous short

clavate protuberances, is often met with in the flints of Sussex and Wilts; a branch is figured in *Lign. 69, fig. 2*.[201]

[201] This spongite is named Polypothecia clavellata, in Miss Benett's Wiltshire Fossils.

SPONGITES TOWNSENDI. (*Pict. Atlas*, pl. xli.)—The cyathiform flints, whose shape depends on the inclosed zoophytes, so much resemble the cup-shaped sponges of commerce, as to be easily recognized in the heaps of nodules that are collected in chalk districts for the roads; they are from one to eight inches in diameter at the upper part, and many are of a globular or spheroidal shape; the surface has the usual calcareo-siliceous coating of flint nodules, giving a sensation of roughness to the touch; the margin of the cup generally exhibits a narrow band of porous structure, and when broken, sections of the enclosed body are exposed. These funnel-shaped spongites terminate at the bottom in a peduncle, whence fibrous root-like processes diverge; by these appendages the original was fixed to the rock. I have collected a few specimens in which the roots are attached to a shell, or pebble, but have never seen any that appeared to occupy the spot on which they grew. They seem to have been detached from their native sites by the waves, and transported to a distance, and subsiding into the tranquil depths of the ocean, became imbedded in the cretaceous sediments that were accumulating at the bottom.

SPONGITES (?) LABYRINTHICUS.[202] *Lign. 80, fig. 5.*—Another abundant species of amorphozoa has given rise to sub-hemispherical flints, rounded below and flat above, with a marginal band of porous tissue, that expands into flexuous lobes which fill up

the area of the upper surface. When found imbedded in the chalk, the form of this zoophyte is often preserved entire; the upper part showing the lobated and flexuous character of the original. Upon breaking these flints, the organic structure is generally apparent; but in many instances has perished, and left a cavity which is either partially filled with stalactitical chalcedony, or lined with quartz crystals. These fossils vary in size from a walnut to that of an orange; the pedicle has long processes.

[202] Foss, S. D. tab. xv. *fig.* 7.

A lobed zoophyte, resembling the above in its general form, and long rootlets, is distinguished by a large central cavity, which is continued above the body in the form of a cylinder.[203]

[203] Beautiful figures of these and other chalk zoophytes are given by Mr. Toulmin Smith in his elegant memoir "On the Ventriculidæ." The specimens above described are named *Bracholites* by Mr. Smith. The plan of the present work forbids the discussion of that author's opinions and inferences.

SPONGITES (?) FLEXUOSUS. *Lign. 80, fig. 10.*—Among the cyathiform flints that abound in the chalk, a very elegant species is distinguished by a flexuous band that runs round the margin, and indicates the lobed structure of the original.

In the chalk of Flamborough Head, Yorkshire, many beautiful cyathiform sponges are preserved, in which the outer surface is thickly covered with projecting hollow papillæ; these fossils are generally silicified, the surface and pores being frosted over with minute quartz crystals. The museum of the York

Institution contains a splendid series of these spongites.[204]

[204] The silicified state of these zoophytes was first detected by Mr. Charlesworth, who by immersing specimens in dilate hydrochloric acid, obtained admirable examples of the delicate structure of the original.

FOSSIL ZOOPHYTES OF FARINGDON.

FOSSIL ZOOPHYTES OF FARINGDON. *Lign.* 70, 71, 72.—The richest locality for fossil sponges in England is in the immediate neighbourhood of the little town of Faringdon, in Berkshire.[205] The Greensand beds that overlie the Oolite in that district, consist of a coarse friable aggregation of sand, comminuted shells, corals, amorphozoa, and echinoderms, more or less consolidated by a ferruginous cement. The gravel-pits, as the quarries are locally termed, expose what evidently were banks of detritus thrown up on the strand of a sea-margin; among the water-worn and fragmentary relics of oolitic as well as cretaceous forms, many perfect sponges of various kinds may be collected in the course of a few hours. Figures of some of the common species are subjoined.

[205] See Excursions, in vol. ii.



LIGN. 70. FOSSIL ZOOPHY

Fig. 1. LUNULITES RADIATUS. *Preston Chalk-pits*; view of the convex si
— 1^a.—Front view; *nat.*
1^b.—Portion of the surface of fig. 1, magnified.

2. SCYPHIA INTERMEDIA; $^1/_2$ *nat. Faringdon.*
—

3. LITHODODENDRON SOCIALE: the left-hand branch shows a vert
— internal structure; $^1/_2$ *nat. Mountain Limestone, Yorkshire.*

4. VERTICILLIPORA ANASTOMOSANS. *Faringdon.*
—

5. SCYPHIA RAMOSA; $^1/_2$ *nat. Faringdon.*
—

6. SCYPHIA FORAMINOSA; $^{1}/_{2}$ *nat. Faringdon.*
—

7. CNEMIDIUM ASTROPHORUM; $^{1}/_{3}$ *nat. Faringdon.*
—

SCYPHIA. *Lign.* 70, 72.—These spongites are of a tubular, fistulous, or cylindrical form, and terminate in a rounded pit; they are either simple or branched, and composed of a firm reticulated tissue; *Lign. 70, fig. 2, 5, 6*, and *Lign. 72, fig. 4*, are examples. The Upper Greensand at Folkstone and Dover abounds in a flexuous species, named Scyphia meandrina (*Morris*).

CNEMIDIUM (*Goldfuss*). *Lign. 70, fig. 7.*—These sponges consist of a cluster of turbinated projections, having a central pit above, and being porous on the external surface, and radiated at the margin. The mass is dense and fibrous, and is traversed by horizontal canals, diverging from the centre to the circumference.



LIGN. 71. FOSSIL SPONGE; *nat.*
(*Chenendopora fungiformis.*)
Greensand. Faringdon.

CHENENDOPORA.[206] *Lign. 71.*—The species of porifera thus named are cyathiform, or cup-shaped; externally furrowed, mamillated, or lobed; internally smooth, and the surface covered with fine pores. The beautiful species figured (*C. fungiformis*) is abundant in the gravel-pits, and well known to the quarrymen as "petrified salt-cellars."

[206] The Pictorial Atlas contains coloured figures of the following:—

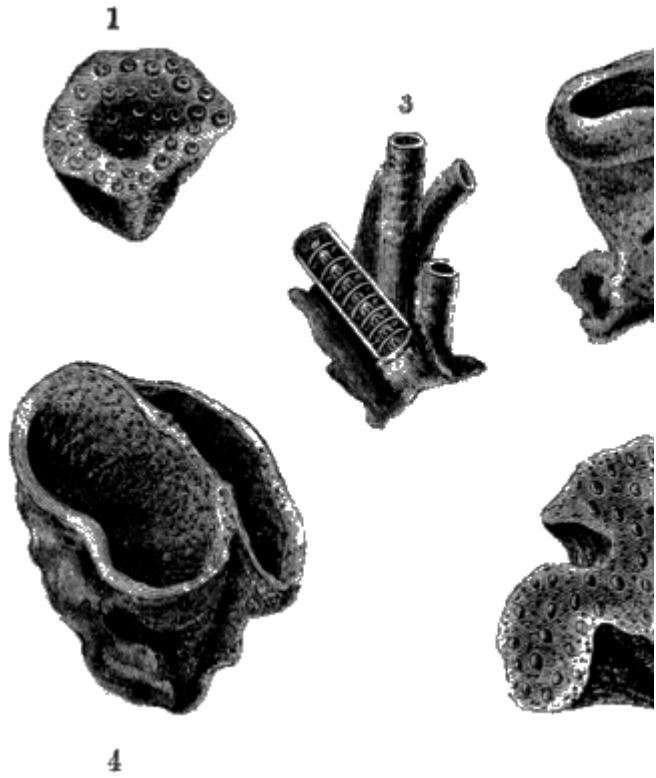
Chenendopora fungiformis (*Michelin*), Pict. Atlas, pl. xliv. *fig.* 5: according to Mr, Morris.

———————— subplana (*Michelin*), ibid, pl. xliv, *fig.* 3.

Scyphia articulata (*Goldfuss*), ibid, pl. xliii. figs. 7, 8, 9.

————- costata (*Goldfuss*), ibid. pl. xliv, fig, 1.

Cnemidium rimulosum (*Goldfuss*), ibid, pl. xliv. *fig.* 3.



LIGN. 72. FOSSIL ZOOPHYTES; *nat. Greensand. Faringdon.*

Fig. 1.— TRAGOS PEZIZA.
2.— Probably CHENENDOPORA in a young state.
3.— VERTICILLIPORA ANASTOMOSANS.
4.— Species of SCYPHIA.
5.— TRAGOS FARINGDONIENSIS.

TRAGOS. *Lign.* 72, *fig.* 1.—These turbinated sponges are readily distinguished from the preceding, by the relatively large oscula, or open papillæ, disposed irregularly on the inner surface; as shown in the specimen, *fig.* 1. Their tissue is dense and fibrous.

The fossil represented by *fig.* 5, though named Tragos by collectors, appears to differ in the structure of the inner surface from the type of this genus: it is a remarkably beautiful species.[207]

[207] It may be convenient to distinguish it as *T. Faringdoniensis*.

The base in all these Greensand sponges is flat and expanded; not fibrous and root-like, as in the spongites of the chalk previously described.

Among the shingle at Brighton, Margate, Dover, Isle of Wight, &c. pebbles containing fossil sponges may frequently be discovered. When the flint nodule has been broken, and the calcareous particles of the inclosed zoophytes are washed away by the action of the waves, a delicate silicified tissue remains.[208] Many of the large solid pebbles, are portions of silicified sponges, and polished specimens are beautiful objects under the microscope.

[208] The pebbles represented in Pict. Atlas, pl. xlv. fig. 5, 12, are specimens of this kind.

SIPHONIA.

SIPHONIA. *Lign.* 73.—These fossil porifera are readily distinguished from those which have engaged our attention by their more symmetrical structure. The body of the zoophyte is a mass of dense porous tissue, of a pyriform or bulbous shape, supported by a slender stem fixed at the base by rootlets. The stem is composed of very fine parallel longitudinal tubes, which extend to a series of canals that traverse the mass, and terminate in openings on the surface of a shallow central cavity, as shown in the section, *fig. 2, Lign. 73*. The characters of this genus are well

exemplified in a common species of the Greensand (*S. pyriformis*, *Lign. 73*), described by the late Mr. Webster, from specimens collected in the Isle of Wight, where it occurs in profusion, near Ventnor, and the Western lines. This zoophyte is pyriform, (*Lign. 73, fig. 1*,) and has a shallow cylindrical cavity, supported upon a long slender stem, the base of which is fixed by root-like processes (*fig. 5*); the transverse fracture shows a section of the longitudinal tubes. This species has been found in numerous localities of the Greensand, and also in the Firestone or malm-rock.[209]

[209] Dr. Fitton's figures, Geol. Trans. vol. ii. pl. xv. *a*, are very beautiful and accurate.

The Portland limestone contains numerous remains of a Siphonia closely resembling this species; and varied sections of its stems produce the white markings commonly observable on the slabs of pavements.



LIGN. 73. SIPHONIÆ, FROM THE GREENSAND; *n*
Wilts, and Isle of Wight.

Fig. 1. SIPHONIA PYRIFORMIS; the body or upper part.

2. Vertical section of the same, showing the internal structure, a

3. Specimen of S. PYRIFORMIS in a young state.

4. SIPHONIA (*Polypothecia*, of Miss Benett,) LOBATA; Firestone or Warminster.

5. The lower part of the stem, and radicles, of S. pyriformis.

A group of Sponges from the Upper Greensand, near Warminster, figured and described by the late Miss Etheldred Benett,[210] under the name of Polypothecia, comprises several forms that are allied in structure to the Siphoniæ. These fossils present considerable diversity of shape; one of the lobed forms is delineated in *Lign. 73, fig. 4*: and a branched species in *Lign. 74*. Upon breaking the stem of one of these zoophytes transversely, sections of parallel longitudinal tubes like those in the Siphoniæ are exhibited.

[210] An elegant Memoir on the Wiltshire Fossils, by this accomplished lady, is published in Sir R. C. Hoare's "Wiltshire."



LIGN. 74.
POLYPOTHECIA DICHOTOMA.
Upper Greensand, Warminster, Wilts.

The Kentish rag contains irregular ramose spongeous bodies, which belong to this group of porifera; and Mr. Bensted has discovered in his quarry, near Maidstone, numerous remains of a polymorphous lobed zoophyte, having a porous structure beset with spicula. In the Firestone of Southbourne, Steyning, and Bignor, in Sussex, I have observed large pyriform and subcylindrical Siphoniæ.

The organization of all these zoophytes was evidently adapted for the imbibition and circulation

of sea-water, in a more perfect and definite manner than in the irregular simple sponges.

Flint-pebbles inclosing remains of Siphoniæ abound on the Sussex coast, especially in the shingle near Brighton, having been washed out of the chalk cliffs. There were several chalk-pits in Edward-street, (now, I believe, filled up and the area built upon,) in which every flint enveloped a sponge or siphonia; many specimens were mineralized by pyrites and beautifully exhibited the internal structure of the originals.

SIPHONIA MORRISIANA. *Lign. 69. fig. 3.*—A polished slice of a pebble from Brighton, whose markings are derived from the transverse section of an undescribed zoophyte is figured, *ante*, p. 224.: though scarcely more than half the diameter of the original is preserved, yet its structure is well shown; the centre is occupied by numerous parallel openings, the sections of longitudinal tubes, and is surrounded by a broad zone of spongeous tissue.

I have seen many examples of this beautiful fossil, set for brooches in the jewellers' shops in the Isle of Wight, and at Brighton.[211]

> [211] The specific name is in honour of John Morris, Esq. F.G.S. the author of the "Catalogue of British Fossils," whose important services to Palæontology and Geology it is gratifying thus to acknowledge.
>
> There are coloured figures of Siphonite in Pictorial Atlas, pl. xxxix. *fig.* 9; pl. xlii. *fig.* 3, 4, 5, 7, 12, and 13; pl. xliii. *fig.* 6.

Siphoniæ (chiefly *S. pyriformis*) are abundant in the Upper Greensand, near Farnham in Surrey, but

their tissues are saturated with phosphate of lime, instead of silica as is ordinarily the case; the entire sponge usually contains between 50 and 60 per cent, of phosphate: hence these fossils have, of late, been in great request for manure.[212]

[212] Mr. Payne, of Farnham, a distinguished agriculturist, has largely made use of them, both in the natural state and treated with sulphuric acid. The Firestone strata on St. Catherine's Hill, Isle of Wight, have been dug for a like purpose. See an "Account of the Phosphate Diggings," in my Isle of Wight, Second Edition, p. 448.

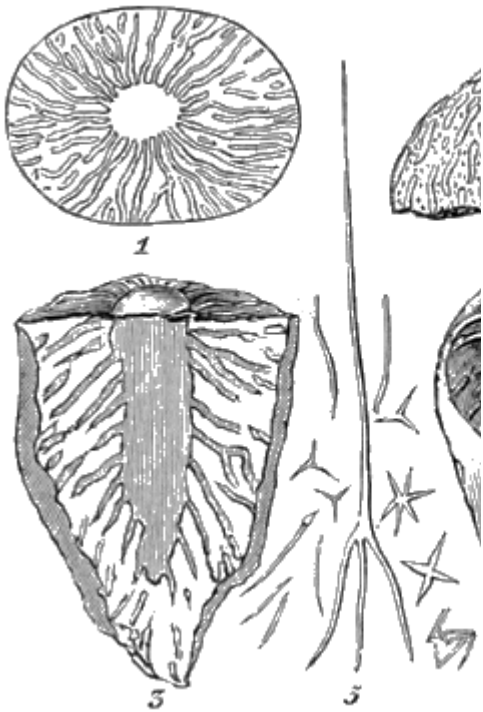
CHOANITES KÖNIGI.

CHOANITES KÖNIGI, *Lign. 75.*—The zoophyte which has given rise to the fossils I have distinguished by the name of Choanites,[213] is of a spheroidal or sub-ovate form, and appears to have been composed of a softer tissue than the ordinary sponges. It has a central cavity, and was fixed at the base by long rootlets: its mass is traversed by numerous tubes or channels, which open on the inner surface of the cavity; it differs from Siphonia in not having a stem composed of bundles of tubes, and probably also in its constituent substance. Among the Sussex and Wiltshire chalk-flints specimens of this zoophyte are very common; they are easily recognized by the peculiar markings produced by the silicified tubes that radiate from the centre, as seen in *Lign. 75, fig. 4*. The semi-diaphanous pebbles on the Sussex coast, more frequently contain Choanites than any other zoophytes. From the beautiful and varied markings observable in the polished sections, they are in great request for brooches, and are termed *petrified sea-animal flowers*[214] by the

lapidaries; among the shingle on the sea-shore at Bognor, Worthing, and other places, very fine examples may be collected.

[213] Foss. S. D. p. 178.

[214] From the supposition that the original was an *Actinia*, or *Sea-Anemone*. A coloured vertical section of a pebble of this kind is figured in my "Thoughts on a Pebble," Eighth Edition, pl. ii. See coloured figures of Choanites in Pict. Atlas, pl. xlii. *fig.* 1, 9, and 10; pl. xliv. *fig.* 8; and pl. xlv. *fig.* 10.



LIGN. 75. CHOANITES KÖNIGI. (
Chalk, Lewes.

Fig. 1. Transverse section of a siliceous specimen.
—
2. Upper portion of a *Choanite*, in chalk, showing the opening of t
—
3. Vertical section of a Choanite, in flint, exposing a section of th
— central cavity, through the substance.
4. Choanite in flint; the usual appearance of these fossils.
—
5. Various kinds of SPICULA of fossil sponges; *magnified*.
—

Lign. 75, fig. 4, represents the usual appearance of a flint deriving its form from a Choanite; *fig. 2*, is the upper part of a Choanite preserved in chalk, and richly coloured by iron; the opening at the summit, *a*, is the orifice of the central cylindrical cavity, which is in this instance filled up by chalk, but in flint specimens, with silex of a different colour to that of the surrounding mass. If *fig. 2*, were placed on the top of *fig. 4*, the general shape of the original zoophyte would be represented. The opening at the base of *fig. 4*, marks the spot whence the processes of attachment proceeded. The vertical section of a flint, similar to *fig.* 4, is shown at *fig. 3*; and in this example are seen the central cavity, and a section of the substance of the zoophyte, which is traversed by numerous tubes, that ramify through the mass of which the body was composed, and terminate in openings on the inner wall of the central cavity, or sac. A transverse section of a similar flint is delineated in *fig. 1*; the central white spot indicates the sac filled with flint, and the tubes are seen radiating from it through the mass; under a powerful lens the interstitial structure appears to be granular rather than porous. The perfect transparency of the body when silicified, and the rich tints it has acquired from metallic solutions, and the compressed

state in which it is often found, seem to indicate that the original mass was a soft gelatinous substance, like that of the *Actinia*, strengthened by spicula; for numerous tri-radiate spines, like those on the left-hand of *fig. 5, Lign. 75*, occur occasionally in chalk specimens.

In many Choanites, which differ in no other respect from the present species, vertical sections show on each side the central cavity, large oval spots, that are sections of a canal which traverses the entire mass, proceeding from the base to the summit, in a spiral coil around the central cavity. This structure was first detected by Mr. Cunnington. Mr. Woodward thinks this spiral tube is common to all the Choanites, and constitutes a generic character; but so many examples have passed under my examination in which no traces of such a canal are perceptible, that it may be a specific difference.

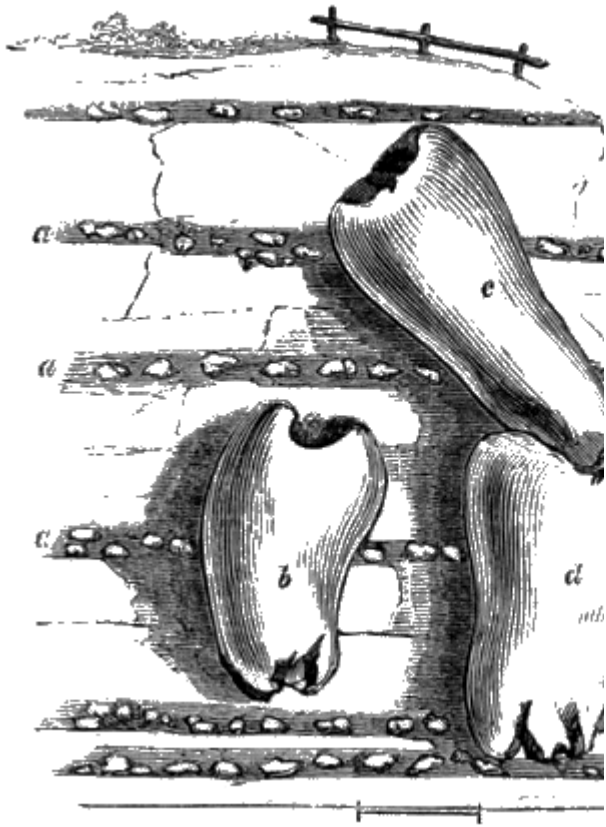
Among the chalk amorphozoa whose true affinities are doubtful, is a small turbinated zoophyte, which I would place provisionally under this genus; it has a shallow central cavity, with a broad smooth margin, a reticulated external surface, and radicle processes proceeding from the base; see *Lign. 80, fig. 1*.

PARAMOUDRA.

PARAMOUDRA. *Lign. 76.*—This vernacular Irish term was introduced by Dr. Buckland, in his account of some gigantic flints, thus popularly named, that occur in the chalk near Belfast, and also at Whitlingham, near Norwich. These fossils are of an irregular, oblong, spherical, or pyriform shape, having a cavity above, which, in some specimens, extends to the bottom; indications of a pedicle are

seen at the base; in short, they closely resemble, upon a large scale, the funnel-shaped spongites, so frequent in the flints of the South Downs. Their appearance *in situ*, is represented *Lign. 76*, from Dr. Buckland's illustrations: *b*, is a single specimen, partly imbedded in the chalk, and *c*, *d*, two of the fossils in contact, the pedicle of the upper one lying in the cavity of the lower.

These bodies are from one to two or more feet in length, and from six inches to a foot in diameter. The appearance, both of the outer and inner surface, is that of the usual white calcareo-siliceous crust of spongitic chalk-flints. Upon breaking them, no decided structure is perceptible; but here and there, patches of red and blue chalcedony occur, as in the Ventriculites and spongites in chalk-flints; the originals were probably large goblet-shaped zoophytes, allied to the sponges, but of so perishable a nature as to leave but few traces of their organization, save their general form. Specimens may however yet be found with the structure preserved, for many years elapsed after the first discovery of flint ventriculites, before I obtained examples that threw light on their origin and formation.



LIGN. 76. "PARAMOUDRA;" SEEN IN A VERTICAL SECTION OF
(*The Very Rev. Dr. Buckland.* Geol. Trans

a, a, a. Layers of flint nodules, alternating with chalk strata,

b. A PARAMOUDRA, imbedded in the chalk,

c, d. Two of these bodies in contact.

In the Devonian slates of Polperro some curious fossils, supposed to be remains of fishes, have been ascertained by Prof McCoy to be Amorphozoa, and are described by that eminent palæontologist under the name of *Steganodictyum*.[215]

[215] "Synopsis of the Classification of the British Palæozoic Fossils," by Prof. Sedgwick and Fred. McCoy. 4to. Fas. 2, p. vii. pl. 2 A. 1852.

CLIONITES (*Morris*) *Lign.* 130.—A recent parasitical sponge (first described by Dr. Grant under the name of *Cliona*), consisting of a fleshy substance, full of siliceous tubular pin-shaped spicula, gives rise to those perforations with which oysters and other shells are often completely riddled,[216] Certain bivalve shells in the cretaceous seas appear to have been peculiarly obnoxious to the depredations of similar zoophytes, and in consequence of the cavities left by the decay of the sponge having subsequently been filled up by flint, a curious series of fossil bodies has resulted, which we shall more particularly notice hereafter. These fossils Mr. Morris has distinguished by the name *Clionites*, to indicate their origin; they are not, however, the silicified sponge, but inorganic casts, moulded in the excavations. The common species is *C. Conybearei*: "cells irregular, somewhat polygonal, with one or more papillæ; surface finely tuberculated; connecting threads numerous."[217]

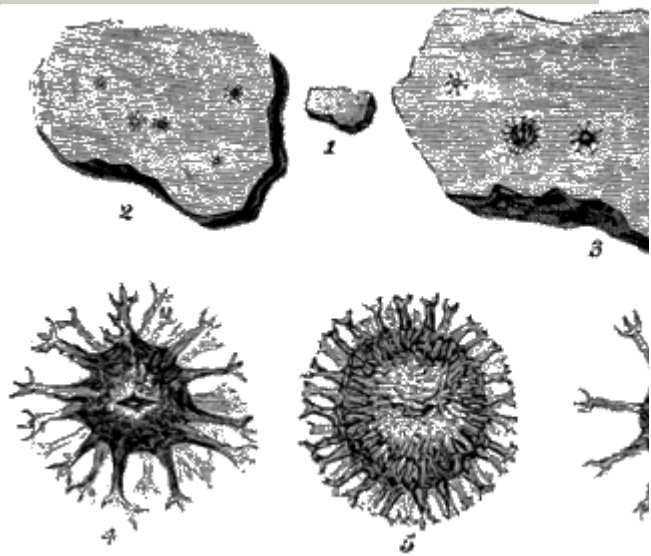
[216] For an account of the characters of the recent Cliona, see a monograph by Mr. Hancock, Annals of Nat. Hist. May 1851.

[217] Ann. Nat. Hist. August 1851, pl. iv, fig. 8.

Spicula, or spines of Porifera. *Lign. 75.*—Siliceous spicules, as we have had occasion to mention, occur in immense quantities in some of those deposits which abound in the remains of spongites. These spines are tubular, and of various shapes; some are acicular, or needle-like; others of a stellate form;

many are tri-radiate or multi-radiate; and some have the shape of a trident; a few of these fossils are figured in *Lign.* 75. As the *Actinia*, *Gorgonia*, and *Alcyonia*, possess spicula, some of the fossil spines may have been derived from those zoophytes. The larger spicules may be discovered with a lens of moderate power, or even by the unassisted eye; but all will amply repay a microscopical examination, and the minutest can only thus be detected.

SPINIFERITES IN FLINTS.



LIGN. 77. A GROUP OF SPINIFERITES IN FLIN
(Seen by transmitted light.)

Fig. 1. A thin-translucent chip of flint; *nat.*
—

2. The same magnified, and viewed by transmitted light; showin
— SPINIFERITES.

3. The same more highly magnified.
—

4. SPIN. RAMOSUS; one of the animalculites seen in fig. 3, very h
—

5. SPIN. REGINALDI; one of the same group; × 300 diameters.
—

6. A variety of S. RAMOSUS; another of the same cluster of SPINII
—

SPINIFERITES (*Xanthidium*, Ehrenb.). *Lign.* 77.—I propose to describe in this place those elegant and very minute bodies, that occur in great numbers in the chalk and flint, and which, on the authority of M. Ehrenberg, were regarded as identical with the siliceous frustules of the genus of fresh-water Desmidiæ, named *Xanthidium*[218] (*ante*, p. 91.) Later and more correct observations have proved that the fossils under consideration entirely differ from their supposed homologues; their original substance not being siliceous, but flexible and membranous; and that instead of being spores of algæ, they are probably the gemmules either of porifera, or of polypifera.

[218] Several recent species of Xanthidium are figured in *Plate IV.* of this volume.

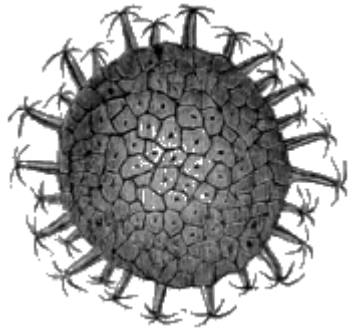
To avoid the perpetuation of the error by the retention of the botanical name of a recent genus of plants, for fossils whose vegetable origin is very problematical, and which are entirely distinct from their supposed analogues, I would substitute that of Spiniferites,[219] a term simply expressive of the general aspect of these bodies; that of a globe or sphere beset with spines. The appearance of these fossils will be understood by the examination of a group discovered by Mr. Reginald Neville Mantell, in a fragment chipped off from a flint pebble; and I will describe the mode by which these minute objects were detected, as it offers a good practical lesson for the young investigator.

[219] From *spina*, a spine, and *fero*, to bear.

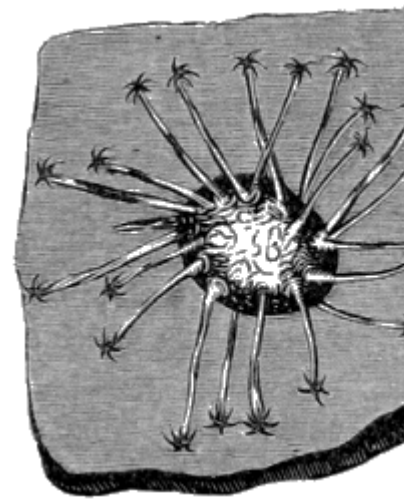
The chip of flint is represented, of the natural size, in *Lign. 77, fig. 1*; it was immersed in oil of turpentine for a short time, and then placed on a piece of glass, and examined with a moderate power, by transmitted light, the turpentine having rendered the translucent flint almost as transparent as glass; this appearance is shown in *fig.* 2; the organisms here represented are from $^{1}/_{300}$ to $^{1}/_{500}$ of an inch in diameter. The half-inch object-glass was next employed, and *fig.* 3 gives the result. The quarter-inch object-glass, and a corresponding eye-piece, were then substituted, and by the adaptation of a camera lucida, *figs.* 4, 5, and 6, were delineated. As *fig.* 5 proved to be a new species, it was named after its discoverer.

The specimens in flint, when rendered transparent and viewed by transmitted light under a high power, as shown in *Lign.* 78, and 79, appear as hollow globular bodies, beset with spinous processes, which in most species are fimbriated at the extremities. There is considerable variety in the form and length of the spines. In *S. Reginaldi*, these appendages are numerous, regular, short, and relatively thick: in an elegant species discovered by the Rev. J. B. Reade (*Lign.* 79) they are long and palmated: in other kinds they are of intermediate size and proportions.[220]

[220] Excellent figures of several species are given in a Memoir by H. H. White, Esq. of Clapham, in the Trans. Microscopical Society, vol. i. p. 77.



LIGN. 78.
SPINIFERITES REGINALDI.
(*Magnified 500 diameters.*)



LIGN. 79.
SPINIFERITES PALMATUS; IN flIN
(× 500 *diameters.*)

The apparently torn and collapsed state of the body and arms of some examples first led me to doubt the siliceous nature of the original substance; and on my discovery of the soft parts of foraminifera in flint and chalk, Mr. Deane undertook to search for the so-called Xanthidia in chalk, that these bodies might be subjected to chemical analysis,[221] Mr. Deane succeeded in detecting all the usual species in the Dover chalk, by digesting some chalk in dilute hydrochloric acid, and mounting the residue in Canada balsam. In this state the shape of the body is that of a depressed sphere; many of the specimens appear to have a circular opening, and the arms or spines to be closed at the extremities. Upon pressure under water between two pieces of glass, they were torn asunder as a horny or cartilaginous substance would be, and the spines in contact with the glass

were bent. Some after maceration in water several weeks became flaccid; a proof that they are not siliceous.[222]

[221] A torn and apparently shrunken specimen from chalk, is represented in my paper on Foraminifera; *Philos. Trans.* 1846, p. 465.

[222] Memoir on Fossil Xanthidia, by Henry Deane, Esq. Microscopical Journal, 1846.

The real nature of these fossils must be regarded as still undetermined: their prevalence in the chalk-flints whose forms are derived from zoophytes, seems to countenance the supposition that the Spiniferites are the gemmules or early state of animals of this family; but I have never detected any organic connexion between them and the porifera with which they are associated; it is possible they may be the germs of the remarkable zoophytes we have next to examine.

VENTRICULITES.

VENTRICULITES.[223] *Lign.* 80, 81, 82.—At every step of our review of the fossil zoophytes, I find myself embarrassed by the conflicting opinions entertained by naturalists, respecting some of the most abundant of the extinct forms; arising from the imperfect state of our knowledge as to the structure of the originals, which compels a comparison with recent types, from which, perhaps, the fossils differed essentially in their organization. This remark especially applies to the zoophytes which have given rise to the fungiform flints so well known to the inhabitants of the chalk districts of Sussex, as

"*petrified mushrooms*," from their close resemblance in form to fungi: a specimen with this name inscribed on it in the cabinet of a friend first drew my attention to these curious fossils. In *Lign.* 80, *figs.* 2, 3, 4, 6, 7, 8, 9, several flints of this kind are represented; *figs.* 3, 6, 8, are fungiform; *fig.* 7, is the upper part of a specimen, the stem having been broken off; *figs.* 2 and 4, are examples of the lower part of the zoophyte; in all, there are openings at the base, and a groove on the margin or edge of the upper part in which the structure of the inclosed fossil is visible; upon breaking these flints, sections of a funnel-shaped body are exposed.

[223] Ventriculite; from *ventriculus*, a ventricle or sac.



LIGN. 80. FLINTS, DERIVING THEIR FORMS FROM ZOOPHY
From the South Downs, near Lewes; $^{1}/_{6}$ *nat.*

Fig. 1.— CHOANITES (?) TURBINATUS.

2, 3, 4, 6, 7, 8, 9.—Flints, whose forms are derived from Ventricul provincially called "*petrified mushrooms*."

5.— SPONGITES LABYRINTHICUS.

10.— SPONGITES flEXUOSUS.

The origin of these fossils will be understood by reference to the four specimens delineated in *Lign.* 81. In *fig.* 3, a fungiform flint, resembling *fig.* 6, of *Lign.* 80, is seen in the lower part of a cup-shaped zoophyte; while above, and surrounding the flint, the impression remains of the reticulated outer surface, deeply coloured by a ferruginous tinge. In *fig.* 4, *Lign.* 81, a small turbinated flint, resembling *fig.* 4, of *Lign.* 80, occupies the base, and three rootlets are seen emerging from it at a. In *Lign. 82, fig. 1*, in which the chalk has been removed so as to expose the outer surface of the Ventriculite, a flint occupies the centre at c; above which, the radiating reticulated structure is spread out on the chalk, *a*; the base, with its roots, is shown at *b*.



LIGN. 81. VENTRICULITES RADIAT
Chalk; near Lewes.

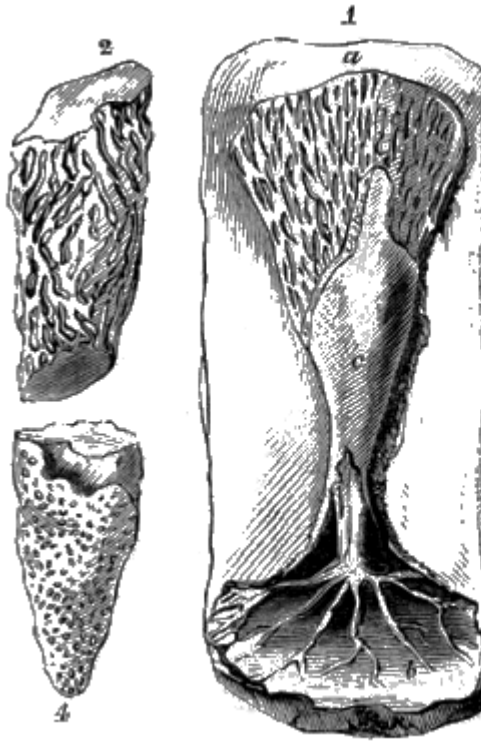
Fig. 1. A perfect specimen in chalk, inverted, showing the external re
— the centre.

2. Specimen expanded, displaying the inner surface, studded ove
—

3. A VENTRICULITE in chalk; the lower part inclosed in flint.
—

4. Portion of a VENTRICULITE; the stem towards the base is envel
— from it into the surrounding chalk at *a*.

These specimens demonstrate that all the flints referred to, have been moulded in the cavities of cyathiform zoophytes; and that their diversity of figure has arisen from the amount of silex that happened to permeate the organism; if but a small proportion of silica in solution was present, then flints, like *fig.* 4, were produced; if the quantity were sufficient to fill up a considerable part of the tissues of the original, fungiform flints, as *Lign. 80, fig. 3*, and *Lign. 81, fig. 3*, were the result. The disciform flints originated from the expanded examples, *Lign. 81*, *figs.* 1 and 2: and when the silex was insufficient to silicify the entire zoophyte, an annular flint, resembling a quoit, was formed.



LIGN. 82. PORTIONS OF VENTRICUI
Chalk, near Lewes.

Fig. 1.— A specimen, in which the middle is inclosed in a flint *c*; the ex
expanded on the chalk; and the pedicle with its roots is expos
originals.

2, 3, 5.—Chalk specimens, showing the external structure of stems

4.— A siliceous cast of the cavity of a Ventriculite covered with pa

The form of the original was evidently that of a hollow inverted cone, terminating in a point at the base, which was attached by fibrous rootlets to other bodies. The outer integument was reticulated, that is, disposed in meshes, like net-work; and the inner surface studded with regular openings, apparently

the orifices of tubular cells. The substance of the mass appears to have been sufficiently flexible to expand and contract without laceration. This opinion is based on the fact, that in many specimens the zoophyte is a nearly flat circular disc (*Lign. 81, figs. 1, 2*); and in others a subcylindrical pouch. In the former state the outer reticulated structure is elongated, while in the latter, it is corrugated; hence I am led to conclude that the original possessed a common irritability, and was able to contract and expand like many of the flexible polypiaria. The openings on the inner surface are cylindrical, and very regular; the flints often present sharp casts of them, which appear like rows of minute pillars. When the flint filling up the cavity of a Ventriculite can be extracted, it is a solid cone, studded with papillæ, the casts of the cells, as in *Lign. 82, fig. 4*.

In the flints, the substance of the Ventriculites is generally as translucent as that of the Choanites, and defined by its rich purple, sienna, or grey colour;[224] but towards the base and margin it is more or less calcareous; and in many examples the whole, or a large portion of the zoophyte, is in this state. But this fact does not invalidate the inference that the original was flexible; for in these instances the tissues may have been immersed in fluid chalk before their envelopment in flint,[225] The chalk specimens are commonly as friable and earthy as the surrounding stone, from which they are distinguishable by their ochreous colour.

[224] Pict. Atlas, pl. xlv. *fig.* 9, represents a beautiful transverse section of the lower part of a Ventriculite in flint, richly coloured. Pl. xliii. *fig.* 16, is a pebble containing the base of a Ventriculite; the orifices on the top have been produced by the transit of the radicle

processes; for the fossil is drawn in an inverted position, a common error before the origin of these flints was ascertained.

[225] A piece of sponge dipped in liquid plaster of Paris, and afterwards inclosed in a transparent substance, as glass, would present such an appearance.

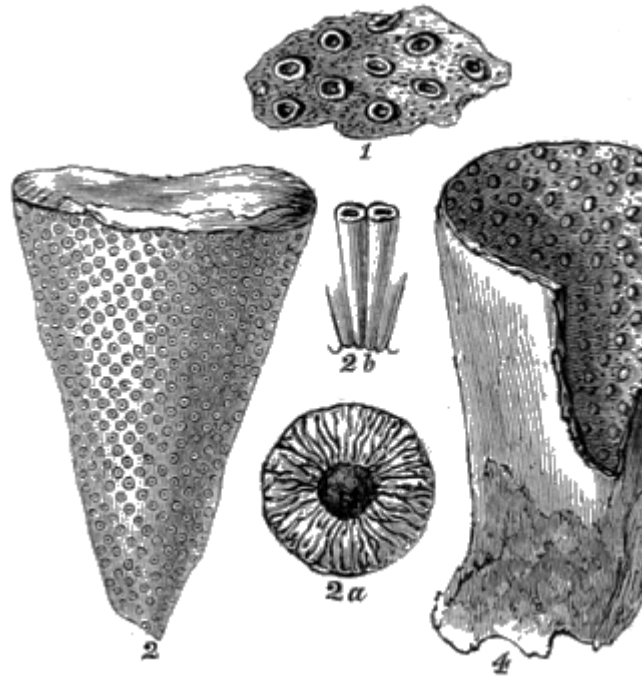
The stain always observable in the tissues of the chalk Ventriculites and other zoophytes, while the surrounding white limestone is uncoloured, may be explained by the chemical changes to which the decomposition of animal matter under such circumstances would give rise. If sulphuretted hydrogen were evolved from the putrifying zoophytes imbedded in calcareous mud containing iron in solution, the sulphur would enter into combination with the iron, the hydrogen escape, and a sulphate or sulphuret of iron be deposited, atom by atom, and thus impart colour and permanence of form to the original.

When the inclosed organisms in the flint nodules have perished, chalcedony, quartz crystals, or crystallized pyrites, sometimes of great beauty, are found occupying the cavities; in short, numerous modifications of the petrifactive process are beautifully exhibited in these common, but highly interesting, cretaceous fossils.

The species to which the previous remarks more immediately refer, is named *Ventriculites radiatus*; from the radiated appearance of the external integument; some of the expanded specimens are more than one foot in diameter.[226]

[226] The reader interested in the history of these objects should consult Foss. South

Downs, p. 167, plates x, xi, xii. xiii. xiv. A memoir by the Author on these fossils, under the name of *Alcyonium chonoides*, with four beautiful plates, was published in the Linnæan Transactions, vol. xi. 1821. The *Ventriculites* are the only organic remains figured in Conybeare and Phillips's Geology of England and Wales, p. 76.



LIGN. 83. VENTRICULITES ALCYONOIDES. *in Flint. Le*
Ocellaria inclusa. König.

Fig. 1.— Portion of the surface of fig. 2, magnified.

2.— The fossil body extracted from the flint, fig. 4.

2*a*.—Transverse section of the same, showing a central spot of flint, surrounded by tubular cells.

2*b*.—Two of the cells of fig. 2*a*, highly magnified.

4.— The hollow flint, from which fig. 2 was extracted; the papillæ
on the surface, are casts of the apertures of cells.

VENTRICULITES ALCYONOIDES. *Lign. 83.*—Under the name of "*Ocellaria inclusa*," the late Mr. König[227] figured and described an elegant fossil zoophyte not uncommon in the chalk and flints of Sussex. This fossil is inversely conical, and somewhat resembles the cast of the cavity of *Ventriculites radiatus*, but a little attention will enable the collector to distinguish it. The flint that is moulded in *V. radiatus*, is surrounded by the substance of the zoophyte, and if found detached, with the investing material removed, shows no structure whatever, but simply a surface covered with minute papillæ. The present zoophyte is generally included in a nodule, and by a slight blow may be readily separated from the surrounding flint; it then has the appearance of a white calcareous cone, beset with regular cells, disposed in quincunx order (*Lign. 83, fig. 2*); leaving a conical cavity in the flint, which is covered with corresponding eminences (*Lign. 83, fig. 4*). Upon breaking the cone itself, it is found to consist of a dense reticulated structure, from one-eighth to a quarter of an inch in thickness (*Lign. 83, fig. 2a*), investing a solid nucleus of flint, the surface of the latter being covered with minute points, which are less regular than those on the cavity of the outer case. The specific name, *inclusa*, was suggested by this character; which, however, is only accidental, for the specimens imbedded in chalk, are simply surrounded by the stone. It is the calcareous nature of the fossil, which renders it so easily separable from the investing flint, while its cells afford numerous points of attachment, and these remain as casts in relief on the interior of the hollow case: I

have not observed the same regularity of structure on the inner as on the outer surface.

[227] Icones Foss. Sect. *fig.* 98.

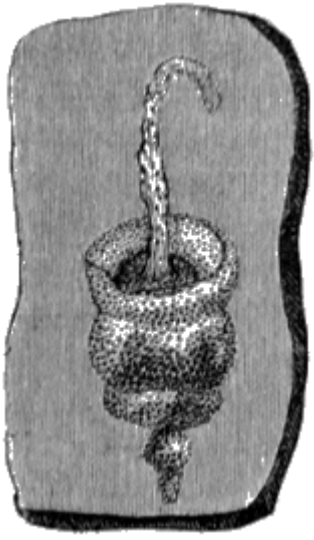
The reticulated integument of this zoophyte resembles in structure that of *V. radiatus*. With regard to the latter, I should state that Mr. Toulmin Smith[228] discovered that the inosculating fibres of the intimate tissue formed an octahedral plexus at each knot or point of union; and this structure Mr. Smith regards as peculiar to the Ventriculites, and states that he detected it in all the fossils he has arranged under the name *Ventriculidæ*. No spicula have been detected in the integuments.

[228] "On the Ventriculidæ;" a series of papers published in the Annals of Natural History, with many figures of cretaceous zoophytes. By Toulmin Smith, Esq.

Until more ample and satisfactory evidence is collected as to the nature of these fossils, the interests of science will be best promoted by allowing the question to remain sub judice, and restricting the term Ventriculites to those zoophytes which possess the general characters of the type to which the name was originally assigned; namely, a vasiform or subcylindrical framework, terminating at the base in a point, and fixed by radicle processes; the substance consisting of a plexiform fibrous tissue; externally constituting a reticulated integument, the meshes disposed in a radiating manner from the base to the periphery; the inner surface studded with open cells regularly arranged.

In the former edition of this work the Ventriculites were placed with the Polypifera from the structure of the openings or cells, for these are so

symmetrical, and disposed with so much regularity, as to present a closer analogy to the polype-cells of a coral, than to the large pores of a sponge. The doubts expressed by many eminent observers as to the correctness of this view, have induced me to insert this notice in the present section; leaving the true affinities of these organisms to be determined by future observers. Possibly we have in these fossils the relics of a tribe of zoophytes of an extinct type, that formed a connecting link between the *porifera* and the *polypifera*; however this may be, I will venture to affirm that no one who had seen the infinitely varied examples of these fossils that I have, would for a moment confound them, as some naturalists have done, with the Scyphiæ, and other simple amorphozoa.



LIGN. 84.
A CORAL-POLYPE IN FLINT.
× 500 *diameters*.
(*Seen by transmitted light.*)

POLYPE IN FLINT. *Lign. 84.*—I will here notice an exceedingly minute and interesting object, discovered by the Rev. J. B. Reade, in a flint containing vestiges of a Ventriculite, and which may possibly belong to this tribe of zoophytes. It must however be remarked, that there was nothing to show the collocation was not accidental. The drawing with which Mr. Reade favoured me, is engraved *Lign. 84*. This object is unmistakeably a polype-cell, with some of the integument of the animal protruding, in the form of a shrivelled tube. The possibility of soft animal tissues being preserved in flint, will not now admit of question, as we shall show when treating of the Foraminifera. The record of this fact may load to the discovery of other fossils of a like nature.

Fossil Polypifera.

POLYPIFERA.

As we proceed in our investigations, the impossibility of rigidly adhering to a zoological classification based on the structure of organs, of which but few, if any, traces exist in the mineral kingdom, becomes more and more apparent; the durable skeletons or polyparia being the only materials from which the palæontologist can gather information, relating to the physiology of the extinct coral-animals which swarmed in the ancient seas, and whose petrified remains constitute a large proportion of the secondary and palæozoic calcareous rocks.

Numerous fossil genera have been established by various authors from the external form of the polyparium, or the disposition and structure of the

cells; but a slight attention to this department of palæontology will disclose corals which differ essentially from the typical forms, and new genera and species will require to be added to the already extended catalogue. The few genera selected for the present work, will convey a general idea of the nature of this class of fossils. To ascertain the names of the species he may collect, the student must refer to works especially devoted to the illustration of the corals of particular rocks; as for example, those of the British *Cretaceous* deposits in the monographs of the Palæontological Society; of the *Palæozoic* in *Sil. Syst.*; and in Prof Sedgwick's Synopsis of the Classification of the Brit. Pal. Foss.; of the *Mountain Limestone* in Prof, Phillips's work; and those of Ireland in Col. Portlock's Geological Memoirs. Those of the palæozoic rocks of New York, are illustrated in Prof. James Hall's splendid work on the Geology of that State.

The fossil zoophytes included in this section present innumerable varieties of form and structure, but agree in the important character of having originated, (with but few exceptions,) from aggregations of those minute beings termed Polypes (many-feet[229]). The common Hydra (*Wond.* p. 600), or fresh-water polype, that inhabits pools and streams, is a familiar example of a free animal of this kind, consisting of a cellular gelatinous substance, in the form of a short tube, or pouch, surrounded at the upper margin by long tentacula, or feelers, which appear to the naked eye as delicate threads. The *Polypifera*, properly so called, are groups of polypes, permanently united by a common integument or axis, each animalcule having an independent existence. A common support or endo-skeleton, termed *polyparium*,[230] is secreted by the

integuments, which varies in its nature from a mere gelatinous, or horny material, to an earthy, calcareous, and even siliceous substance, that remains when the polypes die, and their soft parts have perished. All the varieties of corals, &c. are nothing more than the durable structures of aggregated masses of such beings.

[229] A name derived from the tentacula, or processes, which in some species serve for prehension, and in others for respiration.

[230] The basis, framework, or endo-skeleton, of these groups of animalcules is termed the *polyparium*, or *polypidom* (polype-habitation); those of a stony hardness are familiarly known as corals; these names, therefore, refer to the durable substance, and not to the animals themselves; but in familiar writing, the term Coral is often used to designate the entire living mass. The Red-Coral forms a distinct genus called *Corallium*. In fossils, the *polyparium* alone remains, except in very rare instances.

It may here be necessary to notice a prevailing error, regarding the mode in which the substance called coral is produced. It is very generally supposed that Corals, particularly those bearing stars and cells, have been constructed by animalcules, in the same manner as is the honey-comb, by the Bee; and the expressions often employed by naturalists, of "the coral animalcules building up their rocky habitations," and "constructing their cells," have contributed to foster this error. But the processes are in no respect similar: the insect, under the guidance of an unerring instinct, resulting from its peculiar organization, *constructs* its cells; but the polype is incapable of forming, or even modifying, its support

or cell in the slightest degree. The polypidom is *secreted* by the animal tissues, in the same manner as are the bones in the vertebrated animals, without the individual being conscious of the process. If a piece of white coral be immersed in dilute hydrochloric acid, the calcareous part is dissolved, and the secreting membrane, in the form of a flocculent substance, is seen attached to the undissolved part; even in some coralline marbles of incalculable antiquity, the animal membrane may, in this manner, be detected.[231]

[231] See Pict. Atlas, pl. xxxiv. *fig.* 2.

From the delicate and perishable nature of many of the gelatinous zoophytes, numerous tribes may have inhabited the seas, which deposited the fossiliferous strata, and yet no indications of their existence remain; while, of others, but obscure traces of their structure are likely to be detected.

The Polypifera are separated into two natural groups or classes; viz. the ANTHOZOA (flower-animals), and the BRYOZOA (moss-animals), or POLYZOA.

The Anthozoa are polypes of the most simple type of structure. The body consists of a symmetrical gelatinous sac, capable of contraction and expansion, with one aperture or mouth, which is encircled by tentacula. The Hydra, or fresh-water polype (*Wond.* p. 600), is a familiar example of a single, locomotive, anthozoan animal. In the compound or aggregated forms, the body is either inclosed in a horny sheath (ex. *Sertularia*, *Wond.* p. 615), or is supported by a lamellated calcareous endo-skeleton (ex. *Fungia*, *Wond.* p. 623, pl. vi. *fig.* 15), or the soft parts invest a stony axis (ex. *Madrepora*, *Wond.* p. 620), or a horny

flexible framework (ex. *Gorgonia*, *Wond.* p. 616).

The Anthozoa are subdivided into three orders, which are based on the peculiar characters of the polypes; the *Hydra*, the *Actinia* (Sea-Anemone, *Wond.* p. 622), and the *Alcyonium* (Dead-men's fingers, *Wond.* pl. v. *fig.* 10), being respectively the type of 1. the *Hydroida*, or Hydraform; 2. the *Asteroida* or Alcyonian; and 3. the *Helianthoida*, or Actiniform zoophytes.

In the Hydroida the body in the compound species is implanted in a horny tubular sheath, and the polypidoms form branched corallines, which are fixed by the base to rocks, sea-weeds, shells, &c.

The Asteroida have a horny or calcareous axis, surrounded and inclosed by the soft parts which secrete it.

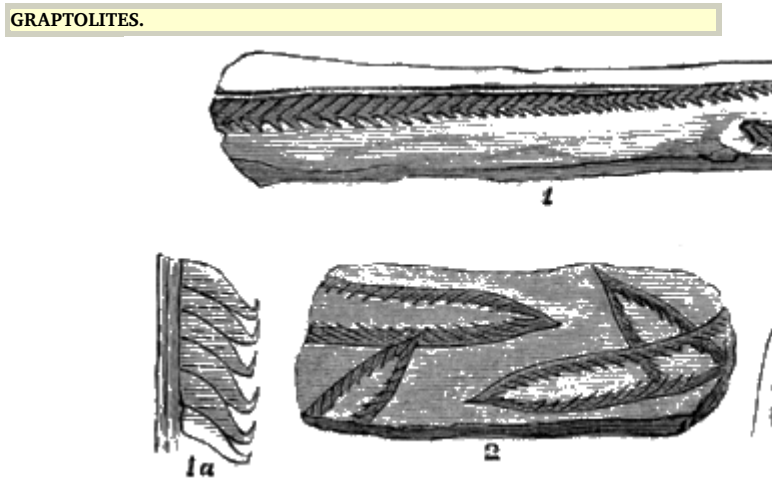
The Helianthoids, except in the simple free species, as the Actinia, have a lamellated calcareous polypidom, the plates of which radiate from a centre.

The calcareous secretions of the Anthozoa, especially of the Helianthoida, in a great measure constitute the mass of the coral-reefs and coral-islands of tropical seas. Their polypidoms, whether external or internal, maintain but little organic connexion with the compound soft substance. These zoophytes increase by gemmation or budding; some throw up germs from the disk, as in Astreadæ; others laterally, as in Caryophillidæ; and some spirally along the stem, as in Madreporidæ; examples of these modes of reproduction are often found in fossil corals. The increase of coral-rocks is produced by the continual formation of new masses, by the successive generations which spring up as it were from the

bodies of their parents; layer upon layer, and tier upon tier, of Helianthoid polypidoms, are found to compose many of the coralline limestones of the palæozoic formations.

FOSSIL ANTHOZOA.—The first group of extinct corals to be noticed under this head is the *Graptolitidæ*, a family restricted to the Silurian rocks, and whose natural affinities have been much questioned; some palæontologists referring them to the *Pennatulidæ*, or Sea-pens, others to the *Sertulariadæ*.[232]

[232] For a full consideration of this subject, refer to Prof. McCoy's Brit. Palæozoic Fossils.



LIGN. 85. GRAPTOLITES IN WENLOCK LIMESTC
(*Murch. Sil. Syst.*)

Fig. 1.— GRAPTOLITES LUDENSIS.[233]
1*a*.— Magnified view of a portion of the same.
2.— GRAPTOLITES MURCHISONI.
2*a*.— Magnified portion of *fig.* 2.

[233] *Ludensis*, from Ludlow—to indicate the habitat of the fossils.

GRAPTOLITES. *Lign.* 85.—These curious zoophytes abound in many of the Silurian deposits; they consist of sessile polype cells, arranged in one or two rows to a flexible stem, like the recent Sertularia, or Virgularia. Prof. McCoy refers them to the order Hydroida.

In a recent state these bodies were probably covered with a soft, or albuminous mass, studded with polype-cells, disposed in rows along the margins of the lateral, curved, grapple-like processes, as in the zoophytes termed *Virgularia*,[234] to which one kind bears a great analogy. If two specimens of the *Graptolites Ludensis* be placed together, so that the elongated smooth edges be in apposition, the united stems will be seen to offer a general resemblance to the axis of *Virgularia mirabilis*.

[234] See British Zoophytes, pl. xxiv.

M. Barrande divides the Graptolites into three groups or genera, which are defined as follow:—

Graptolites (proper), a single series of cells united together at the base, and adhering along the sides nearly to the orifice of each cell, as in *fig. 1a. Monoprion* of M. Barrande.

Rastrites.—The axis reduced to a mere line, on which the cells are placed at relatively wide intervals, and but slightly inclined. These two genera are supposed to have been hydroid zoophytes, and related to the Sertularidæ.

Diprion (*Diplograpsus* of Mr. McCoy), cells in two series arranged along a central axis; these forms

present a foliaceous appearance; they are presumed to resemble the existing genera Pennatula and Virgularia.

Graptolites have been found in strata of the same age in Norway, Sweden, and Scotland.[235] I have received slates literally covered with them, from the Silurian rocks of the United States, by the kindness of my friend, Benjamin Silliman, jun. Esq.

[235] Many species of Graptolites from the Lower Silurian rocks of the South of Scotland, are described and figured by Mr. Harkness in Geol. Journal for 1850, vol. vii. p. 58, pl. 1.

Sir R. Murchison remarks, that the nature of the strata in which these remains occur in Radnorshire, indicates a condition of the sea, well suited to the habits of the family of Pennatulidæ, or Sea-pens; for the recent species live in mud and slimy sediment, and the fossils are imbedded in a finely levigated *mud-stone*, which, from its structure, must have been tranquilly deposited.

I will next describe the single lamellated Anthozoa, and afterwards notice those corals which consist of an aggregation of radiated cells, either frondescent, or disposed in solid masses.

FUNGIA. ANTHOPHYLLUM.

FUNGIA (*Wond.* p. 623).—The corals thus named, from their supposed resemblance to fungi, are of a depressed form, and have the under surface scabrous; they are divided above by numerous lamellæ, or plates, which radiate from a central, oblong depression.

When living, the solid stony polyparium is enclosed in the gelatinous mass by which it was secreted, and there are numerous tentacula around the central cavity, or sac. These zoophytes may be compared to the *Actiniæ*, or Sea-Anemones, from which they differ only in having a calcareous axis, while the Actiniæ have a tough albuminous integument. (*Wond.* pl. vi. *fig.* 15, represents the living animal; and *Lign.* 141, *fig.* 2, p. 641, and *Lign.* 58, *fig.* 4, two fossil species).[236]

[236]

Fungia numismalis. Pict, Atlas, pl. xxxvi. *fig.* 6.
——— polymorpha. Ibid. pl. xliii. *fig.* 1—4; pl. xlv, *fig.* 11.

ANTHOPHYLLUM ATLANTICUM. *Lign. 88. fig. 4.*—In the arenaceous strata of the United States, which the researches of Dr. Morton, of Philadelphia, have proved to be the equivalents of the European Cretaceous formation, a single lamellated coral is not uncommon. It is evidently related to the Fungiæ, and has been named as above by Dr. Morton.

TURBINOLIA KÖNIGI (*Wond.* p. 320).—Polyparium turbinated, striated externally, detached, base not adhering; cell single, radiated.

This genus occurs in all the fossiliferous deposits: a small, well-marked species is frequently met with in the Galt, of which subdivision of the cretaceous strata it is a characteristic fossil. It is figured *Wond. Lign.* 58, *figs.* 1, 2.[237]

[237]

Turbinolia complanata. Ibid. pl. xxxvi. *fig.* 9.
———— mitrata. Ibid. pl. xxxvi. *fig.* 10.

CARYOPHYLLIA CENTRALIS (*Lign.* 89 *figs.* 1, 2: *Lign.* 88, *fig.* 5).—Polyparium turbinated, or cylindrical, simple or branched, longitudinally striated, fixed by the base; cells lamellated.[238]

[238] Monocarya (of Lonsdale), Dixon's Fossils, p, 244.

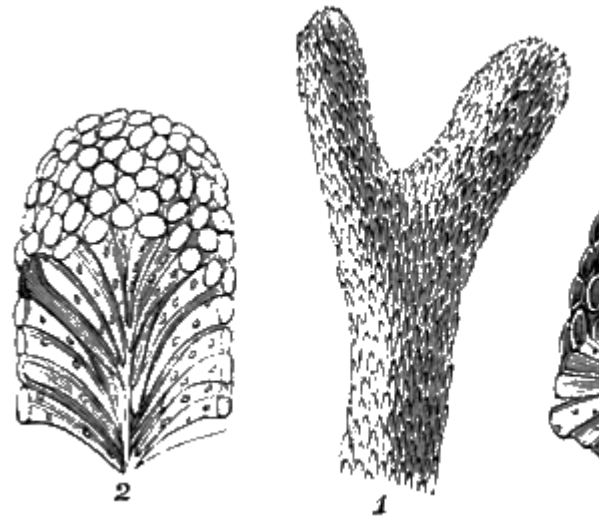
A small recent species (*C. cyathus*), is very common in the Mediterranean, and frequently seen in collections: it is cyathiform, and the base by which it is attached to other bodies, is broad and spreading; the newer tertiary deposits of Sicily contain this species in abundance.

A Caryophyllia, bearing a general resemblance to this species, is common in the chalk, and occurs in beautiful preservation (*Wond. Lign.* 58, *fig.* 3).[239]

[239]

C. centralis, Pict. Atlas, pl. xxxvi. figs. 15, 16.
C. annularis, ibid. pl. xxxvii. *fig.* 5.

Branched Caryophylliæ are found in the Coralline Oolite and Dudley Limestones (*Sil. Syst.* pl. xvi.). A large proportion of the Coral-rag of the Middle Oolite is composed of a branched species (*C. annularis*) of this genus; *Lign.* 88, *fig.* 5, represents a specimen from near Faringdon.



LIGN. 86. FAVOSITES POLYMORPHA. (Goldf
Devonian limestone. Eifel.

Fig. 1.— Portion of a branch of the coral; *nat.*

2.— Fragment, slightly magnified, with part of the surface broken away below, exposing the central axis, and radiated arrangem of the cells, with their lateral pores.

3.— Another portion, magnified, showing the polype-cells hollow.

FAVOSITES POLYMORPHA. *Lign. 86. Lign. 88, fig. 3.*—Polyparium stony, polymorphous, solid internally, compact, composed of a congeries of diverging or ascending parallel, contiguous, prismatic tubes, covered by pores, divided by lamellæ, and communicating by lateral foramina.

The corals of this extinct genus abounded in the Silurian and Devonian seas; the remains occur with those of other fossil zoophytes of that epoch in great numbers, both in Europe and North America. I have many beautiful examples from the Silurian rocks of the Ohio and Niagara, by favour of Dr. Owen, of New Harmony, and Dr. Yandell, of Louisville, in which the

cells are filled up with calcareous spar. The varied markings on many of the Babbicombe marbles, and Torquay pebbles, are derived from the enclosed Favosites (*Wond.* p. 643).

Another species (*Favosites Gothlandica*) occurs in masses of a subconical shape, and is common in some of the Silurian limestones. A fragment, to show the structure, is figured *Lign. 88, fig. 3*.

CATENIPORA. SYRINGOPORA.

CATENIPORA (*Wond.* p. 644, *fig.* 3).—Polyparium hemispherical, composed of vertical anastomosing lamellæ; cells tubular, oval, terminal, united laterally. The oval form of the cells when united laterally, and the flexuous disposition of the lamellæ, give rise in transverse sections to elegant catenated markings, from which appearance the fossil has received the name of *chain-coral*.[240] The species figured (*C. escharoides*) in *Wond.* is common in the Silurian limestones, and sometimes forms hemispherical masses more than a foot in diameter. The chain-coral is extensively distributed through the Silurian rocks of the United States. Coloured figures of this exquisitely beautiful coral are given in *Pict. Atlas*, pl. XXXV.

[240] Org. Rem. vol. ii. pl. iii. figs. 4, 5, 6.

SYRINGOPORA RAMULOSA. *Lign. 88, fig. 2.* (*Wond.* p. 641.) These corals bear a general resemblance to the Organ-pipe Coral of Australia. The polypidom is composed of long, cylindrical, vertical tubes, distant from each other, and connected by transverse tubular processes; the cells are deep and radiated by numerous lamellæ.

The external aspect of these fossils is that of a

cluster of cylindrical pipes, more or less parallel, connected by short transverse branches. They are the *Tubiporites* of Mr. Parkinson, who has given admirable figures of several specimens.[241] In these fossil corals that excellent observer first detected the animal membrane. A slab of marble, whose markings are produced by the section of the inclosed tubes of a Syringopora, is represented, *Wond.* p. 644, *fig.* 2. The Mountain limestones of Derbyshire, and of Clifton, on the banks of the Avon, contain figured marbles of this kind, which are manufactured into vases, tables, &c. The genus is extinct.

[241] Pict. Atlas, pl. xxxv. *fig.* 1. Syringopora geniculata, Pict. Atlas, pl. xxxiv.

LITHOSTROTION COLUMNARIA (*Wond.* p. 641, *fig.* 8).—Polyparium massive, solid, composed of aggregated, contiguous, parallel, prismatic tubes, each terminated by a star: cells shallow, multi-radiate, stelliform.

Species of this extinct genus are common in the mountain limestone, in large masses, which, from the pentagonal form, and parallel arrangement of the tubes, appear like clusters of miniature basaltic columns.[242]

[242] Lithostrotion striatum, Pict. Atlas, pl. xxxvii. figs. 5, 6.

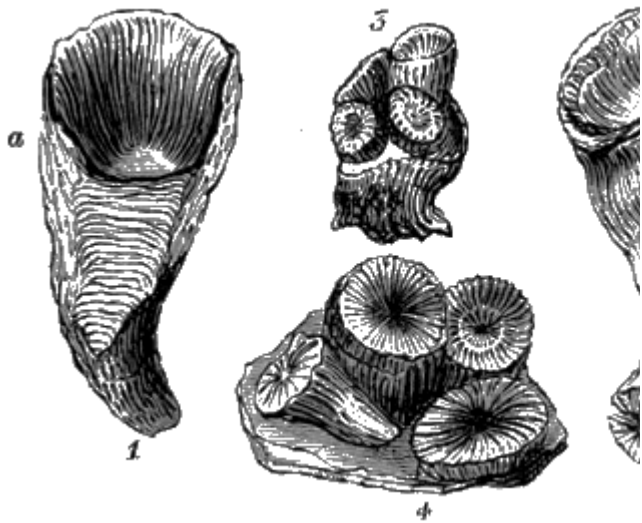
CYATHOPHYLLUM.

CYATHOPHYLLUM. *Lign.* 87, *figs.* 1, 2. (*Wond.* p. 641, *figs.* 1, 3.)—Polyparium turbinated, simple or compound, internal structure transversely chambered or lamellated; cells polygonal, radiated, depressed in the centre.

The corals of this genus are so abundant in the Silurian rocks, that the seas of that epoch must have swarmed with them. The simple turbinated forms are often several inches long, and being somewhat curved, have obtained the popular name of "*petrified rams-horns*."

Upon slitting one of these corals vertically, as in *Lign.* 87, *fig.* 1, the axis of the polyparium, beneath the cell, is found to consist of thin transverse partitions, constituting a series of chambers.

In the compound Cyathophylla, the germs of young cells, occupying the disc of a parent cell, are often met with. *Fig.* 3 represents a group of four germs on the parent cell, of *C. dianthus*, a common and beautiful coral of the Dudley limestone.



LIGN. 87, CORALS FROM THE DUDLEY LIMESTO
(*Sil. Syst.*)

Fig. 1.— CYATHOPHYLLUM TURBINATUM: an oblique longitudinal secti showing at a the transverse lamellæ, or cells, of the internal structure.

2.— The same species.

3.— CYATHOPHYLLUM DIANTHUS: a Specimen, with four young ge arising from the disc below.

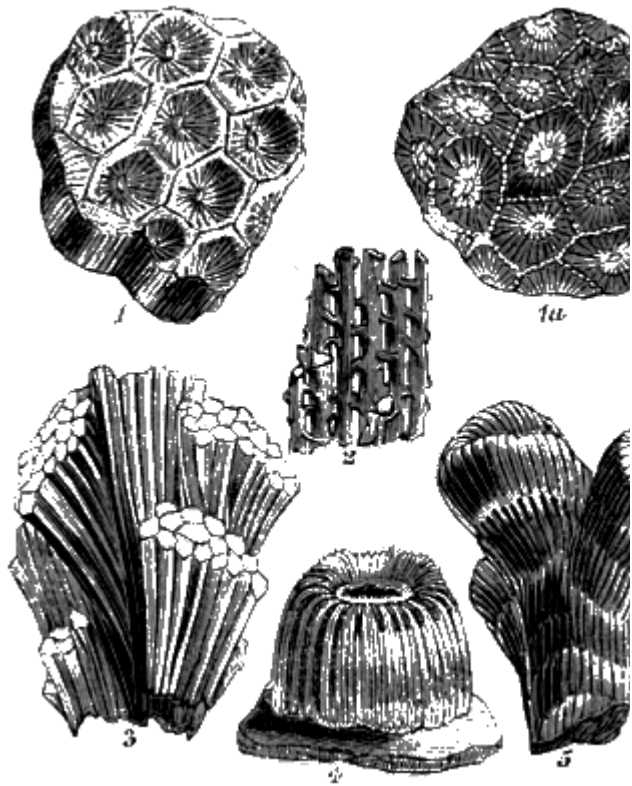
4.— The same species, with four adult cells.

These corals are also prevalent in South Devonshire, and many of the elegant marbles of Babbicombe are figured by the sections of these polyparia.[243]

[243]

Cyathophyllum turbinatum, Pict. Atlas, pl. xxxvi.
————————- fungites, ibid. pl. xxxviii.

Associated with the Cyathophylla in the Silurian rocks, are certain corals that attain considerable magnitude, and which are principally distinguishable by their internal structure. Such are *Cystiphyllum*, constructed of bladder-like cells, and *Strombodes*, composed of spirally contorted lamellæ, or plates (*Sil. Syst.* pl. 16(bis), *fig.* 4). Other hemispherical masses, presenting on the surface concentric wrinkles, with very minute pores, are common at Dudley, and belong to the genus *Stromatopora*.



LIGN. 88. FOSSIL CORALS.
Upper Silurian, Dudley.[244]

Fig. 1.— ASTREA ANANAS.
1*a*.— A polished slice of Marble, formed of ASTREA PENTAGONA. *Devonian. Torquay.*
2.— SYRINGOPORA RAMULOSA. *Mt. L. Derbyshire.*
3.— A Fragment of FAVOSITES GOTHLANDICA. *Ohio.* (*By Dr. Owe*
4.— ANTHOPHYLLUM ATLANTICUM. *Cret. U. States.* (*By Dr. Morto*
5.— CARYOPHYLLIA ANNULARIS. *Oolite. Faringdon.*

[244] Figured in Pict. Atlas, pl. xxxvii. *fig.* 1.

ASTREA.

ASTREA. *Lign.* 88, *figs.* 1, 1*a*.—Polyparium massive, irregular in shape, generally globular, formed by an aggregation of lamellated, radiated, shallow, polymorphous cells.

The corals of this genus are very numerous in the seas of the Tropics, and there are many species in the Oolite, and older secondary formations. The Astreæ, Caryophylliæ, Cyathophylla, &c., form the principal mass of the coralline limestones of the Oolite, termed the *Coral-rag*, from the abundance of these relics: being literally composed of an aggregation of large corals, the interstices of which are filled with shells, radiaria, &c., either whole, or in a comminuted state. The heaps of this limestone placed by the road-side, in the N. W. of Berkshire, appear like fragments of an old coral-reef, and attract the notice even of the most incurious observer. I have figured a specimen of Astrea, *Lign.* 88, *fig.* 1, and a polished section, *fig.* 1*a*, from Clifton, a locality well known for the stupendous mural precipices of mountain limestone rocks, which yield beautiful examples of coralline marble.[245] The mode of increase of the Astrea is very curious; a subdivision takes place in the old cells, after the manner of the Infusoria; and among the fossils, a star or cell may often be seen in progress of division into two, three, or four stars (*Sil. Syst.* pl. xvi. *fig.* 6). A living polype of this genus is figured, *Wond.* pl. vi. *fig.* 13.

[245]

Astrea arachnoides, Pict. Atlas, pl. xxxviii. *fig.* 4.
——— undulata, ibid, pl. xxxviii. *fig.* 10.
——— Tisburiensis ibid. pl. xxxviii. figs. 12, 13.

A species of Astrea (*A. Tisburiensis. Wond.* p. 641, *fig.* 9), is found in large hemispherical masses, completely silicified, at Tisbury, in Wiltshire. The transverse surface displays, in some specimens, beautiful white radiated stars, on a dark blue ground; and in others, the colours of the stars and ground are reversed. This silicified coral is obtained from a bed of chert, a foot in thickness, which is interstratified with the Portland limestone, this division of the Oolite being quarried around Tisbury.[246]

[246] See Catalogue of the Organic Remains of Wiltshire, p. iv. by Miss Etheldred Benett. 4to. 1831.

In the tertiary clays at Bracklesham Bay, Sussex, a beautiful small coral of this type (*Siderastrea Websteri*, Dixon's Foss. tab. i, 5), is found attached to flint pebbles.

Several species of this and the following genus, perfectly silicified, are found in the state of pebbles and boulders in the superficial soil of Antigua, and other islands of the West Indies, associated with the fossil palms, described in a former part of this work. Some of these corals are of great beauty, and polished sections exhibit the coralline structure most perfectly.[247]

[247] In the "Spongitenkalk," at Nattheim, near Heidenheim, all the corals are replaced by chalcedony.

MADREPORA.—Polyparium arborescent or frondescent, porous, fixed; cells deep, with twelve rays, prominent, irregularly dispersed on the surface, and accumulated towards the terminations of the coral.

The term madreporite, or fossil madrepore, was formerly applied to all the branched fossil corals with radiated cells, but is now restricted to those which possess the above characters. The recent common species, figured *Wond.* p. 620, will serve to illustrate this genus. The elevated, branched Madrepores, with minute polygonal cells having twelve rays, the lamellæ of which are denticulated, are termed Porites, and are frequent in the Silurian strata (*Sil. Syst.*).

MILLEPORA. *Lign.* 89.—Coral ramose; cells very minute, distinct, perpendicular to the surface, giving the interior a finely striated fracture, disposed irregularly.

There are many fossil species of this genus, some of which are of considerable size. A small species from the mountain limestone is figured *Lign.* 89, *fig.* 7.[248]

[248] Millepora, Pict. Atlas, pl. xl. *fig.* 6.

LITHODENDRON. *Lign.* 70, *fig.* 3.—Polyparium branched, formed of deep, cylindrical, elongated cells, which are terminal, and radiated, with a prominent central axis.

Large masses of corals of this genus, composed of clusters of branches, are imbedded in the mountain limestone of Derbyshire, Yorkshire, &c.; and a few species occur in the Coralline Oolite; their general configuration will be understood by the figure *Lign.* 70, *fig.* 3; but in this specimen the margins of the cells are worn off, and do not present the original deeply excavated form.[249]

[249] Lithodendron fasciculatum, Pict. Atlas, pl. xxxviii.

There is a remarkable specimen of this coral in the Bristol Institution (of which a portion is now placed in the Museum of Practical Geology, in London), that was discovered by Mr. Samuel Stutchbury,[250] in a vein of hematitic iron ore. It is a large mass, in which the entire substance of the coral is transmuted into a metallic ore, forming one of the most interesting natural electrotypes I have ever seen. In this instance, a block of Lithodendron must have lain in a vein or fissure of the rock, and its animal membrane have resisted the action of the gaseous emanations, or mineral solutions, while the calcareous polypidom was dissolved, and the metallic matter deposited atom by atom, as in the case of pseudo-morphous crystals.

[250] Now of Sydney, Australia.

GORGONIA.—Of the flexible anthozoan coral, which from the flabellated form of the polyparium is generally called "Venus's fan," and by naturalists *Gorgonia*, a few fossil species have been discovered and determined. From the friable arenaceous limestone beds of Maestricht, which abound in corals, fine specimens of a delicate species are occasionally procured. *Wond.* p. 320, *fig.* 5, shows the character of this fossil zoophyte.

FOSSIL BRYOZOA.

FOSSIL BRYOZOA.

The second class of Polypifera, the BRYOZOA or *Polyzoa*, are of a much higher order of organization than those which have engaged our attention. The body is not symmetrical, nor capable of contraction and expansion, as in the Anthozoa: it consists of a digestive cavity or sac, which is bent on itself and

open at both extremities. The outer integument is either membranaceous or horny; sometimes calcareous. The oral aperture or mouth is surrounded by a circle of tentacula, from eight to twelve or more in number, and these tentacles are clothed with vibratile cilia. (*Wond.* p. 606, the polype of *Flustra pilosa*.)

The polypes in this order never occur singly; they are always united by a common integument, but each enjoys an individual existence. The animal can extend its tentacula and protrude the mouth from the cell, but the rest of the body is incapable of extension or contraction. These polypifera increase by germination. In their organization, they so closely approach the mollusca, that in recent zoological systems they are placed in that class. The ciliated character of their tentacula has also led to their being named *Cilio-branchiata*. But as it is desirable in a work of this elementary nature to avoid conflicting opinions as much as possible, the fossil Bryozoa will be considered as corals, in the general sense of that term.

FLUSTRA. ESCHARA.

FLUSTRA (*Sea-mat*). *Lign.* 89, *fig.* 4, 5.—The polyparium is either membranaceous and flexible, calcareous and encrusting, or foliaceous, composed of cells, arranged in juxtaposition, more or less quadrangular, flat, with a distinct border, disposed on a flat surface, or on opposite surfaces, as in the *F. foliacea*.

This is one of the most common genera of the encrusting and frondescent zoophytes. The *Flustra* consists of a cluster, or aggregation of polypes, invisible to the naked eye; under the microscope, the

polype is found to be a transparent gelatinous body bent on itself, with a sac or digestive cavity, having two apertures, the external margin of which terminates in eight or ten tentacula, clothed with cilia; the whole is surrounded by a firm wall, constituting a cell, from which the animal can protrude its tentacula and upper part. (Figures of the living polypes of Flustræ, *Wond.* p. 605, *pl.* vi. *fig.* 6, 7.)

Many species of *Flustræ* occur in the British strata: the encrusting forms are attached to echinites, shells, &c.; the foliaceous are imbedded in chalk, sand, sandstone, &c. In Mr. Morris's *Cat. Brit. Foss.* ten species are enumerated; none of these are from formations below the Chalk. I have selected for illustration a Flustra attached to an echinite from Lewes. *Lign.* 89, *fig.* 5, represents a small portion of the natural size; and *fig.* 4, a few cells magnified, to show their form and arrangement. A foliaceous zoophyte, apparently a bryozoon, is abundant in the Sussex and Kentish chalk, and is often disposed in angular folds. It is generally of a ferruginous colour, and, from its friable texture, it is probable the original consisted of a membranous polypidom or calcareous substance; specimens sometimes extend over several square inches of the chalk. It is common in the chalk-pit at Off ham, near Lewes.[251]

[251] In my South Down Fossils, pl. xv. *fig.* 6, a specimen of this kind is described as a Ventriculite, *V. quadrangularis*. An admirable lignograph of a remarkable example is given by Mr. Toulmin Smith, under the name of *Brachiolites angularis*; it presents ten deep, flat, angular folds, and has radicle and lateral processes; see "On the Ventriculidæ," p. 93.

ESCHARA.[252]—In these zoophytes the polyparium is encrusting or foliaceous, calcareous and brittle; the cells are thickened on their outer margins, and have a small, depressed, round aperture. They are arranged in two series of planes, adhering together, the cells on each surface exactly corresponding.

[252] So named from a supposed resemblance to an eschar.

Species of Escharæ are found either in flints, or attached to echinites, and other bodies; they have the appearance of patches of flustræ, but with a lens may be distinguished by the symmetrical juxtaposition of the cells on the opposite sides of the polyparium.



Ellen Maria Mantell, ad nat. delt.

LIGN. 89. CORALS FROM THE CHALK AND MOUNTAIN LIME

Fig. 1.— CAROPHYLLIA CENTRALIS; *nat.* (G. A. M.) *Cret. Lewes.*

2.— Front view of half the disc of the same.

3.— Two cells of CRISIA JOHNSTONIANA. × ×.

4.— Magnified view of six cells of the Flustra, *fig.* 5.

5.— A portion of an encrusting Flustra; *nat. Cret. Chichester.*

6.— IDMONEA (DIXONIANA) CRETACEA; *nat. Cret. Lewes.*
The figure on the left shows the under surface; that on the right, the upper surface, with a row of polype-cells on each margin: a portion magnified is given *fig.* 12.

7.— MILLEPORA RHOMBIFERA. × ×. *Mt. L. Ph. Yorks.*
The small figure on the left is of the natural size.

8.— PUSTULOPORA PUSTULOSA. × ×. *Cret. Chichester.*
The small figure on the left, *nat.*

9.— HOMŒSOLEN RAMULOSUS. × ×. *Cret. Dover.*
The left-hand figure, *nat.*

10.— CRISIA (?) JOHNSTONIANA. (G. A. M.) × 250 linear. *S. s. Maidstone.*

10[b].— Two cells of the coral, *fig.* 10, seen in profile, × ×.

11.— HOMŒSOLEN RAMULOSUS; *nat. Cret. Lewes.*

12.— IDMONEA DIXONIANA; a portion of *fig.* 6. ×.

13.— RETEPORA LAXA. *Mt. L. Ph. Yorks.*

13†. A portion of the same ×.

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14.— Idmonea Comptoniana. × ×. (G. A. M.) *Chalk, Chichester.* (*Mantell.*)

The small figure on the right is of the natural size.

MICROSCOPIC FOSSIL BRYOZOA.

CRISIA JOHNSTONIANA. *Lign.* 89, *fig.* 3, 10, 10[b].— The minute recent corals thus designated are allied to *Flustra*, but separated from that genus by the cells being disposed in a single series, and united by connecting tubes. I notice this genus to direct attention to a very curious polypidom from the Greensand of Maidstone, presented to me by Mr. Bensted. The specimen is attached to a fragment of shell. The cells, five of which are represented, *fig.* 10, are elliptical, with the aperture above, and towards one extremity; they are united by very slender, hollow filaments: *fig.* 3, two of the cells seen from above × 250 linear; *fig.* 10[b] the same seen in profile. [253] I have named this species *C. Johnstoniana*, as a tribute of respect to the author of the admirable works on British Zoophytes, previously noticed.

[253] I refer this fossil to the genus *Crisia* with some hesitation; perhaps *Hippathoea* would be more correct, but all the described species of the latter are branched.

The fragmentary relics of numerous minute and elegant corals, constitute a considerable portion of the mass of some of the white chalk strata; several genera of these zoophytes are figured in Mr. Dixon's beautiful work, and described by Mr. Lonsdale. Attached to the surface of shells, &c., and sometimes standing erect in little crannies, or hollows, of the flints, many beautiful corals may often be detected with the aid of a lens. By brushing chalk in cold water, and examining the deposit, the student will probably discover several of the species figured in *Lign.* 89, which we proceed to describe.

RETEPORA (*Lace-Coral*). *Lign.* 89, *fig.* 13.—A very thin calcareous polyparium, disposed like net-work in foliaceous and branching plates; cells opening either on the upper or inner side.

These are an elegant tribe of corals, of which many species occur in the Chalk formation at Maestricht, in the white-chalk of England, in the mountain limestone of Yorkshire, (*Phil. York.*), and in the Silurian deposits (*Sil. Syst.*). It may be useful to state, that in the description of the fossil retepores, the openings in the net-work are called fenestrules—the spaces between the ends, *dissepiments*—and those between the fenestrules, interstices. A delicate fossil retepore from the mountain limestone of Yorkshire (*R. flexa*), is figured *Lign.* 89, *fig.* 13.

FENESTRELLA.—Cells very small, indistinct externally, with small prominent openings;

polyparium stony, fixed at the base, composed of branches, which inosculate by growth, and form a cup. Numerous delicate corals, formerly arranged as *Reteporæ*, occur in the Silurian rocks, and have been placed in this genus by Mr. Lonsdale. (*Sil. Syst.* p. 677.)

PETALÆPORA PULCHELLA.[254] *Lign.* 69, *fig.* 1.—This beautiful cretaceous coral is "tubular, free except at the base; framework composed of vertical laminæ, with an intermediate foraminated structure; apertures to the tubular cavities distributed over the surface; exterior varying with age." It has slender round dichotomous branches, and the polyparium when entire must have formed an elegant plexus of coral. A layer an inch thick, full of branches of this zoophyte, is exposed on the face of the chalk cliffs, near Dover; and beautiful masses, several inches square, made up of this coral, Idmonea and Pustulopora, may be obtained. The microscopic specimen figured in *Lign.* 69, was obtained with many other corals by washing chalk with a brush, and examining the detritus deposited.

[254] Mr. Lonsdale. Dixon's Fossils, p. 285.

PUSTULOPORA. *Lign.* 89, *fig.* 8.—Another very common tubular branched coral of the Dover chalk; the tubes are cylindrical, their apertures are arranged in annular or spiral rows, and slightly projecting, giving a pustulous appearance to the stem and branches. Specimens covering a piece of chalk six or eight inches wide, and a foot long, have been discovered. The example figured is a very minute branch.

HOMŒSOLEN RAMULOSUS.[255] *Lign.* 89, *figs.* 9,

11.—This delicate branched coral is formed of large and small tubes variously intermingled, both inclined in the same direction, partially visible on the surface, or wholly concealed, limited to one side of the coral; mouths simple tubular extremities; back without pores, composed of a continuous lamina.[256]

[255] Homœsolen, from ομοιος, similar; and σωλην, a tube.

[256] Mr. Lonsdale, in Dixon's Fossils, p. 307, tab. xviii. B. figs, 3, 4, 5.

The elegant coral, *fig.* 11, *Lign.* 89, is thus named by Mr. Lonsdale; it resembles his *fig.* 4. The fossil, *fig.* 9, *Lign.* 89, though very different in its branching, and in the surface, which is covered with pores, is evidently identical with *fig.* 3 of Mr. Lonsdale, which he refers to the same species.

IDMONEA, *Lign.* 89, *fig.* 6.—In this elegant coral the polyparium is calcareous, branched, porous; the cells distinct, prominent, arranged in single rows, more or less inclined, on each side a median line on the inner face only. The genus is extinct.

A beautiful species of Idmonea, of which a small branch is figured in *Lign.* 89, abounds in the chalk of Kent and Sussex; it often forms a cluster, two or three inches in circumference. The surface of the stems is covered with minute pores, and the cells are distinct, and placed in single rows; the left-hand figure of *fig.* 6 shows the plain surface, and that on the right, the opposite and inner, each margin of which is garnished with a row of cells; a portion magnified is represented *fig.* 12.[257]

[257] In the former edition of this work, I named this species *I. Dixoniana*, to

commemorate the researches of my late friend, Frederic Dixon, Esq., of Worthing, who had formed an interesting collection of chalk fossils, and announced a work on the "Zoology of the Chalk Formation," to be richly illustrated with figures of many undescribed organic remains. It appears that a species, supposed to be identical, had been previously named by Mr. Milne Edwards, *I. cretacea*. See Dixon's Foss. tab. xviii. A. *fig.* 5, p. 281. Mr. Lonsdale places it in a new genus, with the name of Desmeopora semicylindrica. It will convey some idea to the unscientific reader, of the labour bestowed on this department of palæontology, to learn that the description and identification of but 25 species of minute corals, represented on three plates, occupy ninety pages of close printing in royal 4to. of Mr. Dixon's work.

IDMONEA COMPTONIANA,[258] *Lign.* 89, *fig.* 14.—This is a very small and remarkable coral; it is dichotomous, cylindrical, with elongated distinct cells, which are disposed in triplets, at regular distinct intervals, on one side of the stem.

[258] This specific name is in honour of the noble and highly respected President of the Royal Society, the Marquess of Northampton. 1844.

We have now described all the fossil corals figured in *Lign.* 89; and have shown what interesting organisms may be detected in a few grains of calcareous earth. It would be easy to give restored figures of the beings whose stony skeletons are the subject of these remarks, from their close resemblance to existing species; every pore and cell might be represented fraught with life; here the agile

inmates, with their little arms fully expanded, and in rapid motion; there retreating within their recesses, and devouring the infinitesimal living atoms that constitute their food; or rapidly shrinking up their tentacula upon the approach of danger; even their varied colours might be introduced, and thus the beautiful and highly interesting picture drawn by the imagination, of a group of living zoophytes of the ancient chalk ocean, be presented to the eye.

Although, for convenience, I have selected the above examples principally from the cretaceous strata, the reader must not suppose that other deposits are not equally prolific in these remains. The Coral-rag of the Oolite, many beds of the Mountain limestone, and those of Dudley and Wenlock of the Silurian System, contain myriads of minute polypidoms associated with the coralline masses of which we have already treated. Exquisite figures of the Silurian corals, by Mr. Scharf, are given in *Sil. Syst.* pl. xv. xvi. and described by Mr. Lonsdale. A slab of the Dudley limestone often has the entire surface studded with minute corals of many species and genera, lying in bold relief, and in an admirable state of preservation.

VERTICILLIPORA (*Lign.* 70, *fig.* 4. *Lign.* 72, *fig.* 3). —Cells poriform, arranged in meshes on the surface of convex imbricating plates round a hollow axis, forming a fixed, irregular, subcylindrical polyparium. *Lign.* 70, *fig.* 4, represents a coral often met with in the gravel-pits at Faringdon, (*ante*, p. 228.,) which is referred by Mr, Morris to this genus. It is composed of short cylindrical anastomosing tubular branches, emanating from an expanded base, divided internally by transverse parallel plates, covered with exceedingly minute pores or cells, disposed in

meshes; the plates surround a hollow axis; the structure is well shown in the figure.

LUNULITES. *Lign.* 70.—The polyparium is stony, orbicular, convex above, concave below; concavity radiated; convexity covered with cells, arranged in concentric circles on diverging striæ.

A species of this coral is often found in the chalk: *Lign.* 70, *fig.* 1, represents a specimen from the South Downs, discovered by Mr. Walter Mantell. The natural affinities of this genus are not determined with precision; but I have placed it with the Bryozoa in accordance with the opinion of M. de Blainville. It is an elegant white coral, and easily recognized among the minute organisms of the chalk.

DISTRIBUTION OF FOSSIL BRYOZOA.

GEOLOGICAL DISTRIBUTION OF FOSSIL ZOOPHYTES.—Although the geological distribution of fossil zoophytes affords less striking phenomena than that of the vegetable kingdom, yet some interesting reflections are suggested by the facts we have thus cursorily noticed. We find that in the most ancient seas of which any vestiges of their inhabitants remain, these forms of vitality existed, and produced the same physical results as at the present time; giving rise to coral-reefs, and banks of coral-limestones, and largely contributing to the solid materials of the crust of the globe. Nearly 400 British species are enumerated by Mr. Morris, and the list has subsequently been greatly extended by the labours of Phillips, Portlock, Lonsdale, McCoy, Milne Edwards, and other eminent naturalists.

The Tertiary formations afford numerous species

of Caryophylliæ, Flustræ, Escharæ, Spongia, &c.; and the *Crag*, several genera that are as yet but imperfectly determined. The older Tertiary, or Eocene deposits, contain Turbinoliæ, Astreæ, Fungiæ, Meandrinæ, and species of other genera, the recent types of which are inhabitants of tropical seas.

The zoophytes of the British Chalk have been illustrated in detail by Mr. Lonsdale in Dixon's Cretaceous and Tertiary Fossils of the South-East of England; and by Dr. Milne Edwards in the Monographs of the Palæontological Society.

In the Maestricht deposits, lamelliferous corals, as Astreæ, Fungiæ, Meandrinæ, &c. prevail, and may be extracted from the friable arenaceous limestones in a fine state of preservation. In the White Chalk and Greensand of this country, the Spongites and allied genera are abundant, and associated with Caryophylliæ, Astreæ, and many forms of Bryozoa.

But in the cretaceous formation of England, no coral-reefs are observable; the zoophytal remains, with but a few local exceptions, occur promiscuously intermingled with the fishes, shells, Radiaria, and other marine exuviæ; although many layers, or thin seams of chalk and marl, are largely composed of the detritus of corals, like the modern deposits of the Bermudas (*Wond.* p. 613). These phenomena are in accordance with the lithological characters of the White Chalk strata, and the nature of its mollusca, both of which indicate a deep sea; and coral-reefs are only formed at moderate depths. But in regions where the sea was shallow, during the deposition of the cretaceous rocks, beds of coral limestone were produced; and these also contain littoral (sea-shore) shells, associated with the usual sponges and

zoophytes (*Wond.* p. 613).

In the marine secondary formations antecedent to the cretaceous, namely, the Lias and Oolite, coral-reefs, which appear to have undergone no change save that of elevation from the bottom of the sea, and the consolidation of their materials by mineral infiltrations, demonstrate a condition of the ocean in our latitudes, which is now only met with in the tropics (*Wond.* p. 614).

The limestones of the Carboniferous, Devonian, and Silurian formations, abound in anthozoan corals, and among them are many kinds of Cyathophyllum, Lithododendra, Syringopora, Catenipora, Graptolites, &c., which are characteristic of these deposits.

The Silurian zoophytes are figured in *Sil. Syst.*; and the splendid works on the British Palæozoic Fossils, by Prof. Sedgwick and Prof. McCoy, now in course of publication, contain many admirable figures of new, or but imperfectly known species.

The extensive beds of coralline limestones, which are found in the Silurian strata, wherever they occur, —for the limestones of this system in North America are characterized by the same species of corals as those of England,—seem to indicate that a more equal temperature prevailed throughout the ocean, at that geological epoch, than at the present time, when the geographical distribution of the coral zoophytes is strictly limited by temperature. The reef-forming genera are now confined to waters where the temperature is not below 70°; their most prolific development being 76°. The apparent exception, the occurrence of coral-reefs at the Bermudas, is found to depend upon proximity to the Gulf Stream (*Wond.* p. 614), which brings down the

thermal waters of the tropics, and increases the local temperature of the sea in those localities.[259]

[259] Mr. Deane's splendid and masterly work on Corals, should be studied by those who wish to be acquainted with the present state of this branch of natural history.

ON COLLECTING FOSSIL CORALS.

ON COLLECTING FOSSIL CORALS.—Few instructions are required for the collection of fossil zoophytes; for as the most important characters of the several kinds have been pointed out in the previous descriptions, the student will be able to select illustrative specimens for his cabinet. The minute corals, &c. of the Chalk, and other limestones, are to be obtained by the same process as that directed for the discovery and preservation of the foraminifera, and other microscopic organisms, at the end of the next chapter. The larger examples should be left attached to a piece of chalk, when practicable, and the surrounding stone removed with a knife or graver, so as to expose as much of the fossil as may be required for the display of its characters, without loosening its attachment to the block. When the investing chalk is very hard, frequently pencilling the specimen with vinegar, or dilute hydrochloric acid, will soften the stone, and render its removal easy, by means of a soft brush: when acid is employed, the specimen must afterwards be well rinsed in cold water.[260]

[260] It may be well to caution the collector against employing sulphuric acid (commonly called *oil* of *vitriol*) for this purpose, for a white insoluble deposit (sulphate of lime) will thus be formed on the specimen, and its appearance irremediably injured. Many of the

> fossil corals obtained from the chalk of Dover Cliffs, are so saturated with muriate of soda, from long exposure to the spray of the sea, as to be liable to decomposition in the course of a few weeks, and are therefore not worth purchasing of the dealers.

The zoophytes that are in part flint, and part chalk, as the Ventriculites, (*ante*, p. 244, *Lign.* 81,) can rarely be obtained, except through the quarrymen who have been instructed how to extract them from the rock. The first specimen of this kind that came under my notice, I discovered while breaking a mass of chalk, in search of fungiform flints; when, to my great delight, I found the fossil, *Lign.* 81, *fig.* 3, by which at once, and for the first time, was shown the connexion between the chalk specimens, *Lign.* 8, *figs.* 1, 2, and the flints figured in *Lign.* 8, *figs.* 2, 3, 6, 7, 8. Upon showing this fossil to the quarrymen, and exciting their attention by suitable rewards, I obtained the illustrative series now in the British Museum.[261] Much light would be thrown on the nature of other zoophytes of the chalk that are invested with flint, if due care were taken in the collection of specimens, and they were examined before extracted from the rock. Loose, delicate specimens, whether from the chalk or tertiary strata, should be affixed with strong gum-water to cards, or pieces of thin board, covered with coloured paper.

[261] Petrifactions, Room VI. p. 466.

The Greensand Spongites, Siphoniæ, &c. may often be extracted from the rock tolerably perfect, by a well-directed blow of the hammer; but fragile species should be left attached to a block, and the surrounding stone be carefully chiselled away, so as

to expose the most essential characters.

The Faringdon zoophytes are, for the most part, encrusted by an aggregation of minute polyparia, shells, and detritus, which may be partially removed by washing with a stiff brush, and their cavities cleared with a stout penknife, removing the extraneous matter by *chipping*, not by scraping, or the surface will be injured. In this manner the beautiful specimens figured, *ante*, p. 228., were developed.

The Corals in the hard limestones can seldom be chiselled out to advantage; for the most part, polished sections best exhibit the form and structure of the originals.

Weather-worn or water-worn masses of coral limestone often display the structure of the zoophytes of which they are in a great measure composed, in a beautiful state of sculpture and relief: the silicified or calcified corals appearing as perfect as if fresh from the sea. The mural rocks of coral limestone at Florence Court, the seat of the Earl of Enniskillen, are in many parts encrusted, as it were, with syringopora and other tubular corals, laid bare uninjured by the long and insensible effect of atmospheric erosion. A beautiful illustration of the old aphorism,—"Aqua cavat lapidem non vi sed sæpe cadendo,"—is afforded by the splendid examples of cateniporæ, fungiæ, caryophillæ, sculptured in alto-relievo on the face of the Silurian rocks over which dash the rapids at the Falls of the Ohio.

The silicified zoophytes of the West Indies, and those from Ava and the Sub-Himalayas, form beautiful subjects for the microscope; and chips, or sections, should be prepared in the manner recommended for fossil wood in the same state of

mineralization.

LOCALITIES OF FOSSIL ZOOPHYTES.

BRITISH LOCALITIES.—The gravels and sands of the Crag afford most favourable sites for obtaining tertiary zoophytes.

In the London clay at Bracklesham Bay, a species of Astrea (*A. Websteri*) is often met with attached to flints and pebbles.

In the Greensand of Atherfield, in the Isle of Wight, an elegant coral (*Astrea elegans*) is by no means rare.

The Greensand gravel-pits, near Faringdon, in Berkshire, abound, as already mentioned, (*ante*, p. 228.,) in many kinds of sponges, and other porifera; and the quarries of oolitic limestone in the vicinity of that town, yield the usual corals of the Jurassic formation in great profusion, I know of no locality richer in fossil zoophytes, than Faringdon.[262]

[262] See Excursion, Part IV. of this work.

The quarries of that division of the Oolite called Coral-rag (as in the north-west of Berkshire, Oxfordshire, Gloucestershire, &c.), afford the usual corals of the Oolite.

The Oolite near Bath contains many species, and large masses of a minute coral (*Eunomia radiata*), are abundant.

At Steeple Ashton, in Wiltshire, numerous oolitic corals may be obtained. The silicified *Astreæ*, of Tisbury, in the same county, deserve particular notice (*ante*, p. 263).

Clifton, near Bristol, and Torquay and Babbicombe, on the Devonshire coast, are celebrated for their coralline marbles and pebbles; and many of the Derbyshire limestones are equally prolific in similar remains. The Devonian marbles are so largely employed for ornamental purposes,— as brooches, tables, and side-boards,—that the figures produced by the sections of the enclosed corals must be familiar to the reader.[263]

[263] Specimens of these fossil corals, either as objects of natural history, or as ornaments, may be obtained of Mr. Tennant, 149, Strand.

Dudley, Wenlock, and Ludlow, are well known for the abundance and variety of Silurian polyparia.

Other localities of British corals have been mentioned in the course of this review of fossil zoophytes.

CHAPTER VIII.

FOSSIL STELLERIDÆ; COMPRISING THE CRINOIDEA OR LILY-LIKE ANIMALS; AND THE ASTERIADÆ, OR STAR-FISHES.

THE RADIATA, or radiated animals, so designated because the parts of which the body is composed are arranged around a common centre or axis, are

divided into three sub-classes; namely, 1, the *Polypifera*, whose fossil remains were treated of in the previous chapter; 2. the *Acalepha*, or Jelly-fishes, whose structures are so perishable as to render it improbable that any vestiges of them will be found in a fossil state, though imprints of the general outline of certain kinds may possibly occur;[264] and, 3, the *Echinodermata*, comprehending under that term the *Stelleridæ*, or Crinoids and Star-fishes, and the *Echinoderms*, properly so called. This sub-class is the subject of the present section; it comprises four orders, viz.

CRINOIDEA, or Lily-like Animals.
ASTERIADÆ, or Star-fishes.
ECHINIDÆ, or Sea-urchins.
HOLOTHURIADÆ, or Sea-slugs.

[264] The impression of an Acaleph resembling an *Æquorea* (a kind of Medusa), is stated by M. Pictet to have been observed in a slab of schistose rock, in Germany.

Vestiges of the Stellerida are among the earliest relics of animal organization hitherto discovered. Many kinds of Crinoidea abound in the Silurian rocks, and one genus of Star-fishes occurs in the same deposits: the Echinidæ first appear in the Devonian formation.

The Echinodermata possess the radiated type of structure in an eminent degree; especially the Asterioidæ and the Echinidæ, of which the common Star-fish, and Sea-urchin, are familiar examples. The external integument or skin is in many kinds protected by spines, (hence the name Echinoderms or spiny-skin,) and perforated by numerous foramina

for the imbibition and transmission of sea-water, and for the protection of minute soft tubular processes (called *pseudopodia*), which constitute organs of adhesion and locomotion.

The first two orders have endo-skeletons, composed of numerous ossicula or little calcareous bones: in the third order, the Echinidæ, the body is inclosed in a calcareous case or shell, formed of numerous plates closely adjusted to each other; in the fourth order, the Sea-slugs, the body has only a tough outer integument without movable spines.

Diversified in form and external appearance as are the Invertebrata thus grouped together, they are naturally related by their organization. The Crinoidea may be regarded as Star-fishes fixed to one spot by a jointed stem; the Star-fishes as free Crinoidea; the Echinidæ as Star-fishes with the rays coalesced and united into a globular or spherical case; and the Holothuriæ, as elongated Sea-urchins, destitute of spines, and without a calcareous envelop.

CRINOIDEA.

CRINOIDEA.—The animals of this order are subdivided into families and genera according to the number, form, and arrangement of the plates composing the calcareous case or receptacle, and the structure of the arms and column. In one living family, the *Comatulidæ*, the body is free; and in one fossil genus, the *Marsupite*, the animal is capable of locomotion through the water.

The essential character of the *Crinoidea*,[265]—so named because the receptacle and anus of some kinds resemble when in repose a closed lily or tulip,—are well exemplified in the recent *Pentacrinus*; the

only known living form that is identical in structure with the numerous extinct tribes, that swarmed in the seas of the palæozoic and secondary ages.

[265] From κρινον, *crinon,* lily, and ειδος, *eidos*, a form.

The PENTACRINUS (*F. caput-medusæ*, *Wond.* p. 647), is an inhabitant of the Caribbean Sea, and but rarely obtained; there are specimens in the British Museum[266] and in the Hunterian Collection of the College of Surgeons.

[266] Petrifactions, p. 77.

This animal has a long stem or column, which is composed of pentagonal calcareous plates or ossicula, articulated to each other by radiated surfaces, and is fixed by the base to a rock, or other firm body. The column supports a vasiform receptacle or cup, formed of calcareous plates in close apposition; in which the digestive and other viscera are situated. The upper part of the receptacle is covered by an integument in which there is an aperture for the mouth. From the margin or brim proceed ten multi-radiate arms, which subdivide into branches of extreme tenuity. On the upper and inner side of the arms are numerous articulated feelers or pinnæ. The ova are situated externally on and near the base of the arms, as in the Comatulidæ; a family of living Star-fishes, or more properly Crinoids, which have a receptacle, surrounded by articulated and multi-radiate arms, but are free animals, being destitute of a column.

In the living state of Pentacrinus, the skeleton—for such are the specimens in our museums—was of course covered and concealed by the soft

integuments and tissues by which it was secreted. The ossicula composing the stem are pentangular, and very numerous; they have a central perforation, and their articulating surfaces are ornamented by pentapetalous striations. There are numerous side-arms sent off from the column in groups of five, at uncertain distances. The mouth is situated in the centre of a plated integument spread over the top of the receptacle. The arms, which arise from the margin of the latter, surround the mouth, and when spread out, with their numerous pinnæ or feelers expanded, form a net for the capture of prey; and are the organs by which the animal obtains food, and conveys it to the mouth.

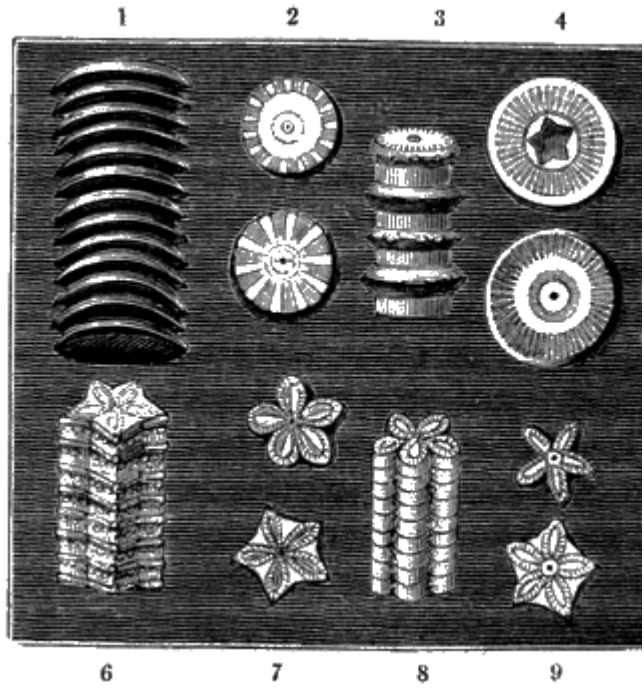
FOSSIL CRINOIDEA.

FOSSIL CRINOIDEA.—The fossil crinoids, like the recent prototype above described, consist of an articulated column, and a receptacle formed of calcareous plates, and articulated arms or tentacula. They constitute two groups; the *Encrinites*, in which the ossicula of the column are subcylindrical and smooth; and the *Pentacrinites*, with a stem composed of pentangular ossicles, as in the living Pentacrinus.

The petrified remains consist of the ossicula of the column, arms, and tentacula; of the plates of the receptacle; and of the peduncle, or process of attachment by which the animal was fixed to the rock. The peduncle is in some species flat and expanded, like that of the *Gorgonia*; in others, it consists of long jointed processes. These several parts are commonly found detached, and intermingled with detritus in the strata; throughout extensive beds of encrinital marble, vestiges of the receptacle are but seldom discoverable. In some localities the

skeletons are preserved entire, and lie expanded on the surface of the layers of shale, clay, or limestone, as if the animals had been enveloped by the soft deposit when alive in their native seas.

These remarks will serve to convey a general idea of the nature of the crinoidal remains which are scattered through certain rocks in such inconceivable quantities; for, much as the columns may differ in form, the ossicula in their markings, and the plates of the receptacle in their configuration and ornament, the same general type of structure prevails throughout the family.



LIGN. 90. STEMS OF ENCRINITES AND PENTACRIN

Fig. 1.— Screw or Pulley-stone. *Derbyshire.*

2, 4.— Articulating surfaces of Encrinital ossicula.

3, 5.— *Entrochites*, or portions of stems of Encrinites.
6, 8, 10.— Portions of Pentacrinital stems.
7, 9.— Articulating surfaces of ossicula of Pentacrinites.

FOSSIL STEMS AND OSSICULA OF CRINOIDEA.—(*Bd.* pl. xlix-lii. *Pict. Atlas*, pl. xlvii.)—The detached ossicula and stems are so common in many places, that they attracted the notice of the earlier collectors, by whom the single pieces were termed *trochites* (wheel-stones), and the united series *entrochites*. In the north of England these fossils are called *Fairy-stones*, and the circular perforated ossicula *Saint Cuthbert's beads*; the latter were worn as ornaments by the ancient Britons, and are occasionally found in tumuli.

These petrifactions present considerable variety in form, and in the markings on their articulating surfaces, which are often radiated and sculptured in floriform and stellular figures (*Lign.* 90, *fig.* 7, 9, and *Lign.* 91, *fig.* 3, 4). The central perforation is small in some species, and large and pentagonal in others. The ossicula of the Encrinites often vary in size in the same column, being circular and elliptical, and thick or thin, alternately, as in the upper part of the column of the Lily Encrinite, *Lign.* 91, *fig.* 6; by which great flexibility and freedom of motion were obtained.

The pentagonal stems also display many modifications; some have five, others but four sides (*Lign.* 90, *fig.* 6, 8, 10, and 91, *fig.* 7, 9); in some the angles are acute, in others rounded.

PULLEY-STONES. *Lign.* 90, *fig.* 1.—The circular, or pentagonal channel formed by the united ossicula of the column, has given rise to the curious fossils called in Derbyshire the Screw, or Pulley-stones,

which are flint casts of those cavities that occur in the beds of chert, interstratified with the mountain limestone. The siliceous matter, when fluid, must have filled up the channel and invested the stem: the original calcareous ossicles have since been dissolved, and the casts, now solid cylinders of flint, resembling a pulley, remain. The masses of chert are often impressed with the ornamented articulating surfaces of the trochites.

In the quarries on Middleton Moor, near Cromford, Derbyshire, where extensive beds of limestone composed of crinoideal remains are worked for chimney-pieces and other ornamental purposes, beautiful examples of these fossils may be obtained.[267] The cavities of the column and ossicles are often filled with white calcareous spar, while the ground of the marble is of a dark reddish brown colour; in other varieties of the Derbyshire encrinital limestones, the substance of the fossils is white, and the ground dark grey or brown,[268] A slab of this marble, with portions of columns lying in relief, and a polished section showing the inclosed entrochites, are figured *Wond.* p. 650.[269]

[267] See Excursions around Matlock, Part IV. of this work.

[268] Pict. Atlas, pl. xlix. figs. 1, 3, 6.

[269] Upwards of 80 figures of Encrinital remains are given in Pict. Atlas, pl. xlvii.



LIGN. 91. ILLUSTRATIONS OF CRINOIDEA.

Fig. 1.— Group of Living COMATULÆ; *nat.* (*Dr. Thompson.*)

1a.— A single COMATULA of the same group, magnified.

2.— PENTREMITES PYRIFORMIS. *Silurian, Ohio.*

3, 4. Surfaces of two pentapetalous ossicula.

—

5.— A single Ossicle of an APIOCRINUS. *Chalk.*

6.— ENCRINUS LILIIFORMIS; the receptacle with part of the column attached; $^1/_2$ *nat. From Brunswick.*

7.— PENTACRINITAL stem with four angles.

8.— ENTROCHITE, composed of five smooth ossicles.
9.— Quadrangular stem of seven ossicles.
10.— CYATHOCRINUS TUBERCULATUS. (*Sil. Syst.*)
11.— Receptacle of BOURQUETICRINUS; *from the Chalk. Lewes.*

The *receptacle* which contained the viscera is extremely diversified in form, and in the number, shape, and arrangement of its plates: the annexed figure 2, *Lign.* 92, illustrates the several pieces that enter into its composition. The genera, or sub-genera, are based on the modifications of shape and structure of the receptacle; and their names are composed of the termination *crinus*, or *crinites* (signifying stone-lily), with a term prefixed expressive of the generic character: thus we have *Apiocrinus*, or *Apiocrinites*, Pear Encrinite.[270]

[270] The termination *crinus* is now generally employed, instead of *crinites*; the latter is preferable, as it indicates the fossil nature of the specimens. A more expressive name than *Encrinite* was suggested by Mr. Martin, of Derbyshire; that of *Stylastritæ* or Column-Stars.

The receptacle being round and inflated, and composed of pieces articulated with the stems, and supporting the arms by similar articulations, are the generic characters of *Apiocrinites* of Miller. When round but not inflated—*Encrinus*, when pentagonal, *Pentacrinus*. When the receptacle is composed of angular plates united at the edges and forming several series or stages, it constitutes the basis of the following genera: viz,—

Platycrinus; two series, the one of three, the other of five plates.

Pateriocrinus; three series each of five plates.

Cyathocrinus; three series of five plates, the last with five intercalated pieces.

Actinocrinus; several series of plates: the first composed of three, the second of five, and the others of many pieces.

Rhodocrinus; several series of plates that are covered externally with radiated ridges. The first course consists of three, the second of five, the third of ten, and the others of many plates.

Eugeniacrinus; of five pieces united into one receptacle.

This brief explanation will enable the student to comprehend the nature of the almost infinite variety of figure and ornament which the fossil crinoidea present, and the principles of nomenclature generally adopted by modern authors. To attempt an enumeration even of the genera would be inadmissible in these volumes. The late Mr. Miller's "Natural History of the Crinoidea or Lily-shaped Animals,"[271] will afford the student satisfactory information on this class of organic remains.[272]

[271] Published in 1 vol. 4to. 1821, with coloured plates.

[272] A beautiful "Monograph on the Recent and Fossil Crinoidea," by Messrs. Austin, in 4to. is in course of publication, of which but eight numbers have appeared.

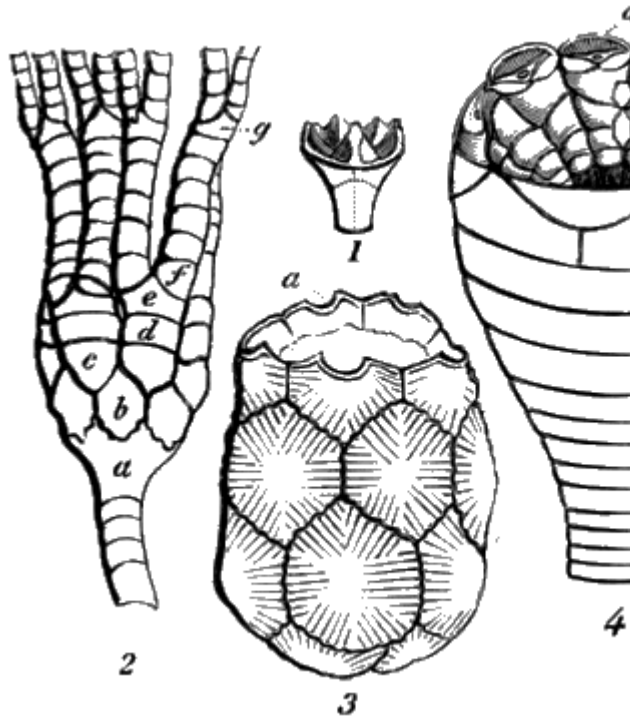
APIOCRINUS (*A. Parkinsoni*). *Lign.* 92, *fig.* 4. (*Wond.*. p. 652.)—The Apiocrinite or Pear-Encrinite of Bradford, from its size, and the abundance of its remains in one particular locality, is the most

generally known of all the British fossil Crinoids. It abounds in the beds of oolite, in the quarries on the heights above the picturesquely situated town of Bradford, in Wiltshire. The receptacle, detached ossicula, and the pedicle, are very common; and in some instances the entire endo-skeleton, from the peduncle to the extremities of the arms, is preserved. The late Channing Pearce, Esq., of Bradford, by unremitting attention to the collection of these fossils, obtained the beautiful specimens deposited in the British Museum.[273]

[273] Petrifactions, Room II. Wall-case G.

This Apiocrinite has a smooth receptacle of a pyriform shape, composed of large thin plates with radiated articulating surfaces; the stem is short and strong; the arms are simple, resembling those of the *Marsupite*; the peduncle spreads out into an expanded base, which is firmly attached to the rock, like that of the Gorgonia, and is generally of a rich purple colour.[274]

[274] Pictorial Atlas, pl. xlix. Pulley-stones and Encrinital marbles; pl. 1. Apiocrinites.



LIGN. 92. FOSSIL CRINOIDEA.

Fig. 1.— EUGENIACRINUS. *Switzerland.*

2.— CYATHOCRINUS PLANUS. *Mountain Limestone.*

a. Basal plate of the *receptacle*.
b. One of the plates composing the walls of the pelvis.
c. Costal plate.
d. Intercostal plate.
e. Scapula, or ossicle that receives the arm.
f. First ossicle of the arm.

3.— MARSUPITES MILLERI (G. A. M.). *Chalk, Brighton.*

a. The semilunar cavity for an attachment of the arm.

4.— APIOCRINUS ROTUNDUS, *Pear-Encrinite. Bradford.*

a. First ossicles of the arms.

Sir Charles Lyell mentions an interesting fact relating to the occurrence of these fossils in the Oolitic limestone at Bradford. In Burfield quarry, on

the heights that overlook the town, a bed of limestone was exposed, the upper surface of which was incrusted with the stony peduncles or roots of Apiocrinites; upon this stratum was a layer of clay, in which were innumerable remains of receptacles and ossicula of stems and arms; some of the stems were erect, others prostrate, and throughout the clay were the dismembered remains. This submarine forest of Crinoideans must therefore have flourished in the clear sea-water, till invaded by a current loaded with mud that overwhelmed the living zoophytes, and entombed them in the argillaceous deposit in which their fossil remains are imbedded.[275]

[275] Burfield quarry, on the heights of Bradford, is the locality referred to; but I believe it is rarely that any specimens of the Apiocrinite are to be found in an erect position. I could not learn from any of the local collectors, that an example had been seen by them. When I visited the quarry in June, 1848, no good section of the beds was apparent: a few detached plates of Apiocrinites were the only relics we could meet with. Mr. Reginald Mantell, when engaged on the construction of the railway near Bradford, sought repeatedly, but in vain, to discover any Apiocrinites in an erect position, or as if lying on the spot where they grew.

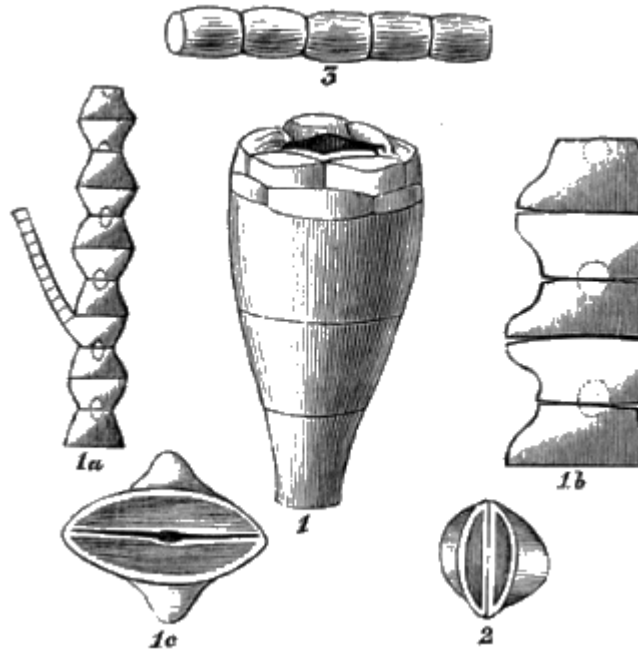
The constituent substance of the ossicula and plates of the Bradford Encrinite is calcareous, and has an oblique fracture; the colour is generally a light ochre, or a bluish grey.[276]

[276] Pict. Atlas, pl. 1. contains figures of the Bradford Encrinites.

APIOCRINITE OF THE CHALK.

APIOCRINUS ELLIPTICUS. *Lign.* 93.—Detached ossicula of this small encrinite are abundant in the White Chalk; the receptacle is known to the quarrymen by the name of "*bottle*." The pieces composing the column are cylindrical in the upper part, and elliptical and angular in the lower, and are articulated by a transversely-grooved surface. The two upper joints are enlarged, and support the receptacle, which is smooth and round (*fig.* 1). The column has articulated side-arms, and the base numerous jointed processes of attachment, which, when found apart from the column, have been mistaken for a distinct type, and named "*Stag's-horn Encriniter*."[277] The specimens figured *Lign.* 93, show the essential characters of this crinoid; when perfect, this species must have borne a general resemblance to the Pear Encrinite of Bradford.

[277] Pict. Atlas, pl. xlvii. *fig.* 31, p. 113. In the same plate there are figures of several specimens of detached portions of the stem of this species from the Kentish Chalk.



LIGN. 93. APIOCRINITES. *Chalk, Lewes.*

Fig. 1.— APIOCRINUS ELLIPTICUS, × 3.

1[a].— Part of the elliptical portion of the column, with a side-arm.

1[b].— Portion of the same, magnified.

1[c].— The articulating surface of an ossicle.

2.— Ossicle of A. flEXUOSUS. (*M. D'Orbigny.*).

3.— Portion of the cylindrical stem.

BOURQUETICRINUS (D'Orbigny). *Lign.* 91, *fig.* 11. —Detached ossicles of other species belonging to the same genus, or to allied genera, are frequently met with in the Kentish and Sussex chalk. A common form is that figured in *Lign.* 91, which is part of the receptacle of a crinoid, named as above; it differs from the other Apiocrinites of the chalk in the articulating surfaces of the ossicles not being radiated, and in the receptacle, which is small and pyriform, not having a distinct cavity; there is only a

median canal, which is seen in a vertical section: but the entire structure of the summit does not appear to be shown in any specimens hitherto observed.

ENCRINUS LILIIFORMIS (*Lily Encrinite*). *Lign.* 91, *fig.* 6.—This exquisite Crinoid is equally interesting and attractive to the amateur collector and the naturalist. Its remains do not occur in the British strata, and are only known in the muschelkalk of Lower Saxony. The specimens in this country are chiefly from Erkerode, in Brunswick; they are found in a layer, about eighteen inches thick, of a soft argillaceous cream-coloured limestone, chiefly made up of trochites, detached ossicula, and a few fragile shells and corals.

The receptacle of the Lily Encrinite is smooth, and in the form of a depressed vase; its base is composed of five plates, upon which are placed three successive series of other plates, with the uppermost of which the arms articulate. The stem is formed of numerous perforated round ossicles, articulated to each other by radiated grooved surfaces, and becoming somewhat pentangular, and alternately larger and smaller, towards the summit, to which the receptacle is fixed; a construction admitting great freedom of motion.[278]

[278] Mr. Miller's work should be consulted for details of structure.

This Encrinite when lying in relief on the rock, with its receptacle entirely or partially closed (see *Wond.* p. 548), so strikingly resembles the bud or expanding flower of a Lily or Tulip, as to justify the popular name of Stone-lily. An exquisite specimen is figured by Mr. Parkinson;[279] the British Museum possesses some fine examples.[280]

[279] Pict. Atlas, pl. xlviii.

[280] Petrifactions, p. 77.

Mr. Parkinson detected the animal membrane in ossicles of this crinoid, by immersing them in dilute hydrochloric acid.[281] My friend Mr. Frederick Harford has repeated the experiment with success.

[281] See Pict. Atlas, pl. xlvii. *fig.* 47.

PENTACRINITES.

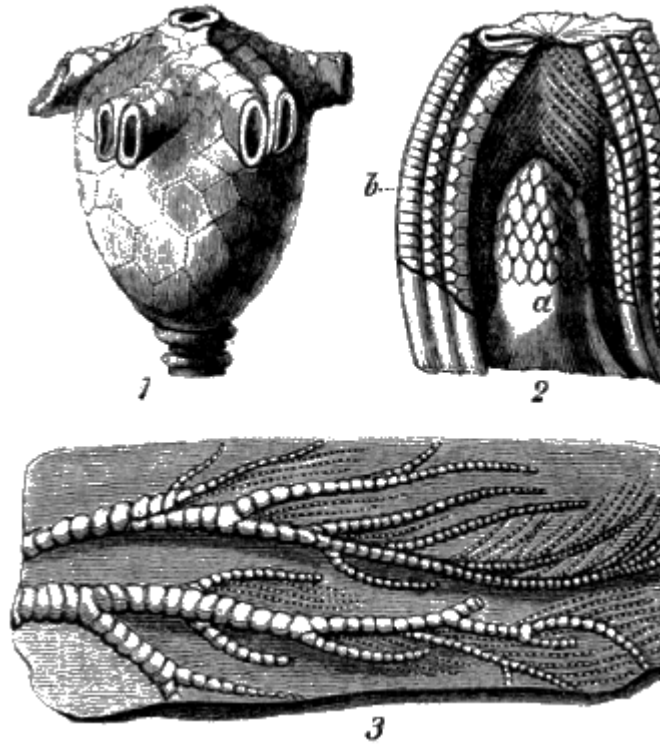
PENTACRINITES.—The description of the recent *Pentacrinus caput-medusæ* (*ante*, p. 282.), illustrates the characters of the crinoideans whose fossil remains are so familiar to the palæontologist, under the name of Pentacrinites. In these animals the pieces composing the receptacle are firmly articulated together; the rays of the disk are fixed immediately to the summit of the column by special ossicula; and the stem is composed of angular pieces, which are generally pentagonal. The receptacle is small, and situated deep between the bases of the arms; it is closed above by an integument covered by minute plates or flat ossicles (*Lign.* 94, *fig.* 2). The fossil remains of several species are abundant in the Lias and Oolite of Dorsetshire, Somersetshire, &c. Slabs of limestone may be extracted with the surface covered with these crinoideans, spread out as if floating in their native element; very commonly they are transmuted into sulphuret of iron, or have a coating of brilliant pyrites.[282] The neighbourhoods of Lyme Regis, and Charmouth, are celebrated for these organic remains. A small specimen of the arms of a pentacrinite on Lias shale is figured in *Lign.* 94, *fig.* 3.

[282] Pictorial Atlas, pl. li. lii.

The arms in many of the plumose pentacrinites are very long and thickly beset with side-arms, and minute pinnæ, all of which are composed of separate articulated ossicles, so that the number of bones in a single endo-skeleton of those crinoids amounts to from fifty to one hundred and fifty thousand distinct pieces. The Briarean Pentacrinite,[283] so named from its numerous tentacula, is literally a tuft of articulated processes, appearing like a delicate fibrous plume attached to a stem. The *Pentacrinus Hiemeri* is a beautiful example of this type of crinoids, of which there is a noble group, comprising upwards of thirty individuals, on a slab in the British Museum,[284] exposed on the surface of the stone in as perfect a state as if just dredged up from the bottom of the sea. The pentacrinites are for the most part entire; the peduncle being fixed, and the column extending upwards in gentle undulations, and supporting the receptacle, from which the arms are gracefully outspread in various attitudes. The structure of the receptacle, and of the arms, and the extreme delicacy of the finer tentacula made up of countless minute ossicula, are admirably shown in this unique and most instructive fossil.

[283] Pictorial Atlas, pl. xlvii. The Briarean Pentacrinite is fully illustrated and described in detail in Dr. Buckland's Bridge water Essay, p. 484.

[284] This species was named and figured by M. König in his "*Icones Fossilium sectiles*," pl. iii. *fig.* 29, in 1826. See Petrifactions, p. 88.



LIGN. 94. ACTINOCRINITES, OR NAVE ENCRINITES.

Fig. 1.— ACTINOCRINUS PARKINSONI. (*Org. Rem.* ii. pl. xvii. *Pict. Atlas*, pl. li.)

2.— Section of an ACTINOCRINUS, (*Miller's Crinoideæ*, pl. ii.)
a. Proboscideal protrusion of the plate and integument.
b. Sections of the folded or closed arms.

3.— Arms of a Pentacrinite, on Lias-shale; *Lyme Regis*.

ACTINOCRINUS. CYATHOCRINUS.

ACTINOCRINUS (*Nave Encrinite*). *Lign.* 94, *fig.* 1, 2. (*Wond.* p. 585. *Bd.* pl. xlvii.)—The column is formed of numerous round ossicula, possesses side-arms, and is fixed by root-like processes. The receptacle is of an irregular subspherical form, the arms passing off at

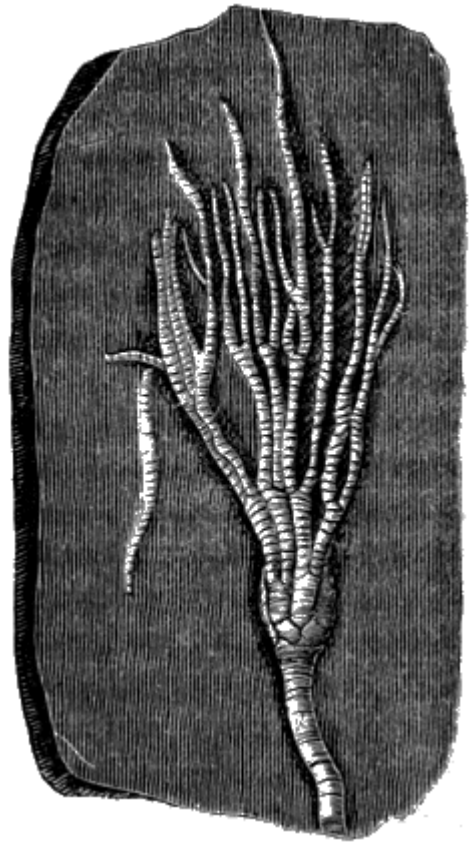
right angles like the spokes from the nave of a wheel; hence the name. The base is composed of three plates which support five hexagonals and one pentagonal, and on these are three other series; from the upper margin of the last, five arms are given off. The receptacle is closed by a dome-shaped tesselated covering (*Lign.* 94, *fig.* 2), having on one side the opening for the mouth and vent. The specimen, *fig.* 1, is a receptacle without a stem, and with but a few joints of the arms; this is the usual state in which these fossils are obtained. *Fig.* 2 is an *Actinocrinite* in which part of the brim of the receptacle and of the arms has been removed in front, leaving a portion of the coalesced arms partially surrounding the proboscideal plated integument that covers the upper part of the receptacle; the figure is from Mr. Miller's work, and is introduced to illustrate the structure of these crinoideans.[285]

[285] Miller's Crinoidea, *fig.* N. pp. 98-100.

The external surface of the plates of the receptacle in the Actinocrinites, is generally covered with radiated markings and ridges, so that detached plates have been mistaken for those of Marsupites; see the restored figure of a Nave Encrinite, *Wond.* p. 654. In some species the receptacle is richly ornamented; but in the specimen figured, *Lign.* 94, *fig.* 1, the surface has been defaced in consequence of the fossil having been immersed in strong acid.

CYATHOCRINUS (*Cup-like Encrinite*). *Lign.* 95, and *Lign.* 92, *fig.* 2.—The column is formed of round, depressed, perforated joints, articulating by radiated surfaces; pentagonal near the summit. The receptacle is composed of five pieces, succeeded by two successive series of five plates, with intervening

plates, and supports five bifurcating, radiated arms.



LIGN. 95. CYATHOCRINITES PLANUS; *nat. Mountain Limestone, Clevedon.*

The Encrinites of this genus have a light and elegant appearance: the forms of the plates composing the pelvis, and of the ossicula of the arms, are shown in *Lign.* 92, *fig.* 2; which represents a specimen of *C. planus*, from the magnesian limestone of Somersetshire; a beautiful example of the same species is figured in *Lign.* 95. The receptacle resembles in shape a depressed vase; its upper part

was probably covered by a plated integument, having an aperture in the centre as in the Actinocrinites. Cyathocrinites occur in the Silurian, Devonian, and Carboniferous formations.[286]

[286] A figure of Cyathocrinus rugosus is given in Pict. Atlas, pl. xlix. *fig.* 4. The same work contains coloured figures of Pentacrinus scalaris (Goldfuss), pl. xlvii. figs. 57, 64, 66; Pentacrinus basaltiformis, pl. xlvii. *fig.* 47.

A remarkable receptacle, with the tentacula partially introverted, is figured Pict. Atlas, pl. xlvi. *fig.* 2, from Gloucestershire; and several beautiful examples of the arms, tentacula, &c. of Pentacrinites in Lias limestone and shale, in pl. li. figs. 9, 15, 16, and pl. lii. figs. 1, 2, 3, from Charmouth.

RHODOCRINUS. (*R. verus. Pict. Atlas*, pl. xlix. *fig.* 7, 8.)—A beautiful form, allied to the Antinocrinoids, occurs in the palæozoic rocks, and is named the Rose-encrinite by Miller. The column is cylindrical and traversed by a pentagonal canal. The rays or arms arise by a single ossicle and then bifurcate: the receptacle is formed of three, five, ten, and more numerous series of plates, which are ornamented externally. A fine example of a crinoid of this type (*Hypanthocrinus*) from the Wenlock limestone, is figured in the London Palæontological Journal, pl. xxi.

In Sir R. Murchison's Sil. Syst. all the crinoids of the Silurian deposits, then known, are figured. Several new genera are described by Professor McCoy, in the Synopsis of British Palæozoic Fossils.

EUGENIACRINUS (*Clove-like Encrinite*). *Lign.* 92, *fig.* 1.—These little crinoids, which resemble a clove

in form, are found at Mount Randen, in Switzerland, in Oolitic limestone. The receptacle is simple in structure, for it has but one series of plates; its cavity is very small. It had five arms: the articulating surface of the ossicles is radiated. When perfect this crinoidean must have somewhat resembled the Lily Encrinite, but the plates are all anchylosed, or blended together, which Mr. Miller attributed to an early stage of growth.

PENTREMITES PYRIFORMIS.

PENTREMITES PYRIFORMIS (*Pear-shaped angular Encrinite*). *Lign.* 91, *fig.* 2.—The column of this remarkable crinoid is short, and formed of cylindrical, perforated ossicula, with radiated surfaces, and has irregular side-arms. The receptacle is composed of polygonal plates, divided by five perforated grooves or furrows, which are of an elongated petalous form, and converge in a rosette on the summit. The marginal longitudinal rows of minute pores are not however for the passage of soft membranous feelers, as in the ambulacra of echinoderms, as was formerly conjectured, but are channels for the transit of vessels that supply an infinite number of delicate simple tentacula, composed of extremely minute calcareous ossicula, as in the other Crinoidea, but not subdivided as in the Pentacrinites and Encrinites.

These articulated tentacula are arranged close together in longitudinal rows on the ambulacral spaces; there being two rows, each consisting of fifty tentacula, on every space. They are directed upwards towards the vertex of the receptacle, and appear to be the instruments for the capture and conveyance of food to the mouth.[287]

[287] See Dr. Fred. Röemer on jointed tentacles found on the ambulacral spaces of *Pentremites*, "Geol. Journal," vol. v. p. 8.

There are several species of Pentremites, some of which swarm in the cherty limestones of Kentucky. Mr. Say, to whom we are indebted for the first satisfactory investigation of these fossils, mentions that such is their abundance, that he has observed, on a piece of rock not larger than three inches by two-and-a-half, above twenty specimens lying in relief

CYSTIDEA.—In the ancient fossiliferous strata there occurs a remarkable family of crinoideans, which is supposed to be restricted to the palæozoic ages; these fossils have been named by Von Buch, *Cystideæ*, from the body of the animal being wholly inclosed in a cyst, or box. The receptacle is of a spherical form, and composed of polygonal plates, articulated to each other; it has distinct apertures for the mouth, vent, and oviduct; the orifice of the latter is closed by valves. It has a short pedicle, but no arms have been discovered, and the Cystideæ are generally described as Crinoids without appendages of this kind. But in some members of this group, there are not only arms and tentacula, but likewise certain organs connected with the plates, which Prof E. Forbes terms, "pectinated rhombs," the functions of which are not obvious. The arms more closely resemble those of the Ophiuridæ than of the Crinoidea.[288] This order comprises several genera, and is the type under which the Crinoidea first appear in the natural records of our planet, according to the present state of our knowledge, and which becomes extinct before the advent of the Pentacrinites.

[288] See a memoir on the British Cystidea, by Prof. Ed. Forbes; in the Mem. Geological Survey, vol. ii.

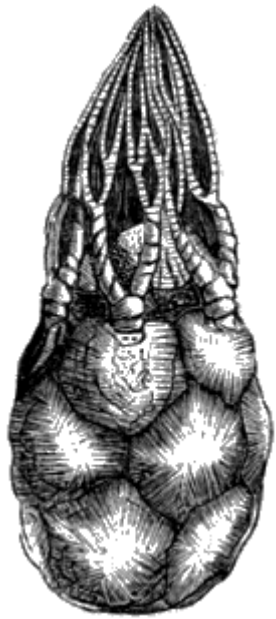
MARSUPITES MILLERI.

MARSUPITES MILLERI. *Lign.* 92, *fig.* 3, *Lign.* 96. (*Wond.* p. 652.)—The fossil remains of a genus related to the Encrinites, but separated from them by being unattached and free, having no column of support, were first described by the late Mr. Parkinson under the name of "*Tortoise Encrinite*" (*Org. Rem.* vol. ii. pl. xiii. *fig.* 24, *Pict. Atlas*, pl. xlvii.); but misled by the resemblance of some of the plates to those of certain species of Actinocrinites, Mr. Parkinson supposed the original to have possessed a jointed column. The examination of specimens obtained from the Chalk of Lewes and Brighton, enabled me to determine the true characters of the original; the purse-like form when the arms are closed suggested the name Marsupites (*purse-like*), by which it is now generally known; the specific name *Milleri*, is in commemoration of the late excellent and able author of the Natural History of the Crinoidea.

The receptacle of the Marsupite is of a sub-ovate shape, and rounded and entire at the dorsal extremity; a large central plate forms its base, on which is placed a successive series of pentagonal and hexagonal plates, the margins of which are in contact, but not anchylosed nor firmly united; to the periphery of this cup are articulated five arms, which subdivide into ten rays, or tentacula. The top of the receptacle was closed by an integument, covered by numerous small semilunar plates, in the centre of which was situated the oral aperture. The external surfaces of the plates of the receptacle are generally granulated and radiated, as in *Lign.* 92, *fig.* 3; but in

some specimens the surface is quite smooth, a character which possibly may be specific. Some examples have the surface granulated and rugous, and these Mr. Miller regarded as distinct, and named *M. ornatus*. I have not of late years been able to obtain specimens to determine this question.

The Marsupites vary in size, from an inch to three inches in length, exclusive of the arms. The receptacle is relatively very capacious compared with that of other crinoideans. The central plate is large, and of a pentagonal form, without the slightest indication of any column or process of attachment: five pentagonal plates are united to the sides of the basal plate, and above these a like number of hexagonals, which receive the five upper plates that constitute the margin; these have each a semilunar depression, to articulate with the first bones of the arms, or brachial appendages.



LIGN. 96.—MARSUPITES MILLERI,
nat.
Chalk, Lewes.

Detached plates and ossicula of marsupites are not uncommon in the Chalk of Kent and Sussex; nearly entire receptacles, filled with chalk or flint, are occasionally found in the pits near Lewes and Brighton; but examples with remains of the arms are extremely rare; and I have seen but one specimen (which I collected from the Sussex chalk), in which the plates of the integument that covered the opening of the receptacle are preserved.[289]

[289] It is figured in my *South D. Foss.* pl. xvi. *fig.* 6.

The Marsupite is an exceedingly interesting type, in a zoological point of view, since it forms a link that unites the Crinoidea with the Comatulæ, or

feather-stars, which we shall presently notice. Its general form and habits are sufficiently indicated by the numerous specimens that have been collected in the Chalk of the south-east of England.

The body of the animal was inclosed in a crustaceous case formed of large plates, articulated to each other by suture; the mouth or oral aperture was situated in the centre of the plated integumental cover of the receptacle. The organs of locomotion and prehension consisted of five arms or brachial appendages, formed of ossicula as in the crinoidea, and the whole was invested with soft tissue or integuments. When floating in the water, the creature could spread out its tentacula, and form a net to capture its prey, and by closing them, secure it, and convey it to its mouth. The figure, *Lign.* 96, is restored from specimens which separately exhibit the parts here represented in connexion.

Fossil Asteriadæ.

FOSSIL ASTERIADÆ.

The radiated animals, popularly called *Star-fishes*, from their stellular forms, are so abundant on our coasts, that the common five-rayed species must be familiar to all my readers who indulge in rambles on the sea-shore, and will serve as an illustration of the general appearance and structure of the beings whose petrified remains now claim our attention. This species belongs to the division of Asteriadæ, in which the rays are elongated, and far exceed in length the diameter of the disk; in another group (*Goniastea*, or Cushion-star), the body is angular, and the lobes or rays are short, and not longer than the

diameter; while in a third subdivision (*Comatula* and *Ophiura*), the arms are distinct from the body, and articulated, elongated, and ramified, as in the *Crinoidea*.

The external surface of the common Star-fish is soft, and attached to a tough coriaceous integument, investing a skeleton composed of an infinite number of calcareous ossicula, arranged in regular series along the margins of the rays. Each ray has a longitudinal furrow, perforated at the sides by alternating rows of pores, through which tubular tentacula are protruded. The mouth is situated in the centre of the under surface. Now if we imagine a Star-fish placed with its mouth upwards, and the five rays fringed with long articulated tentacula, as in the Comatula, and fixed by the centre of its dorsal surface upon a jointed stem, we shall have the essential characters of a crinoidean; and the animals of one recent tribe of *Asteriadæ* are actually in this condition in the earlier stage of their existence: these are the *Comatulæ*, or Feather-stars, in some of which (the *Euryale*), the arms are as numerously subdivided as in the Pentacrinites.[290]

[290] The reader interested in this subject should peruse the charming volume on British Star-fishes and other Echinoderms, by Professor Edward Forbes. 1 vol. 8vo. John Van Voorst. 1841.

From the importance of the Crinoidea in the economy of the ancient world, the history of the only type at present inhabiting Europe, the ancient seas of which swarmed with numerous forms of these beautiful creatures, presents many points of interest. The receptacle of the soft body of the *Comatula*, like that of the Crinoideans, consists of a cup-shaped

calcareous base, which sends off from its margin five arms, that quickly subdivide, and are beset on each side with rows of articulated pinnæ; on the convexity there are also numerous slender, jointed, simple, tentacula. The mouth is situated in the centre of the area surrounded by the arms, and is capable of being elongated into a proboscis. In the young state, the Comatulæ are attached by a jointed stem to other bodies, as shown in *Lign.* 91, *fig.* 1, which represents several of the natural size; *fig.* 1^{a} is an enlarged view of an individual, and closely resembles an expanded Crinoidean. The stem is composed of about eighteen joints, which are pentangular; after a few weeks the Feather-star becomes detached from its peduncle, and ranges the sea in freedom.[291]

[291] The researches of J. V. Thompson, Esq. first brought to light these interesting facts in the Natural History of the Comatula; this eminent naturalist first observed pedunculated Comatulæ in the Cove of Cork. When this discovery was first made known to me, I suspected that the *Marsupite* might have been pedunculated when young; but as very small specimens of this Crinoid are equally free from all traces of a stem as the adult, I was led to relinquish that opinion: still the collector, when searching for Crinoidean remains, should bear in mind the possibility of this having been the case.

In the Comatulidæ, the arms are distinct from the body; these animals therefore closely approach the Crinoideans: in the true Star-fish, the angular processes, or arms, are an integral part of the body, containing a portion of the stomach, ova, &c., and are furnished with rows of pseudopodia.

Fossil Comatulæ have been discovered in the Solenhofen slate; and it is not improbable that some of the numerous Crinoideans may be Asteriadæ in the early stages of development.

In another group, Asteriadæ, (named *Ophiuræ* or Serpent-stars,) the rays are long and slender, and without grooves or tentacula, and are distinct from the body. These organs are extremely flexuous, and in some species beset with spines, and enable the animal to seize and entwine round its prey. The mouth is central, and there is an ovarian aperture at the base of each of the five arms.

Though the fossil Star-fishes comprise many extinct genera, they belong to the same families as the recent; and Comatulæ, Ophiuræ, and Asteriadæ, occur in the Lias, Oolite, and Chalk, in considerable numbers. Professor Edward Forbes has determined many of the British species, and it is to be hoped, will publish a monograph on the Fossil Asteriadæ, as a companion to his delightful work on the recent Star-fishes.

FOSSIL OSSICULA OF STAR-FISHES.

FOSSIL OSSICULA OF STAR-fiSHES.—From the immense number of little bones which enter into the composition of the skeleton of a single Star-fish, and which are but slightly held together after the death of the animal and the decomposition of the soft parts, we can understand how layer upon layer of ossicula of Asteriadæ may have been formed at the bottom of the cretaceous seas; as we find them in the quarries near Arundel, Worthing, &c. Whoever has witnessed the hauling up of the dredge off our coasts, and seen the mass of living Star-fishes which it brings up, as if the sea-bottom were a living bank of

these Radiata, will not be surprised at the vast quantities of their fossil remains. This profusion of the living animals of this family, serves also to account for the enormous amount of those kindred but extinct forms, whose relics were the subject of investigation in the former part of the present chapter.

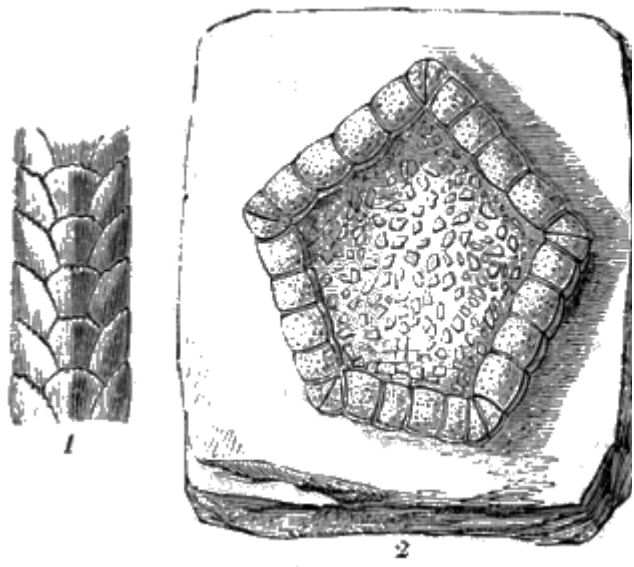
The ossicula vary in shape in different parts of the skeleton, and Prof. E. Forbes affirms, that the careful determination of their characters is of great importance, since they are the only paints of the animals likely to be preserved, and the shape of an ossicle is as truly indicative of a genus or species, as is that of a bone among the vertebrata. There is one ossicle situated on the side of the centre of the disk, which is worthy of remark, because it often occurs in the chalk mingled with the debris of the rest of the skeleton, and should be preserved by the collector. It differs from all the other bones in being marked with radiating grooves, and is called the madreporiform tubercle; it appears to be the analogue of the stem of the Crinoideæ, in other words, a rudimental condition of an organ, which is fully developed in that order of radiata.

OPHIURA.

OPHIURA. *Lign. 97, fig. 1.*—Several species of this genus, which is distinguished by the long, slender, serpent-like arms, and the circular disk covered with plates and spines, have been found in a fossil state: one species was discovered in the Lower Silurian deposits by Prof. Sedgwick, and other forms have been obtained from all the succeeding formations. The Lias near Lyme Regis and Charmouth has yielded many beautiful examples of *Ophiura Egertoni*.

Professor John Phillips has figured a species (*Oph. Milleri*, Geol. York, pl. xiii.) from the marlstone of Yorkshire, and a species from the Oxford Clay has been described as *Ophiura Prattii*. In the Cretaceous formation, remains of several species have been found. The first specimen from the Sussex Chalk that came under my notice, was discovered many years since, by my son, in a quarry at Preston, near Brighton; the rays were admirably preserved, as shown in the portion figured in *Lign.* 97. An example of this species, with the disk entire, and portions of five arms, was found by Henry Catt, Esq. and is represented in pl. xxiii. *fig.* 2, of Mr. Dixon's work. [292]

[292] Three plates are devoted to the Cretaceous Star-fishes: the descriptions by Prof. E. Forbes comprise twenty-five species, belonging to the genera Oreaster, Goniaster, Stellaster, Arthraster, and Ophiura, all from the Chalk of Sussex and Kent.



LIGN. 97. FOSSIL REMAINS OF STAR-FISHES

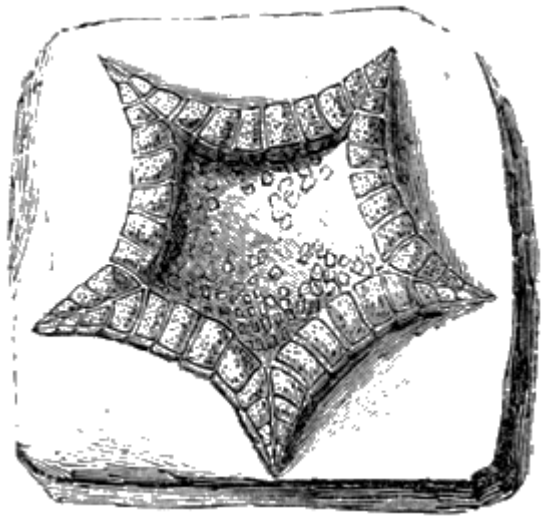
Fig. 1*a*. —Part of the ray of OPHIURA SERRATA; *nat. Chalk, Preston.* (*Mr. Walter Mantell.*)

1. —Portion of the same magnified.

2. —GONIASTER HUNTERI. *Chalk. Gravesend.*

GONIASTER—ASTERIAS.

GONIASTER. *Lign.* 97 and 98.—The star-fishes of this genus, popularly called Cushion-stars, are of a pentagonal form, and have a double series of large marginal plates, bearing granules or spines; the latter are seldom preserved in the fossils. The upper surface is nodulose.



LIGN. 98. FOSSIL STAR-FISH. *Chalk, Kent.* GONIASTER MANTELLI. (*sp Forbes.*[293])

[293] Dixon's Cret. Foss. p. 332.

The detached ossicula of the skeletons of Cushion-stars are frequent in the White Chalk; and the large central bone, the *madreporiform tubercle*,

which is present in the dorsal aspect of all star-fishes, is large, and therefore often observed, and may be easily mistaken for the base of a crinoidean receptacle. The layers in the Sussex Chalk composed of the exuviæ of star-fishes, as previously mentioned, are chiefly made up of ossicula of goniasters.

There are two species not uncommon in the Chalk, of which portions may generally be obtained from the pits near Gravesend; and occasionally very fine examples of the entire goniaster are met with. Mr. Dixon's work contains figures of several exquisite fossils of this kind. These organic remains were familiar to the early collectors: Mr. Parkinson figures several in Org. Rem. vol. iii. pl. i. and ii.[294]

[294] Pict. Atlas, pl. liii.

Goniaster Hunteri (*Lign.* 97), has the body obtusely pentagonal, and the sides nearly straight; the superior intermediate marginal plates are four, equal, broadly oblong, coarsely mamillato-punctate; the ossicula of the disk hexagonal.[295] This species is common in the upper chalk.

[295] Prof. Forbes, Dixon's Cret. Foss. p. 331.

In *Goniaster Mantelli*, *Lign.* 98, the body is pentagonal, but the sides are curved, with projecting angles; the ossicula of the disk are punctated. The superior intermediate marginal plates are oblong, narrow, punctate, marginate, and six in number.[296]

[296] Ibid. p. 332.

Specimens of these Goniasters are sometimes met with attached to a nodule of flint, in an extraordinary state of freshness; sharp imprints of the

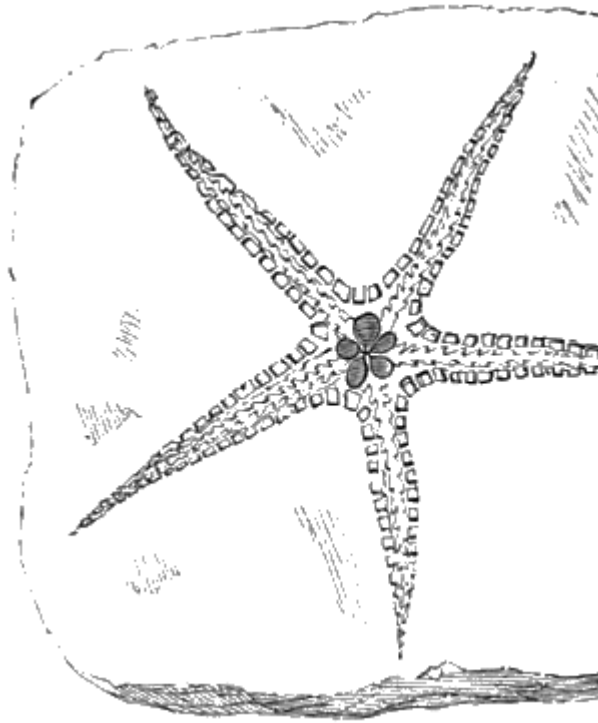
external surface, the skeleton having perished, are also found in flints, and, rarely, casts in pyrites. The whetstone of Dorsetshire often bears distinct moulds of Goniasters! I have found ossicula of this form of Star-fish in the London Clay of the Isle of Sheppey.

ASTERIAS. *Lign.* 99.—The animals of this genus, of which the common Star-fish is the type, are stellate in form; the rays are flat, and extend from the body, of which they are a prolongation—not mere appendages. They have deep grooves or furrows bordered by marginal plates, which are continued to the extremities.

The Lias of Germany has yielded several species of Asterias; one of which is figured, *Lign.* 99. A very large species occurs in the Cornbrash of the Oolite of England. A magnificent specimen of *Asterias arenicola* (Goldfuss), from the calcareous grit, near Pickering, Yorkshire, measuring $10^{1}/_{2}$ inches from the extremity of one ray to that of another, is figured in the London Palæontological Journal, pl. xvii. The same work contains admirable figures of *Ophiura Egertoni*, and *Oph. senatu* in flint, pl. xix.; *Oph. Milleri* in Staithes marlstone, and *Oph. Murravii*, pl. xx.; and two specimens of *Oph. Milleri* on the same slab of Lias from Staithes, near Whitby, pl. viii.

The Star-fishes of the British palæozoic strata are described by Prof. E. Forbes in the Memoirs of the Geol. Survey, *Decad.* 1.[297]

[297] See also Prof. M'Coy's Lower Palæozoic Fossils, p. 58.



LIGN. 99. FOSSIL STAR-FISH. *Lias, Wirtemberg.* ASTERIAS PRISCA. (*Goldfuss.*)

GEOLOGICAL DISTRIBUTION OF CRINOIDEA.

GEOLOGICAL DISTRIBUTION OF THE CRINOIDEA.—The great number of extinct forms of this order of Radiata in the most ancient fossiliferous deposits, is a remarkable fact, which has already been incidentally adverted to. In the palæozoic seas—including the Silurian, Devonian, Carboniferous, and Permian—the Crinoidea were represented by upwards of fifty genera, whose existence began and ended during that geological cycle.

According to the present state of our knowledge

all those peculiar types of radiated animals were created, and each lived through the destined period alloted to its race, and died out ere the deposition of the New Red Sandstone; not a single species, not a relic of the innumerable individuals that swarmed in the palæozoic oceans, has been observed in any strata above the Permian.

The Trias, which ranks as the earliest of the secondary formations, is characterized by the advent of two typical genera; the true Encrinus or Lily-encrinite, and the Pentacrinus; the former is unknown in any other deposits; the duration of its race was comprised within the Triassic epoch. The Pentacrinus, on the other hand, has been perpetuated through all the succeeding periods, and one species inhabits the present seas; the sole existing representative of the most ancient type of this order.

In the Oolite, another living form, the Comatula, first appears.

The ocean of the Cretaceous epoch was inhabited by five genera of Crinoids, unknown elsewhere; among them is that remarkable genus, the Marsupite.

The Crinoidea of the Tertiary seas are as few in number and variety as those of the present day; not a vestige of any of the ancient tribes has been discovered. M. D'Orbigny's *Tab.* 12 presents the phenomena thus briefly noticed, in a striking point of view.

From this review of the fossil Crinoidea and Asteriadæ, the student will be in some measure prepared for the collecting of instructive specimens from the immense accumulation of remains

imbedded in certain strata of the Oolitic, Liassic, Carboniferous and Silurian rocks.

The British species of fossil Crinoidea amount to more than two hundred, and when the great number of bones that enter into the composition of the skeleton of a single Pentacrinite or Encrinite is considered, the prodigious quantity of the fossil remains of these zoophytes in the ancient deposits may be readily conceived. Polished slices of the encrinital marbles of Derbyshire, and of the Lias limestones from Lyme Regis and Charmouth, should be obtained, as they show sections of the imbedded crinoidal stems and detached ossicula; and sometimes of the receptacles.

CHAPTER IX.

FOSSIL ECHINIDÆ, OR SEA-URCHINS.



LIGN. 100. TURBAN ECHINUS, WITH ITS SPINES
(*Hemicidaris crenularis, Agassiz.*)
Jura limestone.

The fossils we have now to examine are among the most familiar of the objects commonly known as petrifactions; for as the enveloping cases of the Echini possess considerable durability, they have served as moulds into which silex, calc-spar, limestone, pyrites, and other mineral substances, when in solution, or in a semi-fluid state, have percolated, and formed sharp and enduring casts, which exhibit the forms of the plates, and the disposition of the pores, striæ, &c. of the original structures.

The common Echinus of our sea-coasts (*Echinus sphæra*), known by the name of Sea-egg, Sea-urchin,

or Sea-hedgehog, presents the typical characters of this order of Radiata, which differs from the Crinoids and Star-fishes in the absence of arms.

The calcareous envelope of the Echinus, or shell, as it is popularly called, is composed of many calcareous, polygonal plates, closely fitted to each other, and arranged in regular and elegant patterns; appearing in the globular and spherical kinds like the lines of the meridian on a globe. The plates are disposed in ten vertical series, united by serrated sutures, and form sections, into which the envelope or case very commonly separates upon the decay of the investing integuments. Of the ten bands five are large and five small. The large bands (*areæ*) are each composed of a double row of plates, ornamented with tubercles supporting large spines (*Lign.* 100). The five narrower bands consist of much smaller plates, and the spines are minute, or altogether wanting; hence these bands appear like avenues through the spinous tracks, and have therefore been fancifully termed ambulacra or walks. They are the equivalents of the grooves or furrows of the Star-fishes (*Lign.* 108, *a.*); and are traversed by numerous pores, for the exsertion of tubular feet, or tentacula. Besides these rows of minute openings, there are two principal apertures, the mouth and the outlet or vent; and also a few large pores, commonly five, on the summit, for the exclusion of the ova, and the free admission of water.

The form and relative position of the parts above described, afford characters by which the order is divided into genera. The mouth, which is situated on the lower part, is in some species furnished with five sharp angular teeth, attached to a calcareous framework that admits of being protruded; this

apparatus, when entire, commonly bears the name of "*Diogenes' lantern*." The eminences on the surface of the plates vary in size from mere granules, or papillæ, to large mamillated tubercles; they serve for the attachment of movable spines, which also present great variety of form and ornament. The spines have a cup-like cavity at the base which fits on the papillæ, and in many species are only supported by the capsular envelopment of the common integument; but in others, the large spines are attached by a ligament which passes from the centre of the socket, and is received in a perforation of the papilla of each tubercle, in the same manner as the *ligamentum teres* of the human thigh-bone. Transverse slices of the spines exhibit the internal structure, and are beautiful objects under the microscope.

There are also minute appendages to the integument, called *pedicellariæ*, or pinchers, of a very remarkable character, whose functions are not known. They are slender columnar bodies, each crowned with three calcareous teeth-like spines, beautifully sculptured, and which in some species are long and slender, in others short and obtuse. I have not observed any traces of these bodies, even in the best preserved echinites, but as they are as durable as the spines and case, they may exist in a fossil state.

TURBAN ECHINITES.

This general view of the structure of the recent Echinites will enable the student to understand the nature of the fossil remains; for the parts above described, are found more or less perfectly preserved, either in their natural arrangement, or separated and dispersed in the rock. The habits of these animals, of

burrowing in the sand, were favourable to their preservation in a mineralized state; and in some of the oolitic limestones, hundreds of beautiful examples of Turban Echinites (*Cidares*), having their spines spread out on the face of the rock, are found lying in the positions they evidently occupied when living. The quarries near Calne and Chippenham, in Wilts, are celebrated for such fossils.

It was my intention to give figures of the genera into which the numerous fossil species have been divided by modern authors: but I found the attempt hopeless, from the changes in nomenclature and arrangement which are constantly taking place. The monographs on the fossil Echinidæ, by Prof. E. Forbes, now in course of publication by the Government School of Mines, will, when completed, place this branch of Palæontology on a satisfactory basis.

For the convenience of study, the fossil Echini may be separated into three principal groups; viz. the CIDARITIDÆ, or Turban Echinites; the CLYPEASTERIDÆ, or Buckler-shaped Echinites; and the SPATANGIDÆ, or Heart-shaped Echinites.

CIDARITIDÆ.

CIDARITIDÆ. *Turban Echinites.*—In these sea-urchins the vent is situated on the summit of the shell, and is surrounded by five minute apertures for the exclusion of the ova. The mouth, or oral aperture, is placed directly opposite, in the middle of the base, or inferior surface. The mouth is large, and furnished with a powerful apparatus, armed with teeth; which is sometimes found fossil (see *fig.* 1, 3, *Lign.* 101). The structure of the animal, in consequence of the symmetrical position of the two

chief outlets of the shells, is strictly radiated; that is, all the parts proceed from, or are arranged around one common centre. The tubercles are larger and fewer than in the other tribes of this family; they support long and powerful spines, which vary much in form and ornament in different species (see *Lign.* 102). The larger tubercles and spines are beset with smaller ones, disposed in regular series.

The Turban Echinites are the most ancient types of the order, some forms appearing in the Carboniferous deposit. The species are very numerous. The echinites of this group are subdivided into four tribes:

1. *Cidares*, properly so called.—In these the tubercles are perforated; the ambulacra narrow, and beset with granular tubercles, and the two lines of pores are close together. The pseudopodia can be protruded to a great length, even beyond the spines, so as to reach objects the latter could not touch.

2. *Echini*, which differ from the above in the tubercles being imperforate, and the ambulacral area wide: the spines and tubes are of a moderate size.

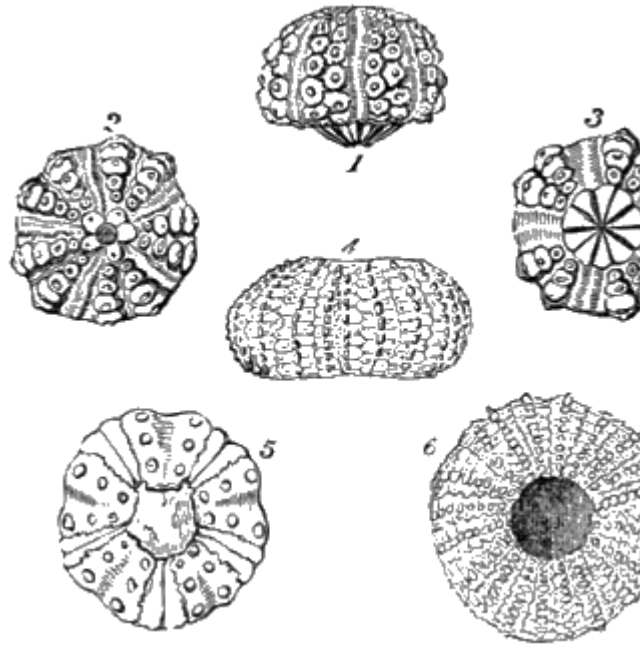
3. *Diademæ.*—The tubercles are perforated, and the ambulacra wide and studded with large tubercles.

4. *Saleniæ.*—The tubercles are imperforate, and relatively large; the chief distinction is a solid ovarian disk on the summit, composed of several large flat plates, anchylosed together.

The case of the Turban Echinites is composed of twenty vertical series of plates, the ambulacra, or porous grooves, forming continuous bands from the

summit to the mouth, which is armed with five angular teeth. This tribe comprises many of the most elegant fossil species; those which, from their shape and highly ornamented surface, have received the popular name of Fairy's night-caps. The genus *Cidaris*, which is characterized by perforated spinous tubercles, affords the most beautiful examples, and these are occasionally found with the spines in contact; a circumstance less rare than might be supposed, when the nature of the attachment of these organs is considered; for, upon the decomposition of the integument, and the ligaments which connect the spines with the tubercles in a living state, these appendages quickly fall off, even in recent specimens.

The interesting fossil figured *Lign.* 100 (*ante*, p. 311.), is a choice example of a Cidarite with the spines attached. This species (*Hemicidaris crenularis*, *Agassiz*) is said to be characteristic of the Upper Jura limestone of Switzerland, and was supposed to be identical with Mr. Parkinson's *Cidaris parpillata var.* (*Pict. Atlas*, pl. lvi. *fig.* 6), from Calne, in Wiltshire; but spines like those of *Lign.* 100, do not occur in the English oolite. These spines are not homogeneous throughout; the central part appears to have been of a less dense tissue than the outer coat, as is shown in the fractured spine in the figure. This structure does not exist in the spines of the depressed Turban Echinites, but is stated by M. Agassiz to prevail in all the species of the genus *Hemicidaris*, of which the fossil figured in *Lign.* 100 is the type.



LIGN. 101. CIDARITES FROM THE OOLITE AND CHALK.

Fig. 1.— HEMICIDARIS INTERMEDIA; view in profile, showing the teeth projecting: $^1/_3$ *nat. Calne.*

2.— The same seen from above, displaying the outlet, and surroun

3.— The same, view of the base, displaying the mouth, surrounded by five angular bipartite teeth. The ambulacral tubercles at the base are omitted in the figure.

4.— DIADEMA ROTULARE (*Agass.*): viewed in profile: not.

5.— A siliceous cast of another species of *Diadema*. *South Downs.*

6.— View of the base of DIADEMA ROTULARE. This species occurs in the so-called Neocomian Formation of France.

CIDARIS (*Hemicidaris?*) INTERMEDIA, *Lign.* 101, *fig.* 1, 2, 3.—The shell of this echinite, from the Oolite at Calne, so closely resembles that of *H. crenularis*, above described. that without the spines it could not be distinguished.[298] It is of a depressed form, and has very long subcylindrical spines; a specimen is figured *Lign.* 102, *fig.* 9. It is this cidarite

which occurs in such immense numbers in the Oolite at Calne, Chippenham, Faringdon, &c. Slabs of limestone are occasionally extracted from the quarries at Calne, with more than thirty of these echinites surrounded by their spines. I have one specimen, attached to a block of limestone, with fifty spines; but it is difficult to detach a perfect spine.

[298] Mr. Woodward. I am indebted to this gentleman for many valuable remarks on fossil Echinoderms.

CIDARIS BLUMENBACHII.

CIDARIS BLUMENBACHII. *Lign.* 127, *fig.* 3.—This is another beautiful characteristic Turban Echinite of the Oolite. The tubercles are very large and prominent, and the spines remarkably neat, being covered with longitudinal granulated striæ; they are of an elongated cucumerine form, and homogeneous in structure (*Lign.* 127, *fig.* 5). They occur by hundreds in some of the layers of friable stone in the quarries around Calne.

Many species of Turban Echinites abound in the White Chalk, especially near Gravesend, Northfleet, Purfleet, Charlton, and other places in Kent; the softness of the cretaceous strata in those localities rendering the removal of the chalk an easy task. Splendid specimens, with the spines and tubercles almost as fresh as if recent, have rewarded the patience and skill of collectors. The British Museum contains many fine examples, especially a specimen of *Cidaris clavigera* from Charlton, with sixteen spines, and the dental apparatus *in situ*.[299]

[299] Several coloured figures of Cidarites and spines are given in Pict, Atlas, pl. liii. and lvi. A fine series of Chalk specimens are figured

in Dixon's Fossils, tab. xxv.; many from the choice cabinet of Henry Catt, Esq. of Brighton.

The collection of Chalk Cidarites with their spines, formed by W. H. Taylor, Esq. F.G.S., of Winterslow-place, Brixton, is the most splendid assemblage of these fossils I have seen.

DIADEMA. *Lign.* 101, *fig.* 4, 6.—The shell in this genus is of a more depressed form than in Cidaris; there are two rows of large tubercles, which are crenulated and perforated, on the ambulacra as well as on the interambulacral spaces. The spines are slender and annulated. Mr. Woodward remarks that the common Chalk species referred by authors to this genus, belong to the sub-genus *Cyphosoma* of M. Agassiz, in which the tubercles are imperforate. There are nearly fifty fossil species known, and they range from the Lias to the Chalk. The recent analogues inhabit the seas of warm regions.

ECHINUS.—The shells of the genus Echinus resemble those of Cidaris in their general structure, but the tubercles are imperforate. More than twenty fossil species are described, from the Oolite and Chalk.

SALENIA.—In the greensand pits near Faringdon, in Berkshire, which abound in fossil sponges and other poriferæ (*ante*, p. 228.), there are immense numbers of a small elegant Turban Echinite, which belongs to the genus thus named by the eminent zoologist. Dr. J. E. Gray, of the British Museum. The collector will easily recognize these sea-urchins by the plated summit. The shell has five ovarian and five interovarian plates, and an eleventh or odd one. The tubercles are crenulated. The common species at Faringdon is *S. petalifera*, of Desmarest. Two species

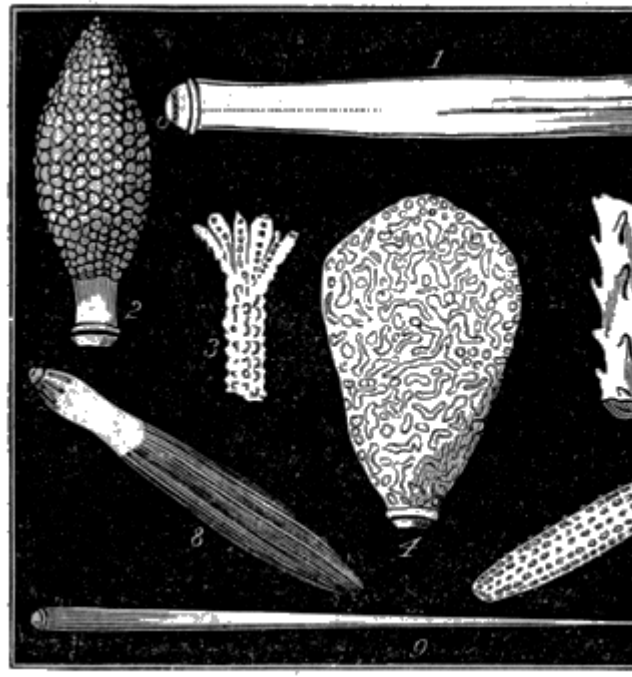
of this genus, viz. *S. scutigera* and *S. stellulata*, from near Warminster, are figured in *Pict. Atlas*, pl. liii. *fig.* 12, 13.

Cidarites of New Zealand.—Detached plates and spines of sea-urchins, belonging to the family Cidaritidæ, have been discovered by Mr. Walter Mantell, in the Ototara limestone of New Zealand; which is a fawn-coloured stone, composed of foraminiferæ, like the Chalk, and containing terebratulæ, corals, and teeth of sharks.[300]

[300] Geol. Journal, vol. vi. p. 319.

SPINES OF CIDARITES.

SPINES OF CIDARITES. *Lign.* 102.—Allusion has been made to the immense numbers of the spines of two or three kinds of Cidarites that occur in the oolitic limestones of certain localities. The spines of other species and genera abound in the Chalk, Greensand, &c.; occurring detached and intermingled with corals, shells, and the usual fossils of those deposits. There is great variety in the form, size, and sculpture of these organs. In the subjoined *Lign.* 102, a few distinct kinds are represented.

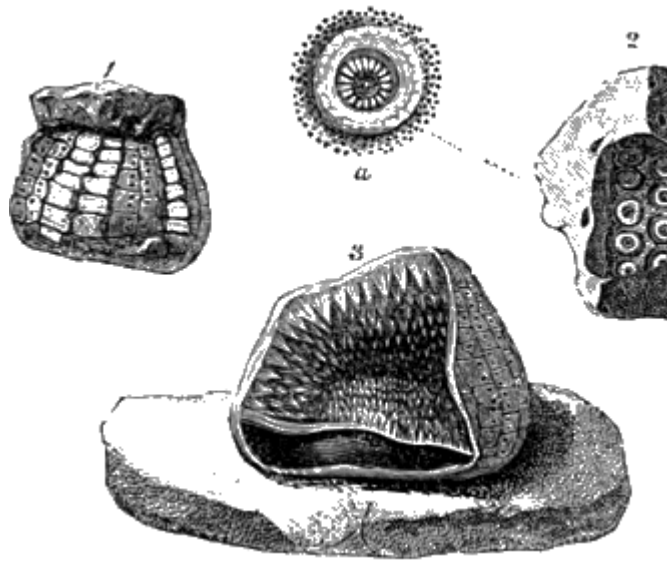


LIGN. 102. FOSSIL SPIKES OF CIDARITES

Fig. 1.— Spine of ACROCIDARIS nobilis (*Agassiz*).
2.— —— CIDARIS cucumifera.
3.— —— —— stemmacantha.
4.— —— —— meandrina.
5.— —— —— spinosa.
6.— —— —— clunifera.
7.— —— —— sceptrifera.
8.— —— —— Parkinsoni.
9.— —— HEMICIDARIS intermedia.

FLINT CASTS OF TURBAN ECHINITES. *Lign.* 103.— The siliceous casts of the shells of the Turban Echinites are interesting objects, for they are often beautiful models of the interior. A specimen of this kind is represented in *Lign.* 101, *fig.* 5. Casts of the

larger Cidarites are often seen on the ploughed lands of the South Downs, in beds of gravel, and among the shingle on the sea-shore of chalk districts; appearing as flattened spherical bodies, with a circular protuberance at each pole, and vertical rows of nodular projections. Impressions of the external surface of the cases are also frequent on chalk-flints, and exhibit exquisite casts, in intaglio, of the mamillated tubercles, and ambulacral grooves and pores.



LIGN. 103. ECHINITAL REMAINS IN FLINT. *Chalk. Lew*
(*One-third the natural size.*)

Fig. 1.— Cast of an ANANCHYTE, showing the form of the plates.

2.— Imprint of a segment of a CIDARITE on a pebble. *a.*—One of the impressions of a spinous tubercle: *nat.*

3.— Portion of an Ananchyte, having the cavity of the shell covered at the bottom with flint, and lined above with crystals of carbonate of lime.

A fragment of a flint, impressed by a portion of a

Cidarite, is represented *Lign.* 103, *fig.* 2. The perforations around the imprint indicate tubular cavities in the flinty formed by the spines, and show that these processes were attached to the shell when the latter was enveloped by the fluid silex; the case and the spines having since perished. But in the Chalk, exquisite specimens of Cidarites occur with the case perfect, and filled with flint: examples of this kind are often attached to a nodule by the slender column of silex that fills up the aperture of the shell. The mineralized condition of the originally friable calcareous cases of Cidarites and other Echini, is worthy of attention: for whether the shell or spines be imbedded in chalk, flint, or pyrites, if the structure and form remain, the constituent substance is invariably opaque crystallized carbonate of lime, having an oblique fracture.

As this conversion of a crustaceous envelope into calc-spar is constant, it has probably resulted from the peculiar nature of the original animal structures; but the cause of such transmutation is unknown.

CIDARITIDÆ OF THE PALÆOZOIC ROCKS.

CIDARITIDÆ OF THE PALÆOZOIC ROCKS.—Three genera of this family, comprising several species, have been discovered in the carboniferous limestone of Northumberland and Ireland. One genus is undistinguishable from Cidaris; and the species are placed under that name in Mr. Morris's Cat. Brit. Foss.

These fossils have been figured and described by Prof. John Phillips, and Col. Portlock. Prof. M'Coy, with his accustomed penetration and sagacity, has ascertained, that notwithstanding the general resemblance between the Cidarites of the secondary and those of the palæozoic formations, the latter are constructed on an entirely different plan. In the turban echini of the secondary, tertiary, and modern seas, the interambulacral plates always consist of *two* rows; but in the palæozoic Cidarites there are *three* or some greater odd number of these plates. This eminent naturalist, therefore, places the earliest type of Echinidæ at present known in the order *Perischoechinidæ*. The case is spheroidal, formed of more than twenty rows of plates; five ambulacra composed of two rows of pentagonal plates each; rows of interambulacral plates, three, five, or more, terminating dorsally in five large pentagonal ovarian plates.

As in the more recent forms, these Cidarites are separable into two groups or families; one in which the spiniferous tubercles are imperforate as in the Echinus (*Palæchinidæ* of M'Coy); the other with numerous small secondary tubercles and a few large primary ones, perforated for the ligament of the spine as in Cidaris (the *Archæocidaridæ* of M'Coy).

[301]

[301] Prof. Sedgwick's "British Palæozoic Fossils," p. 124.

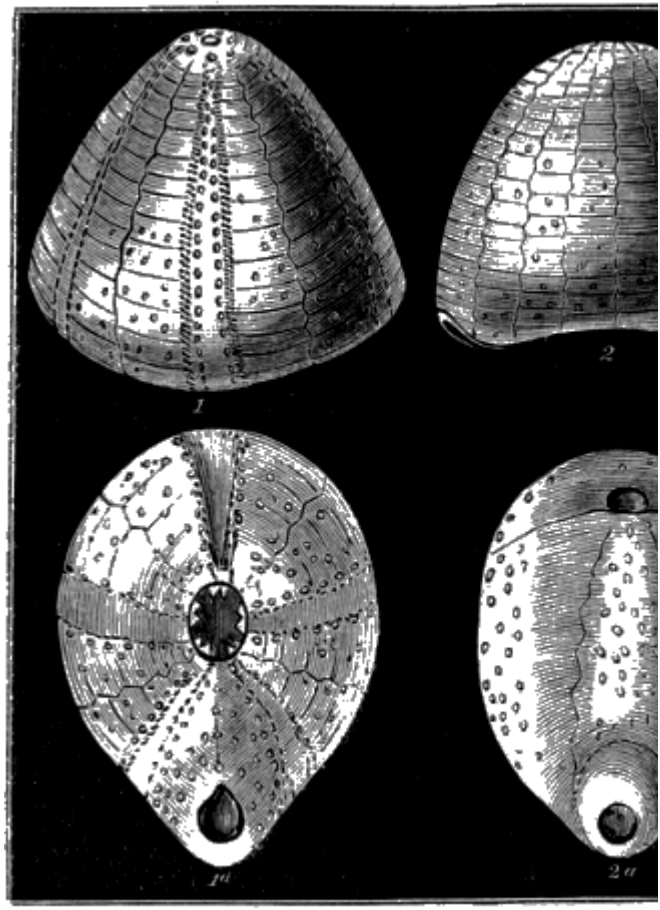
CLYPEASTRIDÆ.—The shell in this family of sea-urchins, is oblong or rounded; the mouth is of an angular form, and situated in the middle of the base or inferior face; it is furnished with well-developed dental organs. The outlet is distant from the summit. The tubercles are mere granulations, and the spines proportionally small. This group is subdivided into two tribes: the GALERITIDÆ (*helmet-like*), and the CLYPEIDEÆ (*buckler-like*).

GALERITES ALBO-GALERUS. *Lign.* 104.—The tribe of which this genus is the type has the shell inflated, orbicular, oblong, or pentangular. The ambulacra are simple, never petaloid; the poriferous zones extend uninterruptedly from the summit to the mouth.

In the species figured *Lign.* 104, *fig.* 1, the shell is of a conical form, in some varieties subpentagonal; narrowest at the hinder part. The mouth is of a decagonal shape, and armed with teeth: it is situated in the centre of the base (*Lign.* 104, fig, 1[a]); the outlet is near the posterior margin of the base. The surface of the shell is covered with granulations irregularly distributed. This species, which received the name of *albo-galerus*, from its fancied resemblance to the white conical caps of the priests of Jupiter, occurs in great numbers and perfection in the Kentish chalk; it is less common in that of Sussex. Siliceous casts of the shell are constantly found among the drift and gravel, and on the ploughed lands of chalk districts; they are popularly termed "*sugar-loaves*." The specimens obtained from the chalk, when filled with flint, yield exquisite casts, if

the shell be dissolved in dilute hydrochloric acid; by this means the form of the plates, and casts of the minutest ambulacral pores are obtained.

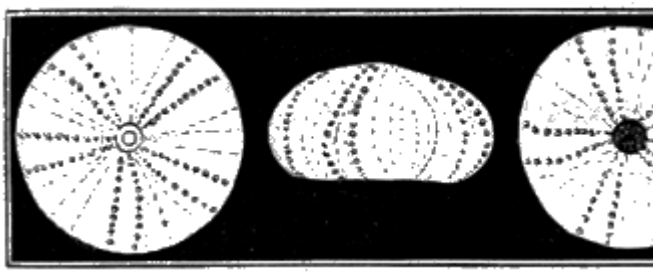
ECHINITES FROM THE CHALK.



Lign. 104. ECHINITES FROM THE CHALK. *Lewes*

Fig. 1.— GALERITES ALBO-GALERUS: *nat.*
1a.— Base of the same, with the five teeth.
2.— ANANCHYTES OVATUS: $^1/_2$ *nat.*

2[a].— Base of the same.



LIGN. 105. HOLECTYPUS (*Galerites*) INFLATUS.
Kimmeridge Clay, Switzerland.
The left-hand figure shows the summit; the middle figure a profile; ai
view of the base, with the mouth in the centre, and the outlet towar
Agassiz).

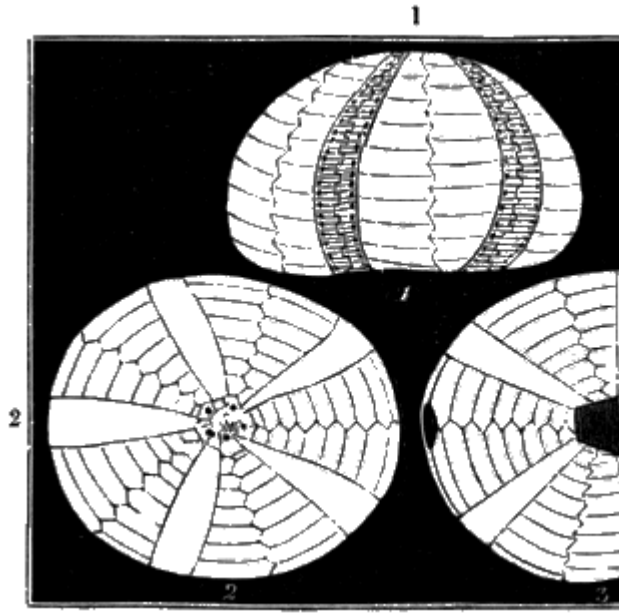
HOLECTYPUS (*Galerites*) INFLATUS. *Lign.* 105.—In certain kinds of Galerites, the shell is strengthened internally by five strong ribs or projections, which of course leave corresponding deep furrows or channels on the flint casts moulded in them; such fossils are not numerous on the ploughed lands of the South Downs. These echinites are placed by M. Desor in the genus of which an example is figured in *Lign.* 105.

The shell is hemispherical, and circular; the base flat; the tubercles are disposed in series; the inside of the case is supported by ribs.

DISCOIDEA CASTANEA.

DISCOIDEA (*Galerites*) CASTANEA. *Lign.* 106.—The Galeritidæ, which have a polygonal mouth, with the tubercles disposed in vertical rows from the summit to the centre of the base, as in the Cidarites, instead of being uniformly spread over the surface, as in *G. albo-galerus*, are placed in the genus *Discoidea*, by M. Agassiz.

A species, in which the mouth is pentagonal, and the outlet on the margin, occurs in the Chalk-marl of Sussex, Dorset, and the Alps; a specimen is figured in *Lign.* 106.



LIGN. 106. DISCOIDEA (*Galeritcs*) CASTANEA. *Chalk-r*

Fig. 1.— Profile. The pores and plates of the ambulacra only are inserted in this figure.

2.— View from above.

3.— The base, showing the central pentangular mouth, and the vent in the margin.

The CLYPEIDEÆ differ from the tribe of echinites last described, in the ambulacra being petaloid, that is, of a leaf-like shape, and disposed in a stellated figure on the upper part of the shell. The ambulacra do not extend to the mouth. The shell is generally of a depressed form; and the petaloid ambulacra in many species appear like an elegant star, richly fretted, spread over the shell. There are numerous

species of this type, both recent and fossil; many of the latter, being of a large size, are beautiful objects in a cabinet of petrifactions.

CLYPEUS SINUATUS (*Pict. Atlas*, pl. liv. *fig.* 1).—Of this genus, which is the type of the tribe, a large species, *C. sinuatus*, is very common in the Oolite of Wilts, Gloucestershire, and Oxfordshire, and must be familiar to collectors. The shell is circular, and much depressed; and has five petaloid ambulacra: the odd interambulacral area forms a deep furrow in which the outlet is situated: the mouth is median, pentagonal, and surrounded by a strong margin. The coloured figures in *Pict. Atlas*, pl. liv. will enable the student to recognize these fossils without difficulty. Splendid specimens of an allied form (*Clypeaster*) occur in the tertiary limestone of Malta, (*Pict. Atlas*, pl. lvi. fig. 7,) and are not uncommon in collections.

NUCLEOLITES (*Wond.* p. 328).—There is a small type belonging to this family, of which several species are so abundant in the Oolite, Greensand, and Chalk-marl, that a brief notice of their characters may be useful. The shell is oblong and inflated, rounded in front and flat behind. The pores are united by grooves; the outlet is in a deep furrow on the superior face; the mouth is sub-central. One species occurs in the Tertiary strata, and there is a recent species inhabits the seas of Australia. There are coloured figures of Nucleolites in *Pict. Atlas*, pl. liv. fig. 5, pl. lv. figs. 6, 8.

SPATANGIDÆ.—In this tribe of echinites, the case is oblong or cordiform. The mouth, elongated transversely and destitute of proper jaws, is situated in front of the centre of the base, near the anterior border of the periphery. The outlet is towards the

posterior margin. The tubercles and spines are very small. Four subdivisions are established, namely,—

1. *Ananchytes*.—A thick and oval shell; the ambulacra simple and converging towards the summit; the mouth transverse; the outlet is situated on the inferior face. (*Lign.* 104, *fig.* 2.)

2. *Spatangus*.—This name is now restricted to those Spatangidæ in which the ambulacra are petaloid, the external row of pores slightly elongated, and the inner rows round.

3. *Micraster*.—By this term are now distinguished the Spatangidæ which have the ambulacra depressed, and the shell cordiform. The pores of the even ambulacra are united by a furrow. The vent is on the posterior face. The common chalk Spatangus belongs to this genus. (*Lign.* 107.)

4. *Holaster*.—The shells are heart-shaped; the ambulacra simple, and converging towards the summit; the mouth is transverse; the outlet is within the posterior face.

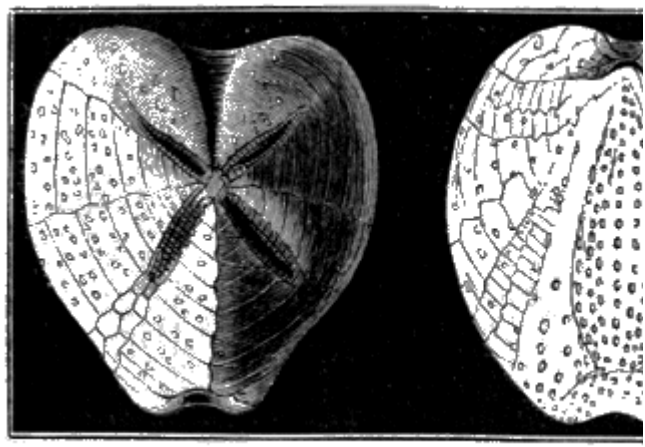
ANANCHYTES OVATUS.

ANANCHYTES OVATUS. *Lign.* 104. *fig.* 2.—These sea urchins are among the most characteristic of the fossils of the Upper Chalk, and are peculiar to the Cretaceous formation. They are readily distinguished by their elevated helmet-like form, and by the transverse mouth and oblong outlet situated on the inferior face of the flat base, and towards the margin. (*Lign.* 104. *fig.* 2[a].)

The vernacular names of "*Shepherd's Crown*," and "*Fairy Loaf*," indicate the form of these abundant fossils. The shell is oval in its longest diameter; flat,

or nearly so, below; and rounded, conical, and somewhat laterally compressed towards the summit. The ambulacra are five, between double lines of pores; the tubercles are minute and scattered; the substance of the shell is of great thickness. More than twenty species of the genus are known.

The helmet Echinites, like the preceding, have given rise to innumerable siliceous casts, which are found associated with those of other forms in the Drift, on the ploughed lands, and among the shingle on the sea-shore; they are often placed as ornaments on the mantel-shelves of the cottagers. A flint cast of an Ananchyte, in which the plates were partially separated, is represented *Lign.* 103, *fig.* 1. The shells are sometimes filled with pyrites; and occasionally are found partially empty, with crystals of calc-spar symmetrically arranged on the inside of the shell, parallel with the rows of ambulacral pores. *Lign.* 103, *fig.* 3, is a remarkable example, in which flint occupies the base of the shell, while the upper surface is lined with crystals of calcareous spar.



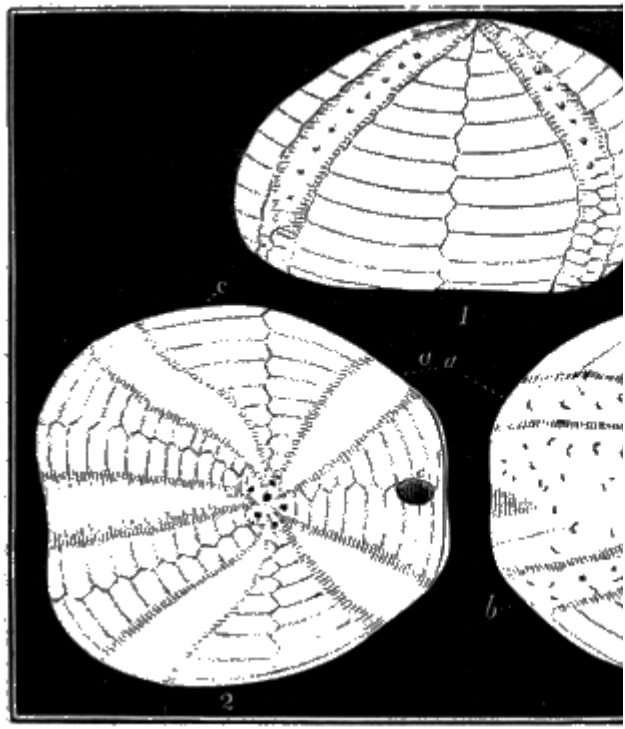
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LIGN. 107. MICRASTER (*Spatangus*) COR-ANGUI
Chalk. Lewes.

Fig. 1.— View from above, showing the petaloid ambulacra.
2.— View of the base, with the mouth.

MICRASTER COR-ANGUINUM (*Snake-heart*). *Lign. 107.*—Of this genus there are many species in the Chalk. This type of Spatangidæ are more or less oval, elongated, and heart-shaped, wider before than behind, with a sulcus, or furrow, in front. The shell is fragile, and composed of large polygonal plates; the tubercles small and irregularly distributed; the spines are short. The mouth is transverse, situated anteriorly, and protected by a strong projection of the odd interambulacrum, which is named the lip. The vent is terminal, and placed above the margin. There are but four ambulacra, and these are incomplete, comparatively of small extent, and situated in deep furrows. A large and new species of Micraster (*M. cor-bovis*, of Prof. E. Forbes), from the Sussex Chalk, is figured in Dixon's *Fossils*, pl. xxiv. figs. 3, 4, p. 342.

TOXASTER COMPLANATUS.



LIGN. 108. TOXASTER COMPLAN
Greensand. Switzerland.

Fig. 1.— Profile.
2.— View of the summit, showing the *Vent* at the side; *e*.
3.— View of the base, displaying the situation of the mouth, and the union of the five *ambulacra*; their pores are not introduced in figs. 2 and 3.
a. The narrow porous divisions of the shell, termed *Ambulacra*
b. Interambulacral spaces.
c. Areæ, or spaces covered by the wide plates.
d. The *Mouth*.
e. The *Vent*, or *Outlet*.

TOXASTER (*Spatangus*) COMPLANATUS. *Lign.* 108. —In this form of Spatangus (constituting the genus *Toxaster Agass*.), the ambulacra are not depressed or furrowed, as in the preceding echinites, nor petaloid

(*leaf-shaped*), as in those which M. Agassiz denominates true Spatangi, but converge to a point on the summit, as is shown in *fig.* 2; the external rows of pores are elongated horizontally, and form a kind of furrow. The odd ambulacrum is in a deep groove. The mouth is transverse, *fig.* 3, *d*; and at the anterior part of the inferior face there is a depression, which results from the convergence of the ambulacral areæ towards that point. The vent is in the posterior face. This species is from the *Neocomian* strata of France; I introduce it to illustrate the characters of several other echinites, which the French geologists suppose to be confined to the so-called Neocomian formation; but which also occur in the Upper Greensand of Blackdown.

HOLASTER is another genus of Spatangidæ established by M. Agassiz, for those echinites that are heart-shaped, with simple ambulacra converging towards the summit. The mouth is elongated transversely; the outlet is on the posterior face. A specimen first described in my *Foss. S. D.* (*pl.* xvii. *fig.* 9, 21), as Spatangus planus, is common in the Lower Chalk, and Chalk-marl, and abundant in the Firestone Malm-rock.

Our limits will not allow of a more extended notice of the fossil *Echinidæ*. The student should consult the Memoirs on the genera, now in course of publication at the Government School of Mines, by Professor Edward Forbes; the plates are exquisite, as works of art, and the descriptions all that can be desired.

Mr. Dixon's work contains three excellent plates of cretaceous Echinites. Several chalk species are

figured in my Foss. South Down. The numerous coloured figures of fossil sea-urchins in the Pictorial Atlas of Organic Remains, have already been mentioned.

GEOLOGICAL DISTRIBUTION OF ECHINITES.—No vestiges of this order of radiata have been discovered in the Silurian deposits: the earliest known occurrence of any type is in the Carboniferous formation. The most ancient Echinidæ, according to the present state of our knowledge, are the Cidares, in the modified form previously noticed,—*Archæocidaridæ* (*ante*, p. 322.).

In the Trias another type appears, *Hemicidaris*, which holds an intermediate place between the Cidarites properly so called and the Diadema.

In the Oolite, and Jurassic formations, numerous forms are for the first time met with, constituting the genera Echinus, *Clypeus*, *Disaster*, *Holectypus*, Diadema, Nucleolites, &c.

The Cretaceous seas swarmed with echini belonging to genera of which no traces have been found in earlier rocks; viz. Holaster, *Salenia*, *Micraster*, Salerites, Discoidea, *Ananchytes*, Cassidulus, &c.

In the Tertiary formations, Spatangus, Scutella, Clypeaster, and other new genera appear, and many of the ancient ones are absent; or at least have not been observed. Of the genera printed above in italics, no living species are known.

ON COLLECTING FOSSIL ECHINODERMATA.

ON COLLECTING AND DEVELOPING FOSSIL ECHINODERMATA.—In the previous remarks on the

fossil remains of radiated animals, we have pointed out those remains that are the most important and instructive, and should be sought for by the student. Thus, in collecting Crinoids, the receptacle or body should be the principal object of research, and if only detached plates can be extracted from the rock, their relative position should be carefully noted, and the specimens glued to a card or board, in their natural order; and some of the ossicula of the column, and of the arms, or tentacula, be placed with them.

Mr. Miller dissected specimens of every genus, and has figured the separate plates or bones that enter into the composition of the receptacle,[302] and arms. Traces of the tentacula, and their subdivisions, must be sought for, and if discovered, should be removed with the stone to which they are attached, and the block be afterwards reduced in size by a mason's saw, and not by the blows of a hammer, which might displace the ossicula.

[302] Natural History of the Crinoidea.

If imbedded in Lias shale, or other fragile material, a thick slab should be removed, for greater safety in conveyance; this, when reduced to a convenient size and thinness, may be imbedded in a tray with plaster of Paris, or glued to a piece of thin, well-seasoned mahogany, or deal. The specimens of the *Pear Encrinite* of Bradford, and of the Pentacrinites from Lyme Regis, in the British Museum,[303] were prepared in this manner.

[303] Petrifactions, p. 78.

The crinoideal remains in Chalk belong but to few genera; they merely require the usual manipulation of cretaceous fossils. The collector,

however, should remember that the ossicula and plates of the receptacle (as for instance of the *Marsupites*), are but slightly adherent to each other, and the chalk must not be wholly removed, or these parts will become detached.

The receptacles of the Apiocrinites of the chalk are rarely found with more than a few joints of the column attached; and I believe no vestiges of the arms have been observed: these parts are therefore desiderata, and should be diligently sought for: the radicles of these crinoideans are long, articulated, and branching, and without due caution may be mistaken for the arms, or for another species. The first remark will also apply to the Marsupite; any specimens with but a few ossicula of the arms are very precious. I may observe that there is yet much to learn as to the number of species and genera, and the peculiar characters of the Crinoidea of the chalk, and that any addition to our knowledge on this subject will be valuable.

The *Asteridæ* are so simple in form and structure, that it is unnecessary to offer any suggestions for their development; of course they must not be removed from the stone.

Among the detached ossicula dispersed through the chalk, the student will remember that the large *madrepore-like* tubercle of the Star-fishes, (*ante*, p. 304.,) may often occur. It may easily be mistaken for an encrinital body, or for a coral, but an accurate inspection will show that it is not composed of anchylosed plates, like the receptacle of an Apiocrinite, but has surfaces for attachment to other ossicula; while the ends, which in a crinoideal column would have radiated surfaces, are rounded

and entire.

In collecting Echinites, much caution is required in dissecting specimens surrounded by spines. If imbedded in hard limestone, or in laminated clay, it is scarcely possible to preserve the spines in connexion with the shell; but it often happens that the Cidarites of the Oolite are attached by the base to the solid limestone, and the case with the spines is imbedded in sandy, friable aggregate, not difficult of removal. A specimen in my cabinet, with upwards of fifty spines attached to the shell, was obtained under such circumstances.[304]

[304] Now in the British Museum.

The Chalk Echinites will be found to possess spines more frequently than is commonly supposed, if care be taken to explore the surrounding chalk before it be removed. T have often procured Cidarites with spines, when there were no apparent vestiges of these appendages, by carefully scraping away the surrounding mass until the extremity of a spine appeared, and then tracing it up to its connexion with the shell; another point was discovered by further removal, and that was developed in the same manner; and at length a Cidaris with several spines was obtained. The chalk around the mouth should always be cautiously removed in the dentated species, in the hope of preserving the teeth, as in the specimens, *Lign.* 101, *fig.* 1, and *Lign.* 104, *fig.* 1.

As the shells of Chalk Echinites, when hollow, are often lined with crystals (see *Lign.* 103, *fig.* 3), it is worth while to break all indifferent specimens of the common species, with the chance of obtaining an

example of this kind.

The chalk must not be *scraped off* from the crust or shell of the Echinites, or the minute granulations and papillæ will be injured or removed; it should be flaked off with a blunt point.

In friable arenaceous strata, as in some of the Maestricht and Tertiary deposits, the Echinites may be extricated in as perfect a condition as if fresh from the sea; it is, indeed, probable, from the habit of these animals of burrowing in mud and sand, that in many instances they were entombed alive by the sediment in which their fossil remains are imbedded.

Beautiful Cidarites and their spines may be collected in the Oolitic strata at Calne, Chippenham, Bath, &c.; and in the coralline Oolite near Faringdon; and of Saleniæ, in the Greensand gravel-pits near that town.

The Upper Greensand near Warminster, and at Chute Farm, near Heytesbury, abounds in small Cidaritidæ and other echinites. The large sinuated Clypeus is found in great perfection in the Oolite at Malton, Cheltenham, Gloucester, &c.

The cretaceous echinites are to be met with in most localities of the white chalk. The chalk-pits in Kent, especially at Gravesend, Northfleet, Chatham, &c. are rich in Cidarites, and their spines. The Galerites, and Ananchytes, are also very fine and numerous; and the softness of the chalk renders their extrication from the stone a delightful task for the young geologist.

Specimens of the common kinds of fossil Echinoderms may be obtained at moderate prices of

the dealers named in the Appendix.

There is a matchless suite of fossil Echinidæ in the British Museum, which has been arranged and named by Mr. S. P. Woodward, and is now the most instructive and interesting collection extant. It contains examples of the following genera, viz., Ananchytes, Echinocorys, Echinolampas, Holaster, Galerites, Cidaris, Diadema, Acrosalenia, Glypticus, Disaster, Pygurus, Clypeaster, Scutella, Salmasis, Echinocyanus, &c. There is also a good series of echinital spines.

CHAPTER X.

FOSSIL FORAMINIFERA— MICROSCOPICAL EXAMINATION OF CHALK AND FLINT.

"Where is the dust that has not been alive?"
YOUNG.

That those infinitesimal forms of animal existence which swarm throughout the waters of the ocean, but whose presence can only be made manifest by the aid of the microscope, are preserved in a fossil state,—that their durable remains constitute mountain ranges, and form the subsoil of extensive regions,—and that the most stupendous monuments

erected by man are constructed of the petrified relics of beings invisible to the unassisted eye,—are facts not the least astounding of those which modern Geology has revealed.

This interesting field of research, which the labours of that eminent observer M. Ehrenberg first made known, has since been explored by other naturalists, and in every part of the world many of the Tertiary and Secondary deposits have been found to contain microscopic organisms in profusion. At present this branch of palæontology is in its infancy, and it offers to the young student an inexhaustible and most attractive path of scientific investigation; it possesses, too, this great advantage over many others, that it can be pursued at home, and the materials for its prosecution are everywhere at hand. Unlike my explorations in the Wealden, in which a few fragments of bones, or teeth, scattered at wide intervals through the rocks, and in localities many miles apart, were often the only reward of a day's labour, here, in the quiet of my study, I may discover in a few atoms of flint, or grains of chalk, picked up by the road-side, the fossil remains of beings as interesting and extraordinary as the extinct colossal reptiles of Tilgate Forest.

MICROPHYTES.

The microphytes, or fossil Diatomaceæ, described in a previous chapter, (*ante*, p. 93.,) were formerly classed with the organisms that now claim our attention, under the name *Infusoria*; from the belief that generally prevailed among naturalists, of their animal origin. In fact, some eminent microscopic observers, while admitting the vegetable character of Xanthidium, Micrasterias, &c. consider the Naviculæ,

Ennotiæ, &c. as belonging to the animal kingdom.

Thus Dr. J, W. Bailey, in a late "Memoir on the Microscopic Organisms in Various Localities of the United States," divides these bodies into three groups; viz. *Infusoria*, *Desmidieæ*, and *Diatomaceæ*; with the remark, that he has separated the two latter tribes from the Infusoria, because so many distinguished naturalists consider them decidedly to belong to the vegetable kingdom: "but," he adds, "while I believe that no positive line of separation can be drawn between certain animals and vegetables, I am yet disposed to regard the *Desmidieæ*, from the sum of all their characters, as most nearly allied to admitted vegetables; while the *Diatomaceæ*, notwithstanding Mr. Thwaites's interesting observations on their conjunction,[305] still seem to me, as they have always done, to be true animals. There is such apparent volition in their movements, such an abundance of nitrogen in the composition of their soft parts, and such resemblance between the stipitate Gomphonematæ and some of the Vorticellæ, that I should be still disposed to class them as animals, even if Ehrenberg's observations of the retractile threads and snail-like feet of some of the Naviculæ should not be confirmed."[306]

[305] The mode of fructification, or *conjunction*, as it is termed, in the Algæ, consists in the adhesion of two cells or frustules together, and their fusion into one; from their united contents a mass of granular substance is produced, that becomes consolidated and forms the spore or fruit, which, when arrived at maturity, is set free by the bursting of the cell. Mr. Thwaites has ascertained that the fructification is similar in the Diatomaceæ.

[306] Smithsonian Contributions, vol. ii. p. 34.

Thus, whilst referring Closterium, Arthrodesma, Euastrum, Xanthidium, Micrasterium, &c. as vegetables, to the Desmidieæ, Dr. Bailey places, *Actinocyclus*, *Campilodiscus*, *Coscinodiscus*, *Ennotia*, *Navicula*, *Gomphonema*, *Pinnularia*, *Triceratium*, &c. among the Diatomaceæ, as animals.

Of the animal nature of the microscopic objects which now require our attention, there is however no question, although the zoological position and affinities of many of the organisms included in this survey are still but imperfectly determined.

The animals designated *Foraminifera*,[307] or Rhizopoda,[308] are of a more simple structure than the Polypifera and Echinodermata described in the previous chapters; yet as their relics are for the most part presented to the notice of the geologist as aggregations of shells, forming extensive beds of limestone, it will be convenient to treat of them in this place.

[307] FORAMINIFERA, *i.e.* bearing foramina —a name derived from the minute openings in the shells and their septa.

[308] RHIZOPODA; root-like feet; from the long fibrous processes, or pseudopodia.

The fact that the fossil remains of Foraminifera, and of *Mollusca*, alike consist of shells, and constitute strata identical in mineral characters, and deposited under like physical conditions, renders the examination of these Microzoa[309] a fit introduction to the study of the durable remains of the higher order—the Mollusca.

[309] MICROZOA; from μικρος, *mikros*, small, and ζωον, *zoon*, animal; a convenient term to denote minute animal organisms whose forms can only be defined by the aid of the microscope.

It is scarcely more than a hundred and twenty years ago, that the existence of this numerous order of microzoa was first made known to naturalists by *Beccarius*, who detected a considerable number of species in the sand on the shores of the Adriatic. But the structure of the animals that secreted these shells is a discovery of comparatively modern date. The early collectors classed these microscopic bodies with the shells of true mollusca; and even M. D'Orbigny, whose elaborate researches justly constitute him a high authority in this branch of natural history, in his first memoir, in 1825, described the involuted discoidal forms as Cephalopoda. This error was corrected by the investigations of M. Dujardin, who in 1835 satisfactorily demonstrated that the Foraminifera are animals of the most simple structure, and entirely separated by their organization from the Mollusca.

But the true nature of this class is so little understood by British collectors of fossil shells,—of course I mean the uninitiated, and the amateur naturalist, for whose use these unpretending pages are designed,—that in order to invest the study of the fossil species with the interest which a knowledge of the structure and economy of the living originals can alone impart, I must give a history of the recent forms somewhat in detail, taking M. D'Orbigny as my chief authority.[310]

[310] The best work for the student to

consult is M. D'Orbigny's "Foraminifères Fossiles du Basse Tertiaire de Vienne, Autriche." Paris, 1846. 1 vol. 4to. with plates. I rejoice to learn that a Monograph on the British Foraminifera is in preparation by Dr. Carpenter and Professor Williamson: than whom there are none more competent.

FORAMINIFERA.

The FORAMINIFERA are marine animals of low organization, and, with but few exceptions, extremely minute: in an ounce of sea-sand between three and four millions have been distinctly enumerated. When living, they are not aggregated, but always individually distinct; they are composed of a body, or vital mass, of a gelatinous consistence, which is either entire and round, or divided into segments, placed either on a simple or alternate line, or coiled in a spiral, or involuted round an axis. This body is covered with an envelope or shell, which is generally testaceous, rarely cartilaginous, is modelled on the segments, and follows all the modifications of form and contour of the body. From the extremity of the last segment there issue sometimes from one, sometimes from several openings of the shell, or through the numerous pores or foramina, very elongated, slender, contractile, colourless, filaments, more or less divided and ramified, serving for prehension, and capable of entirely investing the shell.

The body varies in colour, but is always identical in individuals of the same species; it is yellow, ochreous, red, violet, blue, &c.

Its consistence is variable; it is composed of minute globules, the aggregation of which determines the general tint. It is sometimes entire,

round, and without segments, as in *Gromia*, *Orbulina*, &c., which represent at all ages the embryonic state of all the other genera. The animal increases by gemmation, each segment being essentially distinct, but connected with the preceding one by a tube or neck. When the body is divided by lobes or segments, the primary lobe, as in the permanent condition of the Gromia, is at first round or oval, according to the genus; once formed it never enlarges, but is enveloped externally by testaceous matter.

The segments, which successively appear, are agglomerated together in seven different ways, and these modifications are the basis of M. D'Orbigny's classification. The discoidal forms, as the *Rotalia*, *Rosalina*, *Cristellaria*, &c. are involute, like the Nautilus, and divided by septa or partitions, which, like the enveloping shell, are perforated. The lobes of the body *occupy contemporaneously every chamber*, and are connected by a tube that extends through the entire series. In the spiral form, as the Textularia, &c., the same structure is apparent.

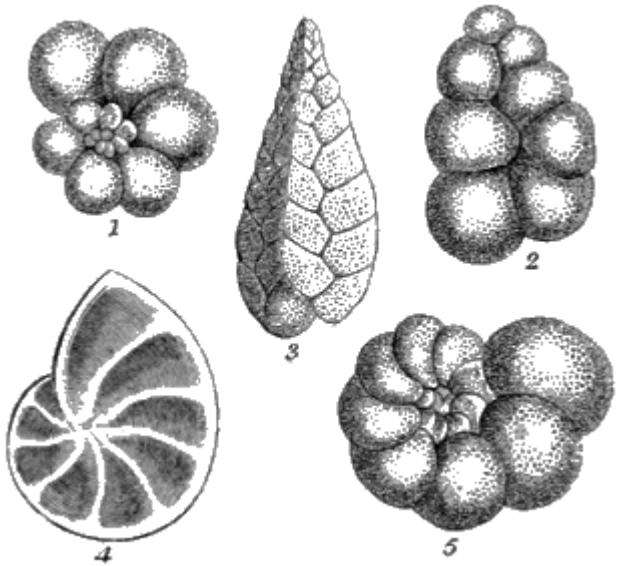
Whatever the form of the body, the filaments always consist of a colourless transparent matter; they are capable of being elongated to six times the diameter of the shell. They often divide and subdivide, so as to appear branched; and though alike in form in the different genera, vary much in their position. In some species they form a bundle which issues from a single aperture, and is withdrawn into the same by contraction; in others, the filaments project only through each of the pores in that portion of the shell which covers the last segment: in many they issue from both the large aperture and the foramina. These filaments or

pseudopodia fulfil in these animals the functions of the numerous tentacula in the Star-fishes; serving as instruments of locomotion and attachment.

Neither organs of nutriment nor of reproduction have been discovered. In the genera having one large aperture from which the filaments issue and retract, we can conceive nutriment to be absorbed by that opening; but this cannot be the case in the species which have the last cell closed up; in these the filaments issuing through the foramina are probably also organs of nutrition. M. D'Orbigny considers the Foraminifera as constituting a distinct class in zoology; though less complicated than the Echinoderms and the Polypifera in their internal organization, they have the mode of locomotion of the first; while by their free, individual existence, they are more advanced in the scale of being than the aggregated and immovably fixed animals of the latter class.

But though I consider the animal of the Foraminifera as single, and the additional lobes, or segments, as the continuous growth of the same individual, I must state that some eminent naturalists regard the entire structure as a series of distinct individuals, developed by gemmation from the first formed segment, like the clusters of the compound *Tunicata*; and not as a single aggregated organism, made up of an assemblage of similar parts indefinitely repeated. In a palæontological point of view, it matters not which opinion is adopted.[311]

[311] See a masterly paper on the structure of Nummulina and Orbitoides, by Dr. Carpenter; Geol. Journal, vol. vi. pp. 21-39, with admirable representations of the structural details.



LIGN. 109. FORAMINIFERA.
Chalk. Charing.

Fig. 1.— GLOBIGERINA CRETACEA;
the original is $^1/_{60}$ of an inch in diameter.

2.— TEXTULARIA GLOBULOSA; $^1/_{40}$.

3.— VERNEUILINA TRICARINATA; $^1/_{30}$.

4.— CRISTELLARIA ROTULATA; $^1/_{40}$.

5.— ROSALINA LORNEIANA; $^1/_{40}$.

CLASSIFICATION OF THE FORAMINIFERA.

CLASSIFICATION OF THE FORAMINIFERA.—The number of genera is so great, that I can only attempt to convey a very general idea of the principles of classification adopted by M. D'Orbigny, and give a few illustrations of some of the most abundant fossil species.

That the reader may be cognizant of the usual aspect of these shells five specimens from the Chalk, belonging to as many genera, are here represented

(*Lign.* 109); the deposit whence they were obtained will be described hereafter.

As the mode in which the growth of the body, and consequently of the shell, takes place, differs greatly in certain groups, an obvious and natural arrangement is suggested, by which the class is divided into seven orders:—

1. The primary, or simplest type; one segment or cell; as in *Orbulina*.

2. The segments arranged in circular lines; as in *Orbitolina*.

3. Segments disposed in a straight or arched single line; successively increasing from the first to the last cell; as in *Nodosaria*, *Lign.* 111.

4. Segments, spirally and discoidally disposed, on the same plane, like cells of the Nautilus; as in *Cristellaria*, *Lign.* 109.

The same type, but coiled obliquely, and inequilaterally, like the shells of Gasteropoda; as in *Globigerina*, *Lign.* 109, *Rosalina*, *Lign.* 109.

5. Segments developed alternately on the right and left of the first, and successively on each side the longitudinal axis; as in *Textularia*, *Lign.* 109.

6. Arrangement of the segments combining the modes of 4 and 5; that is, the segments are formed alternately, but the whole are coiled spirally, either obliquely, or on the same plane; as in *Amphistigena*.

7. Segments round a common axis, on two, three, four, or five, opposite faces, returning after each entire revolution; the new cells being placed exactly

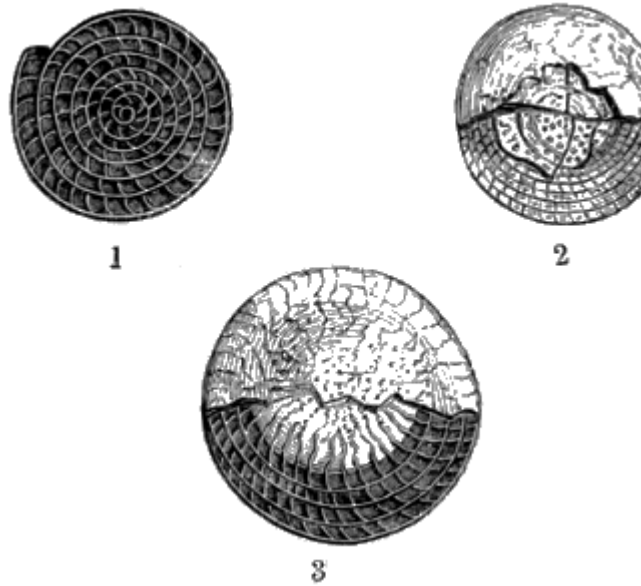
on the preceding series; as in *Quinqueloculina*, *Pict. Atlas*, pl. lxii. *fig.* 12.

The Foraminifera vary considerably in magnitude; by far the greater number of species are invisible to the unassisted eye, and the aid of a lens or microscope is required to define the structure even of the largest; yet many are of sufficient size to be recognized, as for example the *Spirolinæ*, *Lign.* 112. A few genera are from a quarter of an inch to nearly an inch in diameter, as the *Orbitoides Mantelli* of the tertiary formations of North America,[312] and the *Nummulina*, commonly termed *Nummulites*, of Europe, *Lign.* 110.

We will now describe the genera selected for illustration, commencing with the large and well-known type, whose aggregated remains form extensive beds of crystalline limestone in the Alps, and in Asia, and Africa.[313]

[312] Dr. Morton's Synopsis of the Organic Remains of the Cretaceous group of the United States. Philadelphia, 1824, p. 45, pl. v. fig. 9.

[313] Geol. Journal, vol. v.



LIGN. 110. NUMMULITES, OR NUMMULINA; *nat.*
From the Great Pyramid of Egypt.

Fig. 1.— Transverse section of a Nummulite, showing the form and arrangement of the cells.
2, 3. Specimens with part of the external plate removed.
—

NUMMULINA LÆVIGATA. *Lign.* 110.—The shell is of a discoidal or lenticular form, composed of numerous cells, concentrically arranged round an axis on the same plane; both sides of the disk covered by a smooth thick plate.

NUMMULITES.

Under the name of *Nummulites*, from their resemblance to a piece of money, the fossil shells of this genus of Foraminifera have long been known to naturalists, and are figured in many of the early works on petrifactions. They occur in immense

quantities in certain rocks, and are of all sizes, from a mere point, to disks an inch and a half in diameter; thus exceeding in magnitude all other animals of this class.

Perfect specimens appear as a calcareous solid circular body, of a lenticular shape; smooth, and slightly convex on both sides, and without any visible structure. On splitting the fossil transversely, or rubbing down one of the convex planes, a series of minute cells, arranged in a discoidal spire, is brought to view, as shown in *Lign.* 110, *fig.* 1. But this description gives a very inadequate idea of the complicated and exquisite structure of the original, which has been admirably worked out by Dr. Carpenter. This eminent physiologist has shown that each chamber was occupied by a living segment, connected with other segments by one or more tubular prolongations, which absorbed nutrition from without, by means of filamentous pseudopodia, that projected through a system of passages leading from the medial plane to the external surface.[314] A figure of the supposed form of a living Nummulina is given in Pict. Atlas, p. 187.

> [314] Geol. Journal, vol. vi. p. 21. See also a paper by Prof. Williamson, "On the minute Structure of the Calcareous Shells of some recent species of Foraminifera." Trans. Microscop. Soc. vol. iii. p. 105.

The specimens figured in *Lign.* 110 are from the limestone that forms the foundation rock of the Great Pyramid of Egypt, and of which that structure is in great part composed. Strabo alludes to the Nummulites of the Pyramids, as lentils which had been scattered about by the artificers employed on those stupendous monuments, and become stone.

[315] Silicified masses of Nummulites are occasionally met with; polished slices of such specimens are richly figured by the sections of the inclosed Foraminifera.

> [315] An interesting fact was communicated to me by a friend who lately descended the Nile; the Nummulitic limestone rocks are in some parts of the course of the river washed into the stream, and becoming disintegrated, the Nummulites are set free, and re-deposited in the recent mud of the Nile.

The Nummulitic limestones are of the Eocene or ancient. Tertiary epoch, as the labours of Sir Roderick Murchison in the Alps, Apennines, and Carpathians first established: Nummulites are unknown in the Secondary formations.[316]

> [316] Geol. Journal, vol. v.

ORBITOIDES.—The fossil bodies thus named are disciform, like the Nummulites; and one species, which forms the constituent substance of ranges of limestone mountains, 300 feet high, near Suggsville, in North America, was first described by my lamented friend, the late Dr. Morton, of Philadelphia, as *N. Mantelli*, in his work on the Cretaceous Fossils of the United States.

The discovery that the Nummulitic deposits of the Old World were of the tertiary period, directed attention to their supposed geological equivalents in America; and on a careful examination of their fossils, the rocks proved to be tertiary, and the shells true Foraminifera allied to the Nummulites, but generically distinct.[317] A reference to Dr. Carpenters memoir, previously cited, is necessary to comprehend the complicated structure of these

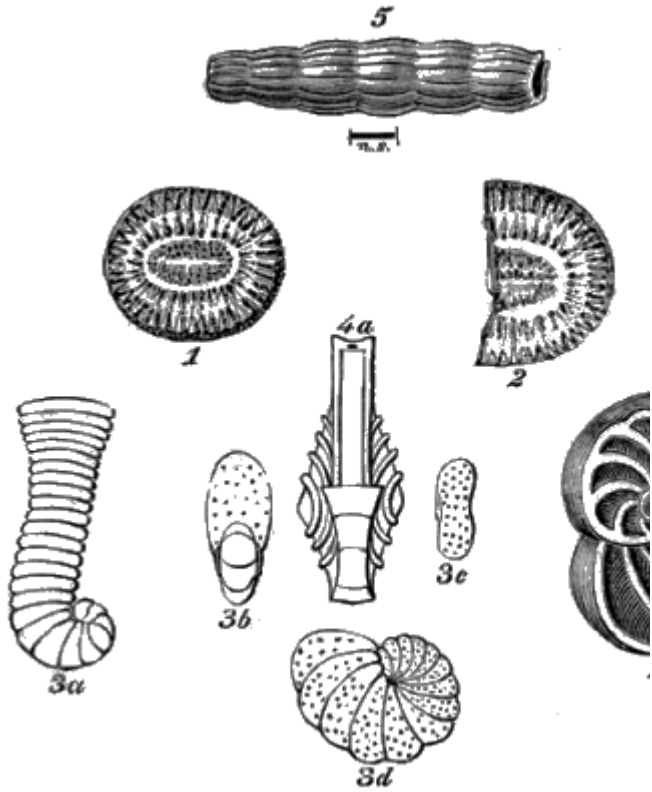
fossils.[318]

[317] Manual of Geology, p. 208.

[318] Geol. Journal, vol. vi.

SIDEROLINA, or *Siderolites*, is a genus of Foraminifera, which may be described as Nummulites, in which the turns of the spire are intercepted by elongated appendages, that project beyond the periphery of the disk, and produce a stellated figure. These fossils abound in the cretaceous strata of Maestricht.

FUSULINA.—The shell is fusiform, being elongated transversely to the axis; the cells are divided internally by constrictions. Only one species is known, (*F. cylindrica*,) and this is confined to the Carboniferous formation; it is the most ancient or earliest type of the class, according to the present state of our knowledge.



LIGN. 111. FORAMINIFERA, &C.

Fig. 1 and 2. CAMPILODISCUS; a perfect frustule, and part of another, — Tertiary; Egra in Bohemia.
See ante, p. 96.

3*a*.— LITUOLA NAUTILOTDEA. *Chalk, Chichester.* (By Mr. Walte × 8.

3*b*.— Front view of the last cell of 3d, to show the foramina w

3*c*.— The last cell of 3*a*.

3*d*.— Side view of a young shell, before the produced, or strai

4*a*.— FLABELLINA BAUDONINA. *Chalk.* (M. D'Orbigny.) A youn profile, × 12.

4*b*.— The same, viewed laterally, shows the oblique arrangem

5.— NODOSARIA. *Chalk, Chichester.* (By Mr. Walter Mantell.) the natural size.

NODOSARIA. LITUOLA.

NODOSARIA. *Lign.* 111, *fig.* 5.—Straight, elongated cells placed end to end, separated by constrictions; the last formed cell has a round central aperture. Several beautiful species abound in the Chalk; specimens often occur adhering to the surface of the flint nodules.

Nodosariæ are abundant in tertiary deposits. Mr. Walter Mantell discovered Foraminifera of this genus in the blue clay of Kakaunui, in New Zealand.

Cristellaria. *Lign.* 109, *fig.* 4.—The shell is in the form of a compressed Nautilus; it has a single aperture, which is situated at the angle of the keel; the cells are oblique.

This genus comprises seventy fossil species, which occur in the Lias, Oolite, and Chalk. Living species are abundant in almost every sea.

FLABELLINA. *Lign.* 111, *fig.* 4*a*.—In a young state, this shell, like the preceding, resembles that of a Nautilus, and the cells are oblique; but in the adult, are of a zigzag (chevron) form. It has a single round aperture. *Fig.* 4*a* shows a young individual, seen in profile; *fig.* 4*b* a lateral view, exhibiting the obliquity of the cells.

Species of Flabellina are often found in cretaceous strata. The genus is not known in a recent state.

POLYSTOMELLA.—In its general form this genus resembles the other nautiloid shells above described, but its structure differs essentially; for there are several apertures along the side of the shell, as well as the opening in the last segment. The cells are

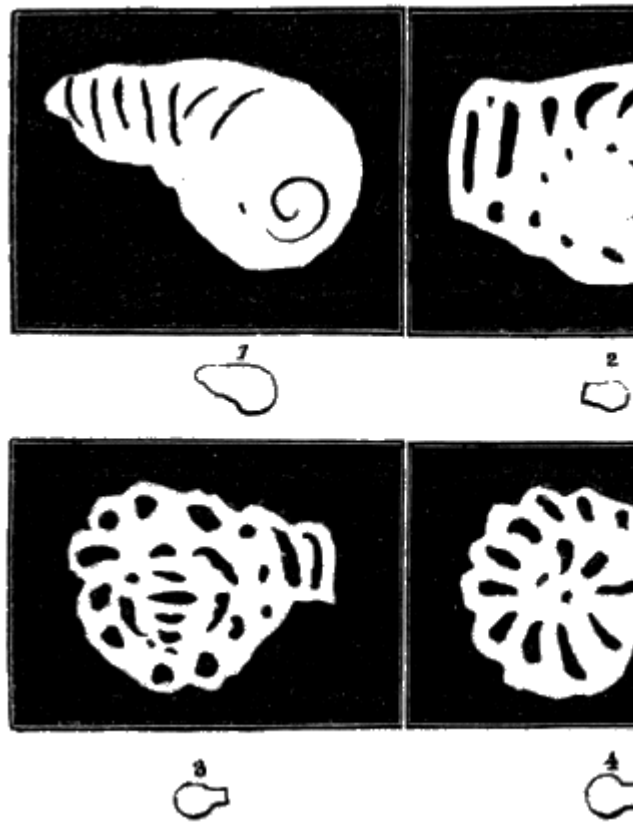
simple, and each is a single cavity. The figures and details of structure, given by Professor Williamson, must be referred to, for an insight into the organization of this beautiful and complicated type of Foraminifera.[319] One species of Polystomella is said to occur in the Chalk; I have not detected this genus in our cretaceous deposits. Recent species swarm in our seas; and may be easily obtained from the mud and sand on the shores at Brighton.[320]

[319] Trans. Microscop. Society, vol. ii.

[320] Mr. Poulton has specimens of the shells, and the bodies of the animals deprived of the shell, mounted for the microscope.

LITUOLA. *Lign.* 111, *fig.* 3*a*.—In a young state the shell is nautiloid, as in *fig.* 3*b*, 3*d*; but becomes produced by age, and assumes a crosier-like form, as in *fig.* 3*a*. The cells are filled with a porous testaceous tissue, as shown in *figs.* 3*b*, 3*c*; which also illustrate the foraminiferous character of the shells in this class of animals; for both the external testaceous covering, and the septa of the cells, exhibit perforations.[321]

[321] The perforations are omitted, by mistake, in the figure of the adult shell, *fig.* 3*a*.



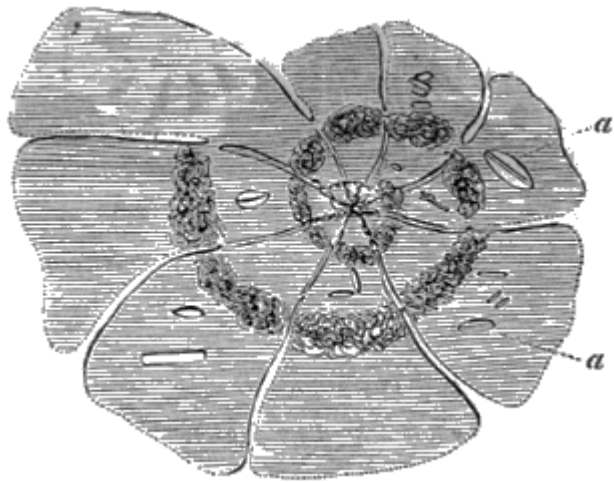
LIGN. 112. SPIROLINITES IN FLINT.
Chalk. Sussex.
(*By the late Marquis of Northampton.*)
The specimens are only sections of the shells Imbedded in flint, and se
lens of moderate power. The small figures denote the size

SPIROLINA.

SPIROLINA. *Lign.* 112.—The general form resembles that of Lituola: the young shell being a discoidal, involute, and becoming produced by age; but the internal structure is different; the cells are simple cavities.

The chalk and flints of Sussex abound in these crosier-like shells, whose existence in the cretaceous rocks was first made known by my deeply lamented friend, the late Marquis of Northampton. The annexed lignograph, from drawings by his lordship, shows the form and structure as displayed by sections in fractured flints. Four species were named by Lord Northampton (see *Wond.* p. 32-5); but it is doubtful whether all the specimens belong to more than one species; the apparent diversity of structure may arise simply from the different planes in which the sections happen to have been made.

GLOBIGERINA. *Lign.* 109, *fig.* 1.—The shell is turbinated, the cells are spheroidal, and the last, or terminal one, has a semilunar aperture at the umbilical angle. Several fossil species abound in the Chalk and in the tertiary deposits; and many living species swarm in our seas.

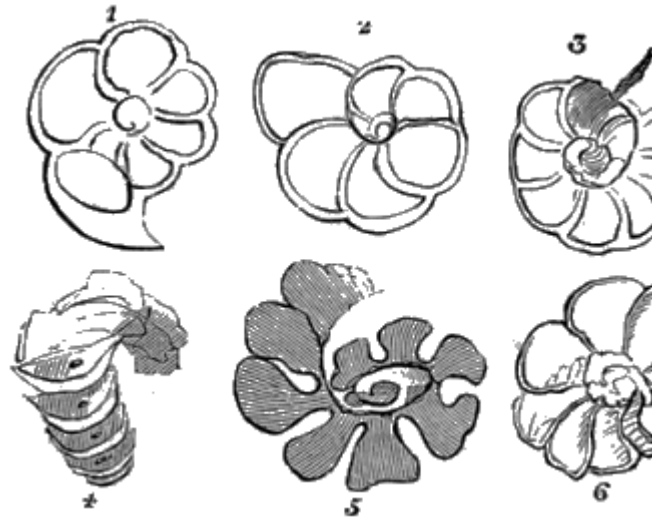


LIGN. 113. NONIONINA GERMANICA, × 290.
A recent specimen of the body of the animal; the shell removed by ac
From the North Sea, Cuxhaven. (*M. Ehrenberg.*)

a, a.—Naviculæ and other organisms in the segments of the anima

NONIONINA.—*Lign.* 113.—A nautiloid shell, with simple cells; the last cell has a single narrow aperture placed transversely over the dorsal aspect of the spire. One species occurs in the chalk formation of Germany; several in tertiary deposits, and in the existing seas.

The figure, *Lign.* 113, represents the body of the animal deprived of its shell, to illustrate the nature of certain fossils from the Chalk.



LIGN. 114. FORAMINIFERA IN CHALK AND FLINT. ×
(*Seen by transmitted light.*)

Fig. 1, 2, 3, 6. Different forms of ROTALIA.
—

2.— Resembles the recent ROTALIA STIGMA; Ehrenberg; > fi
near Cuxhaven.

4.— Portion of a NAUTILUS, showing five chambers, partiall
pierced by the siphunculus: in Flint, from
Ireland.

5.— The BODY OF A ROTALIA, in Flint; the shell is not appa

ROTALIA. *Lign.* 114.—The shell, though nautiloid in its contour, is regularly turbinated, the cells not globular; the last cell has a central, semilunar, transverse, aperture. There are fifty fossil species. The Rotaliæ appear in the Lias, Oolite, and Chalk, in immense numbers, and swarm in the present seas.

ROSALINA. *Lign.* 109, *fig.* 5.—The shell is depressed; the spire apparent on one side; the aperture is a prolonged slit extending from one cell to another, and opening on the umbilicus; that is, on the side opposite to the spire. There are eighteen fossil, and many recent species of this genus.

TEXTULARIA. *Lign.* 109.—This, and the following genus, belong to that order of Foraminifera in which the segments or cells are arranged in two or three distinct axes (*ante*, p. 342.), and by their gradual increase give rise to an elongated conical but not spiral shell, which in its general outline resembles that of certain gasteropoda, but is easily distinguished by its internal structure. The shell is conical, compressed, formed of alternate cells, with a transverse aperture placed on the inner side. Upwards of thirty fossil species are known. The Textulariæ are in great abundance in the cretaceous rocks; and, together with Rotaliæ and Rosalinæ, constitute a large proportion of the minute organisms of the secondary formations as well as of the present seas.

VERNEUILINA.—*Lign.* 109, *fig.* 3.—A turriculated shell, with a slit or aperture transverse to the axis of involution, and placed on the umbilicus. This genus, of which but one species is known, is peculiar to the cretaceous deposits.

CHALK ANIMALCULITES.

STRATA COMPOSED OF FORAMINIFERA.—From this concise exposition of the characters of the genera that most frequently occur in a fossil state, we pass to the examination of the organic composition of those limestones which are in a great measure made up of the debris of Foraminiferæ. We will commence the investigation with that common substance, the white chalk of the South-East of England.

It has long been known that a large proportion of the purest white chalk consists of minute chambered shells,[322] and corals.

[322] Often termed *Polythalamia*, meaning many chambers or cells.

Mr. Lonsdale, some years since, first showed that by brushing chalk in water, and examining the sediment, shells, corals, and foraminifera might be obtained in abundance; but it was not at that time suspected that the residue of the detritus was almost entirely composed of distinct organic structures, so minute as to require high magnifying powers, and a peculiar mode of manipulation, for their detection and definition.

M. Ehrenberg demonstrated that even the fossils discovered by Mr. Lonsdale are colossal, in comparison with the infinitesimal structures of which the finer particles of the chalk consist; for one cubic inch of the limestone is found to contain upwards of a million of well-preserved animal organisms.

The chalk, therefore, is an aggregation of extremely minute fossils and inorganic particles. The

yellow, soft, writing chalk of the North of Europe, according to M. Ehrenberg, is composed of about half its mass of organic remains; but in the chalk of the South of Europe, the fossils predominate. The amorphous atoms of the cretaceous limestone do not, as was formerly believed, arise from a precipitate of lime previously held in solution, but from the disintegration of the assembled organisms into more minute calcareous particles; and these have subsequently been reunited by a crystalline action, into regular, elliptical, granular, bodies.

M. Ehrenberg infers that the compact flint nodules have originated from an aggregation of pulverulent particles of siliceous organisms; and upon this hypothesis explains the absence of flint nodules, and the abundance of siliceous infusoria, in the beds of marl that alternate with the chalk in the south of Europe, and their presence in the chalk of northern Europe, in which the marls are wanting. In other words, he supposes, that in the former case the siliceous shells of the animalcules were spread abroad and deposited in layers or strata; and in the latter were aggregated into nodular masses. This opinion is not, however, supported by facts; for, though the animal origin of lime, flint, and iron, may be admitted to a great extent, yet the deposition of silex and lime from aqueous solutions, is carried on at the present moment upon an enormous scale; and it cannot be doubted that to such a process is attributable the formation of the nodules, layers, dikes, and veins of flint, which traverse the chalk, and other rocks.[323]

[323] See my "Memoir on a Microscopical Examination of Chalk and Flint," Annals of Nat. Hist., Aug. 1845.

The most abundant microscopic organisms in the English chalk and flint which I have examined, are *Rotaliæ*, or *Rosalinæ*, and *Textulariæ*. Immense numbers of minuter Foraminifera also occur, and many shells, which are unquestionably the young state of testaceous Cephalopoda (as *Nautilus*, *Ammonite*, &c.).

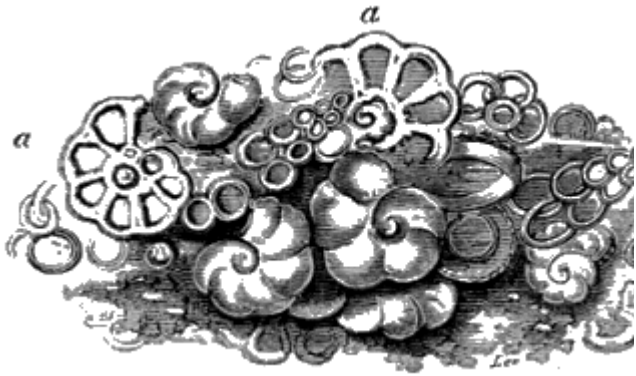
Spines of Sponges, and of Echinoderms, also frequently appear in the field of the microscope: and a spongeous structure is so common in flint, that an eminent observer conceives that all the flints, both nodular and tabular, have originated from poriferous zoophytes;[324] an hypothesis altogether inadmissible.

[324] "Memoir on the Siliceous Bodies in the Chalk, Greensands, and Oolite," by J. S. Bowerbank, Esq. F.R.S. &c. Geol. Trans, vol. vi. p. 181.

The assertion that the chalk every where consists almost wholly of organic bodies must likewise be accepted with some limitation. The assiduous observer who searches for hours chalk and flint carefully prepared, and with the aid of an excellent microscope, though he will meet with immense numbers of organisms, will often find a great proportion of atoms without traces of structure. Neither is there much variety in the easily recognizable forms of the English chalk (I write from my own limited experience); many of the species described by M. Ehrenberg, and others, are few and far between; and I have not detected a single example of diatomaceæ. The student therefore must not be discouraged, if, after perusing the glowing accounts of the discoveries of M. Ehrenberg, he should not be more successful than myself. It must,

however, be borne in mind, that as the fossil remains of the larger animals and plants are commonly associated together in particular localities, while in similar rocks in other districts they are altogether wanting; in like manner, some strata of the same series may be made up of organic bodies, while others are destitute of them. In fact, such is the case with our English Chalk: some layers in the cliffs at Dover are literally an aggregation of foraminifera and corals, while other beds have but few vestiges of organic remains.

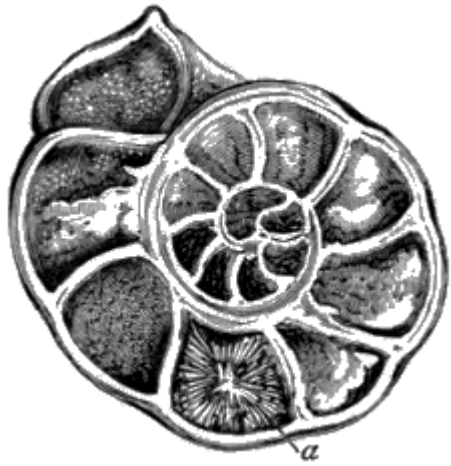
CHALK FORAMINIFERA.



LIGN. 115. CHALK-DUST; CHIEFLY COMPOSED OF FORAMINIFERA; *h*
(*Seen by reflected light.*)
a, a. ROTALIÆ. *b.* TEXTULARIÆ.

FORAMINIFERA OF THE CHALK AND FLINT. *Lign.* 115.—If a few grains of soft white chalk from Gravesend or Dover be examined under a high power ($^1/_4$ inch object-glass of Ross), groups of foraminifera will be perceived, chiefly of Rotaliæ, Rosalinæ, and Textulariæ, as shown in *Lign.* 115. If some of the powder be immersed in Canada balsam, (as directed in the instructions at the close of this chapter for preparing chalk for microscopical examination,) the

outline of the shells, and the cavities of, the cells, will be apparent; as in the sketches *Lign.* 114, *ante* p. 351. If a chip or slice of flint, rendered transparent by immersion in oil of turpentine or Canada balsam, be viewed first with a low power, (1 inch object-glass,) to discover a good specimen, and afterwards under a high magnifier, (a $^1/_4$ or an $^1/_8$ object-glass,) the form of the shell and of the cells will be distinctly seen, as in *Lign.* 116. In this beautiful fossil Rotalia, the segments are as sharply defined as in a recent example: and one of the cells (*a*) is seen to be lined with quartz crystals.



LIGN. 116. SECTION OF A ROTALIA IN FLINT.
(*Seen by transmitted light, and showing the chambers partially filled with mineral matter.*)
a. A cell lined with spar.
(× 250 *diameters*.)

At first sight this fossil might be mistaken for a nautilus partially filled with spar; but the reader will remark that the septa, or partitions, have their convex surface towards the aperture; whereas in the shells of the Cephalopoda (Nautilus, Ammonite, &c.)

the septa are concave anteriorly. In *Lign.* 114, *fig.* 4, a series of casts in flint of the septa of a young Nautilus is represented; by comparing it with the Rotaliæ in the same lignograph, *figs.* 2, 3, this distinction will be obvious. And here it may be necessary again to point out the essential character of the animal of the foraminifera, as distinguished from that of the cephalopoda with chambered shells. In the latter, the body of the mollusk only occupies the large outer chamber; the internal compartments are empty dwellings, which the animal has successively quitted in the progress of its growth, and with which it has no connexion except by the siphunculus. In the Rotalia, and allied forms, the body of the animal is inclosed within the shells, and occupies every chamber contemporaneously at every stage: the cells are always filled by the segments of the body. Hence when the shell, which is calcareous, is dissolved in weak hydrochloric acid, the soft body is exposed, and seen to extend to the innermost chamber. The segments are connected by a membranous tube, which some naturalists regard as a common channel of communication between the several digestive sacs of which the body consists; for minute diatomaceæ which the animal has swallowed, (according to Ehrenberg,) are seen within the membranous sacs; as shown in *Lign.* 113, which represents the body of a Nonionina, deprived of its shell. The importance of obtaining a correct idea of this structure will presently appear.

When a recent Rotalia is immersed in dilute acid, the soft parts of the body, deprived of the shell, may be obtained entire; they consist of a series of little bags or sacs, united by a tube. The constituent substance appears to be a tough membrane, and is generally of a rich brown or amber colour. The sacs

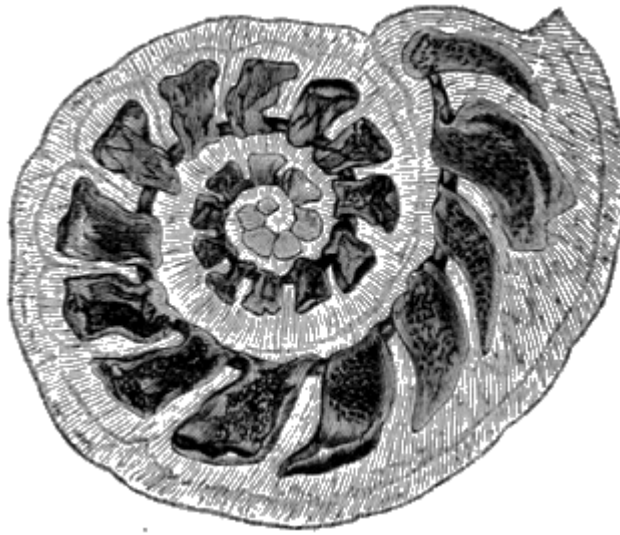
are sometimes full of a granular substance, but are often empty and collapsed.

FOSSIL BODIES OF ROTALIÆ.

FOSSIL REMAINS OF THE SOFT PARTS OF FORAMINIFERA. *Lign.* 113.—When examining chalk[325] and flint under the microscope with the view of discovering the fossil bodies described by M. Ehrenberg, I observed that the cells of the Rotaliæ in flint were frequently occupied by a substance varying in colour from a light amber to a dark brown, and closely resembling in appearance the body of the recent foraminifer deprived of its shell. Under a high power, the folds of the membranous sacs and the connecting tube were apparent, and I felt convinced that the substance filling the cells was not inorganic, but the original animal tissues in the state of molluskite.[326] In short, that the animal had become immersed and preserved in the fluid silex like the insects in amber. The appearance of the first discovered example of this kind is represented in *Lign.* 117.

[325] In 1845.

[326] *Molluskite*: a name by which I proposed to distinguish the carbonaceous substance resulting from the soft bodies of testaceous mollusca.



LIGN. 117. ROTALIA IN FLINT, WITH THE FOSSILIZED BODY OF THE ANI
IN THE SHELL: *highly magnified.*
(*Seen by transmitted light.*)

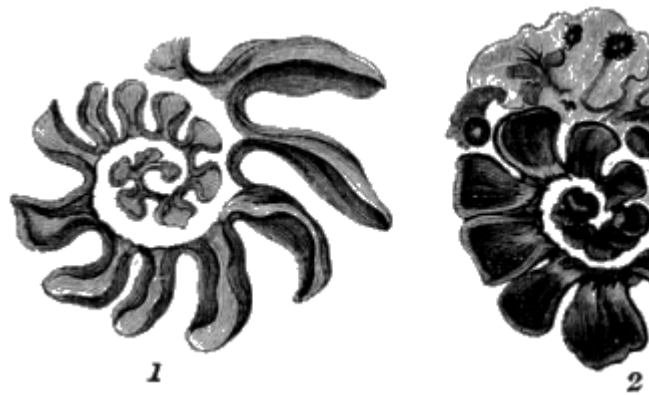
SOFT BODIES OF FORAMINIFERA.

In a paper read before the Geological Society in 1845,[327] I ventured to affirm the animal nature of the fossils in question; but the supposition was regarded by geologists as very startling and unsatisfactory; and as the specimens were enveloped in flint, the appearance was attributed to the infiltration of mineral matter of a different colour from the surrounding silex, into the empty chambers; a circumstance of frequent occurrence in Ammonites, Nautili, and even in the foraminifera; for the latter are often filled with chalk, flint, silicate of iron, crystal, &c. as in *Lign.* 116. In these instances, I conceive the shells were either empty when immersed in the fluid chalk or flint, or speedily became so by the decomposition of the soft parts of the animal. But in the fossils under consideration, I

believe the live animal was suddenly enveloped, and hermetically sealed, as it were, in its shell, and that putrefaction was thus prevented. The uniformity in colour, and the structure of the substance in the cells, appeared to me incompatible with its assumed mineral origin, and I resolved to follow up the inquiry by an examination of Rotaliæ in chalk; in the hope that by dissolving the shell in acid (as in recent foraminifera), the body of the animal might be detected in an unmineralized state. After many fruitless attempts, several examples of the soft bodies of Rotaliæ were obtained from the grey chalk of Dover, in an extraordinary state of preservation.[328]

[327] Notes of a Microscopical Examination of the Chalk and Flint of the South-East of England, with Remarks on the Animalculites of certain Tertiary and Modern Deposits. Published in the Ann. Nat. Hist., Aug. 1845.

[328] To Henry Deane, Esq. of Clapham Common, I am indebted for some of the most illustrative specimens hitherto obtained.



LIGN. 118. THE SOFT BODIES OF FORAMINIFERA; EXTRACTED FRO
magnified.
(*Viewed by transmitted light.*)

Fig. 1.— An exquisite example of the body of a ROTALIA; the sacs partially collapsed.

2.— Body of a ROTALIA; the sacs distended with a dark granular substance.

These marvellous relics were obtained by subjecting a few grains of the chalk to the action of weak hydrochloric acid, by which the calcareous earth and the shells it contained were dissolved; the residue, consisting of particles of quartz and green silicate of iron, and remains of the animal tissues, were placed, in the usual manner, in Canada balsam. Two exquisite specimens of the bodies of Rotaliæ thus obtained are figured in *Lign.* 118.[329]

[329] I communicated this discovery to the Royal Society. See Philos. Transactions, 1846, p. 465.

In these fossils the sacs are generally more or less distended with a dark substance, as in *Lign.* 118, *fig.* 2: but in some, they are empty and collapsed in folds, just as membranous pouches would appear under similar conditions; as in the exquisite fossil, *Lign.* 118, *fig.* 1.

The sacs regularly diminish in size from the innermost to the outermost cell, and vary in number from fourteen to twenty-six; being more numerous than in the recent species of Rotaliæ that have come under my notice. In some instances small papillæ are seen on the outer surface of the integument; apparently the vestiges of the pseudopodia.[330]

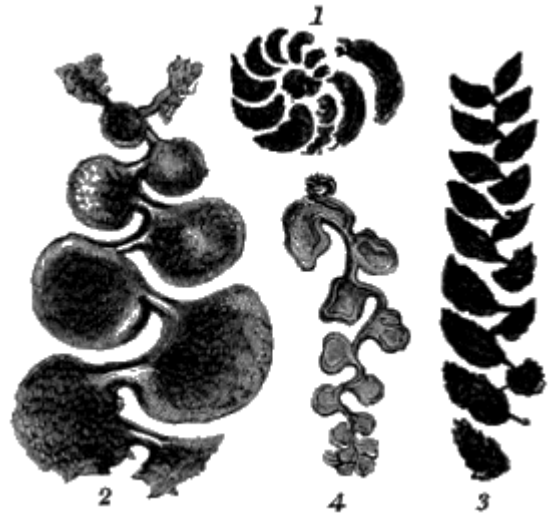
[330] Admirably as my excellent engraver, Mr. Lee, (of Prince's Square, Kennington,) has executed the lignograph, 118, I would refer the reader to the steel plate in Philos. Trans. 1846,

pl. xxi. for figures of these marvellous fossils.

Not only is the form and general character of the animal substance preserved, but even its flexibility; for in one instance, the body, released by the solution of the chalk and shell, was uncoiled and pressed out, as shown in *Lign.* 119, *fig.* 4.

In one specimen, (figured in *Philos. Trans.* 1846, pl. xxi. *fig.* 10,) the membrane of the largest sacs is much corrugated, and disposed in numerous duplications, probably owing to the empty state of these segments, when immersed in the chalk; but the discoidal contour of the original is well preserved. This fossil so closely resembles the decalcified body of a recent Rotalia or Rosalina, that an eminent observer who saw it under the microscope at the meeting of the Royal Society, without knowing its history, concluded it to be the body of a recent animal. This extraordinary preservation of the soft delicate tissues of an animal of the cretaceous seas, invisible to the unassisted eye, through the incalculable ages that must have elapsed since the deposition of the chalk in which it was enshrined, is a fact as remarkable as the occurrence of the carcass of the Lena Mammoth, in the frozen soil of Siberia.

FORAMINIFERA IN CHALK AND FLINT.



LIGN. 119. REMAINS OF FORAMINIFERA; IN CHALK AND F
(*Viewed by transmitted light; highly magnified.*)

Fig. 1. Shell of a ROSALINA, filled with mineral matter; in flint.
—
2. Soft parts of a TEXTULARIA; in flint.
—
3. Cells of TEXTULARIA ELONGATA; filled with mineral matter; th
— in flint.
4. The soft body of a ROTALIA, deprived of its shell, and partially
— obtained from Chalk, × 450 *diameters*.

The soft parts of other foraminifera have been discovered in a similar state of preservation. A fine example of the body of a Textularia, in flint, is figured, *Lign.* 119, *fig.* 2.

The form and disposition of the segments in *Textularia elongata*, is shown in *Lign.* 119, *fig.* 3. These cells are filled with inorganic matter. The shell of a Rosalina filled with an opaque mineral substance, forming casts of the cells, is represented in *Lign.* 119, *fig.* 1.

The preservation of the soft parts of foraminifera and of mollusks, in a fossil state, is a phenomenon of frequent occurrence, and no longer questioned by geologists, notwithstanding the scepticism with which my first announcement of the fact was received. Dr. Bailey, of West Point Military Academy, soon after the publication of my first paper, sent me specimens from the marls of New Jersey.

FORAMINIFEROUS LIMESTONES OF INDIA.—So much doubt was expressed as to the accuracy of my opinion respecting the nature of the fossil Rotaliæ, that its corroboration by observations on certain limestones in India, by H. J. Carter, Esq. Secretary of the Bombay Royal Asiatic Society, was as gratifying as unexpected. According to the researches of that gentleman, the south-east coast of Arabia is chiefly composed of two distinct limestone formations; the one averaging about 4,000 feet above the level of the sea, and the other 600 feet. The latter forms the desert of Akaf, and with the intervention of the mountains of Oman, which belong to the greater formation, passes up into the lower Sindh; while the former constitutes the high land of the coast, which, parting from the western border of the Desert of Akaf, extends nearly to Cape Aden.

The limestones of both these groups, or formations, consist chiefly of foraminifera; the largest forms being visible to the naked eye. Mr. Carter states that his attention was first directed to the organic composition of the Porebunder limestone, which is imported into Bombay for building, by small amber-coloured specks on the stone, that resembled the soft parts of foraminifera figured and described by me in the Philosophical Transactions. "On subjecting a portion of the

limestone to the action of acid, I found them to be what Dr. Mantell's observations had led me to expect, the actual remains of the animals, of exquisite beauty in form and symmetrical development. The minute kinds in the Porebunder stone do not average more than $^{1}/_{900}$ of an inch in diameter; and the composite forms are held together by thread-like attachments, which indicate the tubular communications that existed between them when living."[331]

> [331] "On the Existence of Beds of Foraminifera, Recent and Fossil, on the South-East coast of Arabia," by H. J. Carter, Esq.; Proceedings of the Bombay Royal Asiatic Society, 1848,

FORAMINIFEROUS DEPOSIT AT CHARING.

FORAMINIFEROUS DEPOSIT AT CHARING. *Lign. 109.*—The little town of Charing, in Kent, has acquired a celebrity among those naturalists who are interested in the present inquiry, by the researches of William Harris, Esq. F.G.S. who some years since made known the existence of a remarkable deposit of chalk detritus, about one foot in thickness, which extends over the outcrop or exposed surface of the firestone in that locality.

This bed consists of a soft, whitish, tenacious clay, which, when immersed in water, is found to be largely composed of minute grains, that prove to be foraminifera. These shells belong to many species and genera; and are associated with the cases of entomostraceous crustaceans, spicula of sponges, &c. The organisms readily separate from the amorphous particles by washing, and specimens may be easily obtained as distinct and perfect as if recent. See *Lign.*

109, *ante*, p. 342. Intermingled with the cretaceous forms, are minute fresh-water shells, apparently derived from a modern source.

The Charing deposit appears to have originated from the action of water on the unconsolidated chalk of the neighbouring Downs, before the surface of the hills was protected by a covering of vegetable soil.

Through the liberality of Mr. Harris, I have been able to examine an extensive series of the Charing Foraminifera; and Prof Williamson has figured and described the principal types in an interesting memoir in the Transactions of the Manchester Philos. Soc. vol. viii. 1847. As in most of the cretaceous strata, the prevailing species are referable to the genera Textularia, Rotalia, Rosalina, Cristellaria, Lagena,[332] &c. There are numerous spicula of sponges, and needle-like calcareous prisms, which are the detritus of the fibrous shells, called Inoceramus.

[332] This interesting type of Foraminifera is the subject of a Memoir by Prof. Williamson; Annals, Nat. Hist. 1848, vol. i.

FORAMINIFERA OF THE OOLITE, LIAS, &C.—The occurrence of certain genera in particular rocks has been incidentally noticed in the previous descriptions, and it is needless to particularize any localities of the Oolite, Lias, and other secondary deposits. It must suffice to state that Dr. Carpenter, Prof Williamson, Prof Phillips, Mr. Sorby, Mr. Rupert Jones, and other able observers, have figured and described foraminifera from the strata between the Chalk and the Carboniferous formations: the report to be drawn up by the two first-named gentlemen for the British Association, will present a resume of the

British fossil genera and species.

It is deserving record, that no vestiges of foraminifera have been found in the Wealden strata; the fluviatile origin of those deposits renders it improbable that the remains of these marine organisms should occur in great numbers, yet from, the estuary character of some of the beds, the presence of foraminifera might be expected.

FORAMINIFEROUS DEPOSITS OF THE UNITED STATES.—Dr. Bailey has made us familiar with the foraminiferous rocks of North America. The various memoirs on this class of fossil animalculites, and on the diatomaceæ (*ante*, p. 93.), published in the American Journal of Science, and in the Smithsonian Transactions, attest the acumen, and unwearied spirit of research, of this able observer. Not only from the United States, but from numerous localities in Asia and Arabia, Dr. Bailey has transmitted me specimens of limestones containing foraminifera, chiefly of the genera Rotalia and Textularia.[333]

[333] From Beyrout, Damascus, the Mount of Olives, Anti-Libanus.

In the calcareous marls of the Upper Missouri river, extending nearly to the Rocky Mountains, similar fossils are met with.

In the interior of Florida, the white orbitoidal limestone is traversed by flint; and the calcareous and siliceous masses are full of microscopic foraminifera.[334]

[334] Smithsonian Contributions, vol. ii. p. 161.

FORAMINIFERA OF THE CARBONIFEROUS FORMATIONS.

FORAMINIFERA OF THE CARBONIFEROUS FORMATIONS.—In the carboniferous limestones of England, the late Mr. Bowman, Prof. Tennant, and Mr. Darker, detected shells of foraminifera, apparently of the genus Fusulina.[335] Prof. Phillips mentions the occurrence of nautiloid foraminifera in the palæozoic limestones of Carrington Park, South Devon, and Yorkshire.[336]

[335] Edinburgh New Phil. Journal, vol. xxx. p. 44.

[336] Proceedings of the Polytechnic Society of the West Riding of Yorkshire, 1845.

Dr. Dale Owen is said to have obtained "well characterized polythalamia from the oolitic portion of the carboniferous (Pentremitic, *ante*, p. 298.,) limestone of Indiana."[337] And M. de Verneuil discovered a species of Fusulina, in the Millstone-grit of the coal formation of the Ohio.

[337] American Journal of Science, vol. xlvi. note to p. 311.

But the most remarkable deposits of foraminifera in the palæozoic rocks, are those of Russia, described by Sir Roderick Murchison.[338] The upper beds of the Mountain limestone in the Lower Volga, consist of laminated calcareous shales, composed of an aggregation of shells of Fusulinæ. Bands of limestone, through a vertical extent of two hundred feet, are loaded with Fusulinæ; layers from five inches to five feet in thickness, consist of a pure white Fusulina limestone; the foraminifera are all of one species, the *Fusulina cylindrica*.

[338] Geology of Russia in Europe, vol. i. p. 86. pl. i. fig. 1.

FORAMINIFEROUS LIMESTONE OF NEW ZEALAND. —"On the eastern coast of the Middle Island of New Zealand, to the north of Otago, strata of yellow and fawn-coloured limestone appear on the surface at Ototara, and continue to Kakaunui. This rock is generally friable and porous; it contains terebratulæ, spines and cases of echinoderms, pseudo-belemnites, teeth of sharks, &c. A microscopical examination shows it to be in a great part composed of an aggregation of very small polythalamia."[339] The specimens of the Ototara limestone received from my son, are very rich in minute corals and shells, and foraminifera of the European cretaceous type: species of Rotalia, Cristellaria, Globigerina, Textularia, Rosalina, Nodosaria, Dentalina, &c. Among them are two forms which occur at Charing: namely, *Rosalina Lorneiana*, *Lign.* 109, *fig.* 5, and Textularia elongata: of the latter a specimen in flint is figured, *Lign.* 119, *fig.* 3. The soft parts of Rotaliæ are preserved in the Ototara limestone, as in our chalk.

[339] Notes on the Geological Structure of the Middle Island of New Zealand, by Walter Mantell, Esq. of Wellington. 1848.

There are likewise, as at Charing, cases of Entomostracæ of the genera *Basidia* and *Cythereis*. [340]

[340] See Geol. Journal, vol. vi. p. 339. pl. xxix.

The assemblage of fossil remains in the Ototara rock has decidedly a cretaceous aspect, but till the geological position of the strata in relation to the other formations of the Island is determined, it would be premature to regard these limestones as the equivalents in time of the Chalk formations of

Europe.[341]

[341] A list of the Ototaran fossils collected by Mr. Walter Mantell, is given in Geol. Journal, vol. vi. p. 329.

TERTIARY FORAMINIFERA.—The marine tertiary deposits which contain foraminifera in abundance, are so numerous, that it is unnecessary to particularize any. The sands of the Paris basin in some localities are so full of microscopic forms, that a cubic inch of the mass contains sixty thousand. The friable calcareous strata at Grignon are a loose aggregate of the shells of foraminifera and minute mollusks; and as the fossil shells from that locality are very common, and generally filled with debris, the student will have no difficulty in obtaining specimens for examination. The tertiary argillaceous deposits of England are less rich in foraminifera than the arenaceous; but the usual types occur in the London Clay, at Highgate, Clapham Common, Bracklesham Bay, &c. The Eocene marls of the United States are rich in foraminifera.

FORAMINIFERA OF THE FENS.

FORAMINIFERA OF THE FENS OF LINCOLNSHIRE AND CAMBRIDGESHIRE.—Though the alluvial deposits of the fen-districts are comparatively of modern date, yet the rich assemblage of foraminifera contained in the clay of certain districts is so interesting and instructive, that a brief notice of them must not be omitted. The foraminiferous character of the Lincolnshire alluvium was first made known to me by specimens from Bolton, sent me by Professor Williamson; and their extension over a wide area in Cambridgeshire, by a liberal supply from Mr. Smith, of March. The bed that abounds in

these shells, is about seven feet beneath the surface, and consists of a fine sea sand combined with carbonaceous and argillaceous matter. By washing about a gallon of this earth in water, an ounce of polythalamia and organic detritus may be obtained. The perfect shells are as fresh as if just dredged up from the sea; the soft parts—the membranous segments held together by their tubular connexion—in many instances remaining in the shell; these parts may be obtained by the solution of the shell in acid. When the Rotaliæ are rendered transparent by immersion in Canada balsam, their appearance, by transmitted light is identical with that exhibited by the fossil specimens; and if viewed by reflected light, the body may be seen occupying all the cells of the shell; but the segments are somewhat collapsed; evidently from the shrinking of the animal tissues after death.[342]

[342] Two specimens are figured in my notice of fossil Foraminifera. Phil. Trans, p. iv. for 1846, pl. xxi. figs. 13, 14.

The organisms of the Lincolnshire alluvium have been thoroughly investigated by Prof. Williamson; they comprise many species and genera, of the usual types; as Rotaliæ, Rosalinæ, Polystomellæ, Textulariæ, Lagenæ, Nodosariæ, &c. It is remarkable, that though a marine estuary deposit, no vestiges of diatomaceæ have been observed.

The bed so rich in foraminifera, extends west and south-west of the Wash. Mr. Smith sent me a mass of sandy clay, from a well sunk in the town of March, to the depth of twenty-five feet, that was loaded with these beautiful organisms.[343]

[343] The reader interested in these

inquiries should peruse the highly interesting Memoir by Prof. Williamson, "On some Microscopical Objects found in the Mud of the Levant, and other Deposits." Manchester Phil. Trans, vol. viii.

RECENT FORAMINIFEROUS DEPOSIT AT BRIGHTON.—An interesting fact connected with the phenomena under review is deserving record. The presence of the fossils of an older formation, in strata subsequently deposited, and in part composed of the detritus of the rocks whence the organic remains were derived, is not uncommon: such fossils are termed by the French geologists "*fossiles remaniés*." The nature of these re-deposited fossils is generally obvious; either by the water-worn condition of shells, bones, &c. or from their containing particles of their parent bed; or if casts, from their mineral composition. Thus in the chalk of St. Catherine's Mount, near Rouen, there are numerous casts of Ammonites, Scaphites, and other shells, composed of marl full of particles of greensand. These have evidently been washed out of the preceding cretaceous beds of firestone or glauconite; and re-deposited in the chalk strata in which they are now imbedded.[344] * * * * *

[344] M. D'Orbigny.

Along the sea-shore, to the east of Brighton, there is a bank of sand and calcareous mud, the detritus of the neighbouring cliffs, in the progress of formation; and in this sediment Mr. Reginald Mantell discovered recent Rotaliæ, Nodosariæ, &c., with frustules of Bacillariæ, Coscinodisci, Naviculæ, and other diatomaceæ; associated with cretaceous polythalamia washed out of the chalk,[345] The difference in the aspect of the recent and fossil organisms was so

evident, as to leave no doubt of the correctness of this interpretation. Here, then, at the present moment, a deposit is going on, whose organic contents consist of an assemblage of species of living animalcules of our seas, with the fossil forms of the ancient chalk ocean; in like manner as in the bed of the Nile, the Nummulites of the tertiary rocks are being imbedded with the existing mollusks and desmidiæ of that river (*ante*, p. 345.).

[345] See *ante*, p. 99.

GEOLOGICAL DISTRIBUTION OF THE FORAMINIFERA.

GEOLOGICAL DISTRIBUTION OF THE FORAMINIFERA.—According to the observations of M. D'Orbigny, the first appearance of the tribes of minute beings which have played so important a part in the elaboration of materials for the formation of the sedimentary rocks of the secondary and tertiary ages, and are at this moment invisible but powerful agents in the accumulation of calcareous sediments at the bottom of the sea, was in the Carboniferous epoch, and by a single type, the *Fusulina* (*ante*, p. 346.). I believe no certain evidence of the occurrence of Foraminifera in Silurian or Devonian deposits has been obtained.

M. D'Orbigny gives the following summary of the distribution of the known fossil and recent species:—

	GENERA.	SPECIES.
Carboniferous System	1	1
Jurassic	5	20
Cretaceous	34	280
Tertiary	56	460
Living in the present Seas	68	1000

Of the recent species,	575	inhabit the	Tropics.
———	350	——	Temperate zones.
———	75	——	Cold regions.

The above statistical view was published six years ago; but the great activity of research that has since prevailed, has largely augmented the known number both of fossil and recent forms. M. D'Orbigny's recent Tables[346] give for the Jurassic or Oolite 10 genera; Cretaceous, 38 genera; Tertiary, 60 genera; but this estimate must be far too low.

[346] Cours Elémentaire de Paléontologie.

I have thus endeavoured to convey a general idea of the highly important results obtained by the microscopical investigation of the minute organisms that enter so largely into the composition of many of the fossiliferous deposits.

Without the aid of the most perfect optical instruments which modern science and art have produced, even the existence of many of these structures could not have been demonstrated; and we cannot doubt, that were the powers of the microscope increased, the fossil remains of beings still more minute would be detected; and that rocks and strata which now appear to consist of amorphous particles of lime, of silex, and of iron, would prove to be the aggregated skeletons of animals, yet more infinitesimal than those which have formed the subject of our contemplations. How strikingly illustrative are these phenomena of the profound remark of the illustrious Galileo—"*La*

nature fait beaucoup avec peu, et ses opérations sont toutes également merveilleuses."

INSTRUCTIONS FOR THE MICROSCOPICAL EXAMINATION OF CHALK, FLINT, AND OTHER ROCKS.

MICROSCOPICAL EXAMINATION OF CHALK.

CHALK.—The following method is that recommended by M. Ehrenberg, Place a drop of water upon a plate of thin glass, and put into it as much scraped chalk as will cover the fine point of a knife, spreading it out, and leaving it to rest a few seconds; then withdraw the finest particles which are suspended in the water, together with most of the liquid, and let the remainder become perfectly dry. Cover this dried spot of chalk with Canada balsam (the turpentine of *Abies balsamea*), and hold the plate of glass over the flame of a lamp, until the balsam becomes slightly fluid, without froth or air-bubbles; it should be maintained in this position (the glass being kept as hot as the finger will bear) for a few minutes, until the balsam is found to have thoroughly permeated the substance to be examined. It is preferable to place a piece of very thin glass upon the balsam, and gently press it down, and allow it to remain. The best flatted crown-glass should be used for placing the chalk or other objects on. It is convenient to have the slips of glass of one size, or the specimens will require different boxes for their reception; three inches by one inch is that usually employed. These objects require to be viewed with a power magnifying three hundred times linear, that is, in diameter; and if the process has been properly conducted, it will be seen that the chalk is chiefly

composed of well-preserved organisms. In these preparations the cells of the foraminifera appear at first black, with a white central spot; this is caused by the air contained in those cavities, for air-bubbles always appear as black annular bodies; by degrees, the balsam penetrates into all the single cells, the black rings of the air vesicles disappear, and the structure of the original is beautifully displayed.[347]

[347] Specimens of chalk, flint, and other rocks for examination; or specimens prepared on slides, may be obtained of the microscopic artists, named in the Appendix.

SOFT PART OF ROTALIÆ IN CHALK.—The manner in which I obtained the unmineralized soft bodies of foraminifera from chalk has already been mentioned (*ante*, p. 360.); but it may be useful to offer a few additional suggestions; for such fossil remains are not easily extracted. Many experienced microscopical observers have not succeeded in obtaining one good specimen; but others have been more fortunate, or persevering.

In several glass test-tubes, (the more the greater chance of success,) put a few grains of chalk powder: pour the tube half full of diluted hydrochloric (muriatic) acid—about ten parts water to one of acid—agitate, and set the mixture by: when all action has ceased add one or two drops of undiluted acid to each tube, and repeat the process at due intervals till all the calcareous matter is dissolved. Pour off the fluid, substitute distilled water, agitate, and then let the sediment subside. The residue will consist of atoms of quartz and other insoluble mineral matter, and animal tissue, if there be any. Then, with a camel-hair pencil, place a small portion of the sediment on a glass slide, and when dry cover it with

Canada balsam, and treat it as above directed. Among a dozen slides thus mounted, there will probably be two or more good examples of the body, or detached membranous segments of Rotaliæ or Textulariæ, like those figured in *Lign.* 118.

CALCAREOUS SANDSTONES AND MARLS.—These substances may be examined by the same process; but if of loose texture, Dr. Bailey recommends that some of the sandy powder should be spread very thinly on a plate of glass, with or without water, and by the aid of a lens of moderate power the roundish grains should be selected and picked up with fine forceps, or the point of a needle, and transferred to another piece of glass, having on one spot a thin coat of Canada balsam. This should be gently heated over a spirit lamp, when the balsam will penetrate the grains, and render them transparent; by this process the minutest shells, &c. may be detected. For a hasty exploration, the dust may be rendered sufficiently transparent by a drop or two of oil of turpentine.

Sandy calcareous marls may be examined by diffusing a few grains in water in a wine-glass, the lighter portions will be suspended in the fluid, and may be placed on glass, and when dry prepared with Canada balsam in the usual manner.

MICROSCOPICAL EXAMINATION OF FLINT.

FLINT.—Flint, and other siliceous stones, require to be chipped into very thin fragments, and immersed in oil of turpentine. A clear, translucent flint should be selected, from which fragments may be shattered off by smart blows of a hammer, over a sheet of white paper: the most transparent flakes are to be selected, and these should be put in oil of turpentine, in a wide-mouth glass bottle. Take out

the pieces for examination with forceps, and inspect them as transparent objects, by transmitted light. When good specimens are discovered, mount them in Canada balsam.

It is hazardous to entrust such fossils to the lapidaries; an interesting group of twenty spiniferites was reduced to ten, by one of our best workmen, in whose hands it was placed for polishing, with the view of rendering it more transparent.

CHAPTER XI.

FOSSIL TESTACEOUS MOLLUSCA, OR SHELLS.



LIGN. 120. FOSSIL OYSTER, FROM THE CH
Kemptown, Brighton.

ON FOSSIL MOLLUSCA.—Numerous as are the fossil remains of the various types of animal organization which have already passed under review, they are far exceeded in number and variety by those of the beings whose mineralized relics we now propose to investigate. Although every one is familiar with the external appearance of the shells cast up by the waves on the shores of our island, and of those which, from their varied colours and elegant forms, are preserved in the cottage of the peasant, and in the mansion of the rich, but few persons are conversant with the nature of the animals that secreted and were protected by these beautiful and

enduring structures. The organization even of the oyster, mussel, whelk, &c., is known only to the naturalist. Appearing to the uninstructed eye as a shapeless gelatinous mass, there is nothing to arrest the attention, or excite the curiosity. Yet the beings which inhabited these durable cases, are objects of the highest interest and present a rich field of instructive investigation.

Except as shedding some light on the structure and economy of their inhabitants, the shells, in the estimation of the naturalist, are the least interesting part of the organization of the Mollusca; but to the geologist, from their permanent nature, and the proofs they yield of the conditions under which the strata that contain them were deposited, they are important in the highest degree. It has even been found convenient to classify formations, in which fossil shells largely prevail, by the relative numerical proportion of the recent and extinct species found in the different groups of strata; and the terms, Eocene, Miocene, and Pliocene, (proposed by Sir C. Lyell,) have reference to this character, as we have previously explained (*ante*, p. 24.).

FOSSIL MOLLUSCA.

The *Mollusca*, a name indicative of the soft nature of the integuments of these animals, constitute a very comprehensive subdivision of the animal kingdom, and are separable into two principal groups, viz. the *Acephala* and the *Encephala*.

I. The ACEPHALA (so termed because they are destitute of a head) have neither jaws, tongue, nor a distinct mouth. They are aquatic, and are subdivided into classes, according to the modification of their integument, or of their gills.

a. The TUNICATA (from the elastic *tunic*, or *mantle*, in which they are enclosed) have no shell, and therefore do not come within the scope of our inquiries: yet it is possible that the soft parts even of these perishable structures may have left some trace, or that markings of their integument on the silt or mud may be preserved;[348] and I would recommend the student to search for such indications on the rippled surface of clays and sandstones.

[348] The *Ischadites Königi* of the Ludlow rock was supposed to resemble *Boltenia*, a pedunculated Ascidian.

b. The BRACHIOPODA (*arm-feet*) have two long spiral fleshy arms, or brachia, developed from the sides of the alimentary orifice, are enclosed in bivalve shells, and respire by means of their vascular skin, or mantle. They have not the power of locomotion, but are fixed by a peduncle to other bodies.

c. The LAMELLIBRANCHIA (*plated gills*) have also bivalve shells, but their respiration is effected by gills composed of vascular membrane disposed in plates, and attached to the mantle; the *beard* of the Oyster is the branchial or respiratory apparatus of that animal. These bivalve Mollusca are subdivided into those which close their shells by one adductor muscle, hence called *monomyaria*, as the Oyster; and those which have two muscles, *dimyaria*, as the Cockle. As the impressions left on the shells, by the attachment of these adductor muscles, and by the margin of the mantle, are found as perfect in the fossil as in the recent, they constitute important distinctive characters.

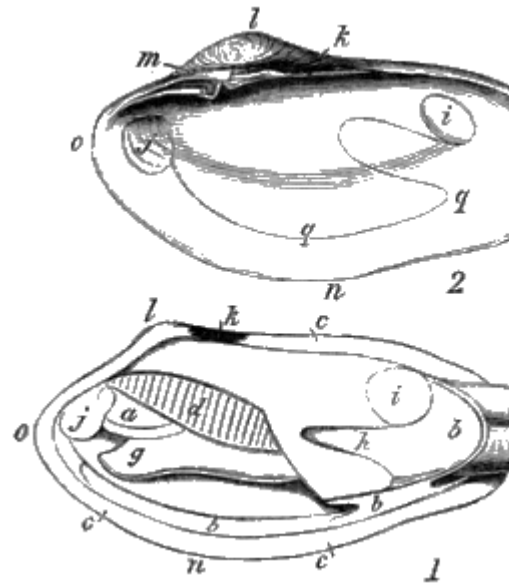
Dr. Gray's definition of the respective parts of

univalve and bivalve shells is at once clear, concise, and natural, being conformable to the structure of the body of the enclosed mollusk.

The *front* of the shell is the part which covers the head of the animal; the back of the shell is the part which covers the tail; the left and right sides correspond with the same parts of the mollusk.

In univalves, the apex of the shelly cone whether it be simply conical or spiral (except in Patella) is over the hinder part of the animal: when the shell is placed on its mouth with the apex towards the observer, the parts of the shell correspond with the position of the person looking at it.

FOSSIL BIVALVE SHELLS.



LIGN. 121. ILLUSTRATION OF FOSSIL BIVALVE PETRICOLA PATAGONICA. *D'Orb.*
Interior of right valve, and the same valve with the animal as seen

a. Labial Palpi.
b. Mantle.
c. Margin of shell.
d. Branchiæ.
e. Anal siphon.
f. Branchial siphon.
g. Foot.
h. Retractor muscle of siphons.
i. Posterior adductor.
j. Anterior adductor.
k. Ligament.
l. Umbo.
m. Lunule.
n. Base, or ventral margin.
o. Anterior side.
p. Posterior side.
q. Pallial line.

(The length of the shell is estimated from *o* to *p*, its breadth from *l* to *n*.)

In bivalves (*Lign.* 121) the ligament is always on the dorsal surface of the animal, and the mouth in front of the apex or umbo of the valves, before the ligament. A bivalve placed with the hinge side uppermost and the ligament towards the observer is in the same relative position as the person looking at it; viz. the HEAD in front, and the right and left valves in their natural relations. The length of the shell is therefore from the front to the back of the animal: the width or transverse diameter is from the umbo to the margin. Much confusion has arisen from many conchologists having described the length and width of a shell diametrically opposite to the proper position of its inhabitant.

II. THE ENCEPHALOUS MOLLUSCA.—These possess a head, with feelers or soft tentacula, eyes, and a mouth with jaws; they are arranged in classes, according to the modification of their locomotive organs; for, with but few exceptions, they are free animals, and can crawl, climb, or swim. Their shells are, for the most part, composed of one piece, or valve, hence they are termed *Univalves*. In some genera the shell is a simple cavity, spirally disposed, as in the Snail; in others, it is conical, consisting of one or many pieces, as in the *Limpet* and *Chiton*. In

the Cephalopoda it is internally divided into cells, or chambers, as, for example, in the Nautilus.

The Encephalous Mollusca are subdivided into the following classes; viz.—

a. PTEROPODA (*wing-feet*).—In these the organs of progression are two wing-like muscular expansions, proceeding from the sides of the neck, by which they can swim and float in the open sea: all the species are of small size.

b. GASTEROPODA (*feet under the body*).—These crawl by means of a muscular disk, or foot, which is attached to the under-part of the body; most of the species are marine, but some are terrestrial, and others inhabit fresh-water. They are very widely distributed; the garden snail is a familiar instance of a terrestrial Gasteropod.

c. CEPHALOPODA (*feet around the head*).—The mollusca of this order have powerful muscular arms, or tentacula, which surround the head, or upper part of the body; some genera have no shell, but possess an internal skeleton, as the recent Sepiadæ and the fossil Belemnitidæ. Most of the testaceous Cephalopoda have a discoidal, univalve shell, which is divided internally by septa or partitions; as the Nautilus.

FOSSIL MOLLUSCA.

In many univalves the aperture or opening is entire, that is, without any notch or groove; in others it is notched or extended into a canal, or siphon, and this character has relation to the respiratory organs: thus the Gasteropods, in which the water is conducted to the interior by a muscular tube, or siphon, have the margin of the aperture of the shell

channelled; as in the Whelk, or *Buccinum*. Many of the land and fresh-water species have entire openings, and are, for the most part, herbivorous; while the greater number of the marine univalves have the aperture indented or notched, and are carnivorous.[349] Some of these mollusca, too, have a retractile proboscis, armed with minute teeth, by which they can rasp or bore into the shells of the species on which they prey. There are some exceptions to the above rules, but the prevalence of the characters specified afford pretty certain indications of the fluviatile or marine nature of the originals. The application of these data to geological investigations will be considered hereafter.

> [349] The form of the aperture does not necessarily indicate fresh-water genera. *Melanopsis*, *Pirena*, and most of the *Melaniæ* have a channelled or notched aperture. Fresh-water univalves frequently have the spire corroded; in a fossil state they can only be determined [to be fresh-water species] by their analogy to recent genera and sub-genera.—*Note by Mr. Woodward.*

In the generic distinctions of the simple univalves, the form of the mouth is an important character; while in the bivalves, the configuration of the hinge affords an equally convenient aid for their classification.

Some tribes of testaceous mollusca are exclusively marine; many are restricted to the brackish water of estuaries; others live only in fresh-water; and some on the land. Their geographical distribution is alike various: certain groups inhabit deep water only, and are provided with means by which they can maintain themselves near the surface of the ocean, far away

from any shore; while others are littoral, that is, live in the shallows along the sea-shores. Many exist in quiet, others in turbulent waters; some are gregarious, like the oyster; while others occur singly, or in groups. The vertical range, that is, the relative depths in which the mollusca live in the sea, is also strictly defined; certain genera being, in a great measure, restricted to moderate depths, others to a few fathoms, and many to the profound abysses of the ocean, which neither the dredge nor the plummet can reach. All these varieties of condition are more or less strongly impressed on the shells, which may be considered as external skeletons;[350] and the accomplished conchologist is enabled, by certain characters, to determine the nature of the animals which inhabited them, and the physical conditions in which they were placed.[351]

[350] In equivalve bivalves the animal lives in an upright position. In inequivalves, *i.e.* one large and one small valve, the animal lies on its side. The situation of bivalve shells, as oysters, should therefore be noticed, for if they lie on their concave shell, with the flat valve uppermost, it is evident they were overwhelmed in their native bed and in a living state; if they lie indiscriminately on either valve, they were probably dead shells and overwhelmed in that state. If the pallial imprint is notched by a sinus, it shows the presence and size of the tubes of the mantle. Whether there be one or two muscular impressions is of far less importance.

[351] For an extended notice of the geographical distribution of testacea, see Prof. Edward Forbes, British Marine Zoology, Part I. p. 141.

The number of living species of mollusca known to naturalists, not including the shell-less genera, exceeds twelve thousand; and almost every day is adding new species, for scarcely a vessel arrives from distant seas without enriching the stores of the conchologist. The numerous genera into which they are divided by systematists, and the constant changes effected in arrangement and nomenclature by every writer on the subject, render it difficult if not impossible to present the reader with any satisfactory epitome of modern conchology.

I must restrict myself to a brief account of some of the most common genera that occur in the British strata; and shall dwell more particularly on those species which prevail in the secondary formations, because they present the most important deviations from the recent types that are familiar to the general observer; by this means, and by reference to figures in standard works, the collector will, I trust, be enabled to identify the fossil shells which may most frequently come under his notice in the course of his geological rambles.

FOSSIL BIVALVE SHELLS; INCLUDING THE BRACHIOPODA AND LAMELLIBRANCHIA.

FOSSIL BIVALVE SHELLS.

Although in the modern Tertiary strata, as the Crag, and in the arenaceous beds of the Eocene formations, shells are generally found in so perfect a state, that no caution or knowledge is requisite for their collection, yet a few preliminary remarks are necessary to point out certain conditions in which the remains of mollusca, or evidence of their

existence, occur in the mineral kingdom, and particularly in the older fossiliferous rocks. Shells are found in the strata in the three following states:—

1stly. Shells in which the constituent substance has undergone but little change. Many of the specimens in the sands of the Crag in Norfolk and Suffolk, and in the Eocene beds at Grignon, near Paris, and the Pliocene of Palermo, in Sicily, are as perfect as if collected from the sea-shore, having suffered no loss but that of colour. In some instances, even the varied markings on the surface remain; but in general the shells are bleached, or have a ferruginous stain.

2dly. The form preserved, but the constituent substance mineralized. This state is very common in shells that are imbedded in hard rock, whatever may be the age of the deposit. In calcareous strata the testaceous substance is generally transmuted into calcareous spar, as in most of the specimens from the chalk, oolite, mountain limestone, &c. In sands abounding in silex, the shell is changed into flint, as in the exquisite fossils from the Greensand of Blackdown, Devonshire; in deposits permeated with sulphuret of iron, the shells are often metamorphosed into pyrites, as in the Ammonites in the Lias, Galt, &c.

3dly, In the state of casts and impressions. Although in loose sand the shells are either empty, or filled with detritus easily removable by washing; in clay, limestone, and sandstone, the cavities are generally occupied by consolidated materials, which had entered when in a soft or fluid state; and frequently the substance of the shell has disappeared, and the stony cast of the interior alone remains. In

many instances, the spaces left by the dissolution of the shells are filled with spar, or the casts are closely invested by the surrounding stone, from long-continued superincumbent pressure while the matrix was in a plastic state; and in such cases the casts are often distorted and flattened. But the vacancy is occasionally empty, and on its walls is found an impress of the external surface of the shell, with all the lines and ornaments of the original as sharp as if cast in plaster of Paris.



LIGN. 122. TURRITELLÆ, FROM BRACKLESHAM, SUSSEX

Fig. 1.— TURRITELLA CONOIDEA; the perfect shell: *nat.*

2.— SEPTARIUM, with TURRITELLÆ; a polished slab: $^{1}/_{3}$ *nat.*

3.— A cast of one of the shells, in calcareous spar: *nat.*

SEPTARIUM WITH SHELLS.

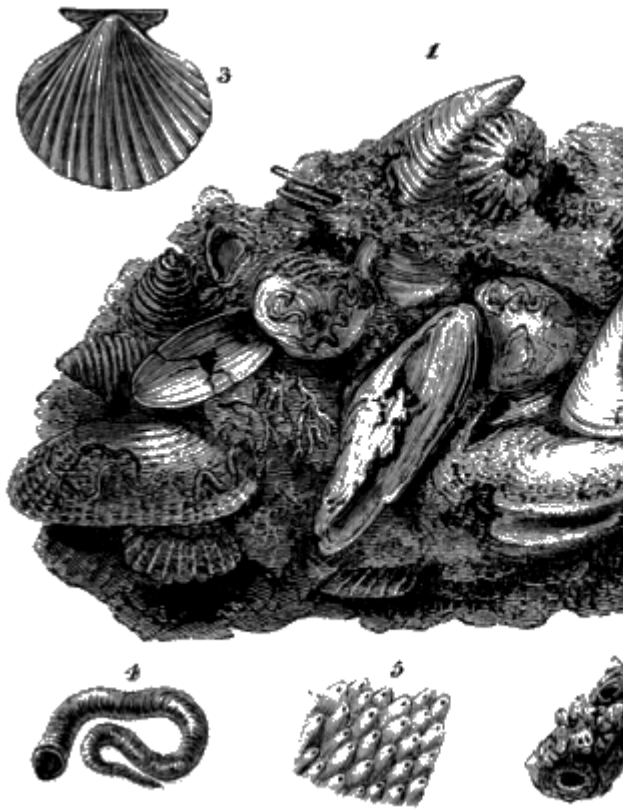
The specimen, *Lign.* 122, *fig.* 2, from the tertiary

strata at Bracklesham Bay, Sussex, is a polished slice of indurated argillaceous limestone, from a septarium (*nodule divided by fissures*), abounding in spiral univalve shells, called *Turritellæ*. *Fig.* 1 is a perfect shell of the same species, extracted from soft clay; and *fig.* 3, a cast in calcareous spar, obtained from the septarium. In the polished slab, *fig.* 2, sections of numerous shells are seen. The dark partitions, or septa, are veins of spar, which occupy interstices that have been formed in the clay-nodule by shrinking; and if the specimen be closely examined, the shells will be found split across and displaced by the fissures; thus presenting an interesting illustration of the faults, or dislocations, of the strata, so familiar to the geological observer. In the present instance, the lines on the exterior of the shell do not materially differ from those on the interior, and, consequently, the cast, *fig.* 3, and the shell. *fig.* 1, resemble each other; but in many species there is a striking contrast between the outer and inner surfaces, the external aspect being strongly ornamented, while the internal is smooth; the cast, therefore, in such examples, so little resembles the shell, that an inexperienced collector may readily suppose it belongs to a different species. The bivalve called Trigonia, *Lign.* 127, *figs.* 1, 2, is an instance of this contrast.

The polished slab of the Septarium, *Lign.* 122, *fig.* 2, demonstrates another condition of fossil shells—that of a compact argillaceous limestone—and entire beds of marble are composed of an aggregation of this kind, formed of shells and other animal exuviæ, consolidated by mineral infiltrations. In the older secondary strata this state prevails; and the beautiful markings of many valuable marbles, are merely sections of the enclosed shells. But this process is not

restricted to the deposits of ancient date; at the present moment the same operation is silently but constantly going on in our seas, and an examination of the specimen, *Lign.* 123, will afford an exemplification of the manner in which these shelly limestones are produced.

BRIGHTON SHELL-CONGLOMERATE.



LIGN. 123. SHELL-CONGLOMERATE; NOW FORMING IN T
Dredged off Brighton.

Fig. 1.— An Aggregation of Shells and Corals; the interstices filled up with sand, and the mass is consolidated by infiltration of carbonate of lime.

2.— TROCHUS ZIZIPHINUS; extricated from the mass wit

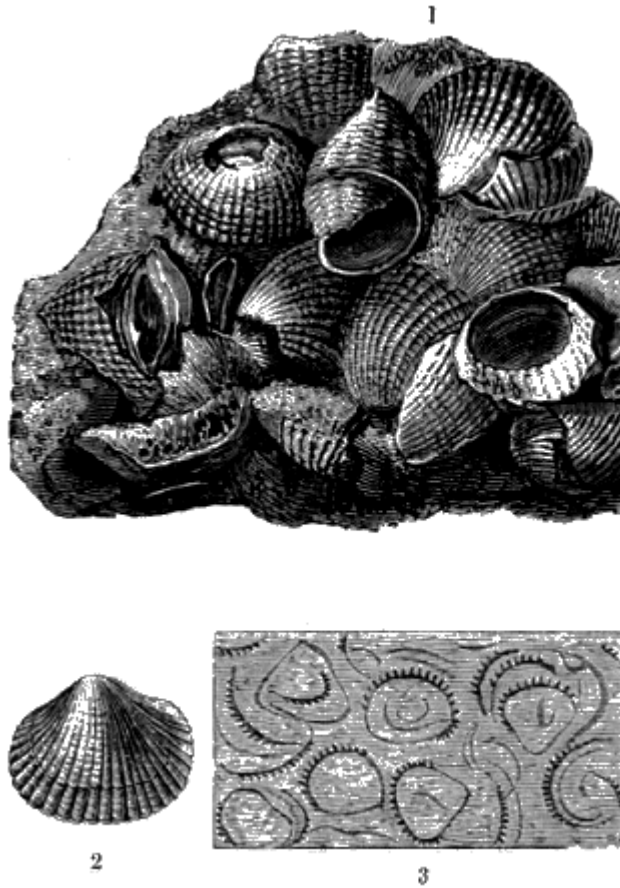
3.— PECTEN OPERCULARIS.

4.— SERPULA.

5.— Portion of a CELLEPORA; magnified.

6.— SABELLA.

We have here a solid mass of stone, composed of several recent species of shells, corals, &c. It is a fragment of a large block, dredged up from the British Channel, off Brighton. Similar masses have been obtained at different soundings along this part of the Sussex coast; and in some specimens numerous other species of recent shells, as oysters, mussels, whelks, &c. enter into the composition of the consolidated rock. The shelly and coralline limestones and sandstones, so abundant in the ancient strata of England have been formed in a similar manner; and when the modern conglomerate of Brighton shall have been permeated with crystalline matter, and subjected to great pressure by superincumbent deposits, through countless centuries, and at length be elevated above the waters, it will constitute beds of shell-marble, in some mountain range, and become an interesting, perhaps the only memento, of the races of mollusca and polypiaria of the present seas, when all record and traces of Great Britain and its inhabitants shall be destroyed.



LIGN. 124. SHELL-LIMESTONE; FROM THE MOUTH OF

Fig. 1.— A mass of Cockle-shells and Whelks, consolidated into a coarse
2.— One of the shells, CARDIUM EDULE, extracted from the block.
3.— A slice of the rock, polished, the markings on the surface being derived from sections of the shells.

MODERN SHELL-LIMESTONE.

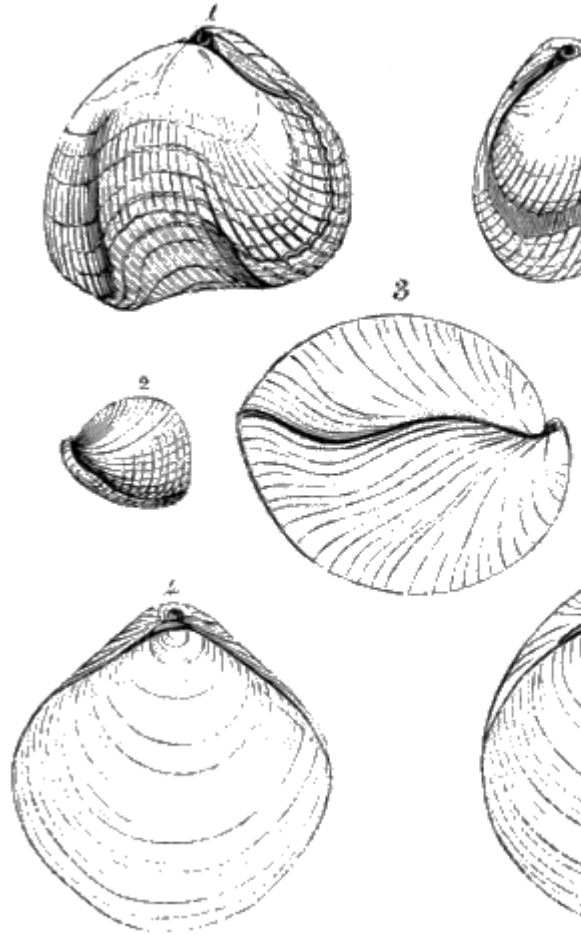
Off the Kentish coast, near the mouth of the Thames, a bank of consolidated shells, chiefly of one species, is in the progress of formation, from which blocks may be obtained of great firmness and solidity

(*Lign.* 124); these, when cut and polished (*fig.* 3), display a variety of markings, produced by the sections of the shells. Extensive shoals of loose shells, composed almost wholly of the *Cardium edule*, exist in several localities, near the embouchure of the Thames; and these are continually shifting with the changes of the wind and tide; it is only in a few places that consolidated blocks occur, like that of which a fragment is figured in *Lign.* 124. These examples of shelly limestones and sandstones now in progress of formation will familiarize the student with the nature and origin of those ancient deposits of a similar character, which contain extinct species and genera of mollusca.

"The vast deposits of fluviatile shells which exist in Florida, at Picolata, Volusia, and Enterprize are of great geological interest. The two latter places present bluffs and hills of from forty to fifty feet in height, extending half a mile or more from the river, that are composed of scarcely anything but well-preserved shells of *Paludina vivipara*, *Ampullaria depressa*, some undetermined species of *Unio*, *Helix septemvolvis*, *Melania*, and a few others. There is but a scanty mixture of earth, and the shells are clean, and look as if they had been washed ashore after the death of their inhabitants. In some places the beds are sandy, and are hardening into a calcareous shelly sandstone. In one such bed the superficial stratum furnished a few bones of turtles and undetermined fragments, the bones of some large vertebrate animal. This is, I believe, the locality where Count Pourtalés collected human bones in a recent sandstone.... No microscopical forms were detected in these beds after the most careful search."[352]

[352] Dr. J, W. Bailey, in Smithsonian

Contributions, vol. ii. Article viii. p. 23.



LIGN. 125. TEREBRATULA AND RHYNCHONEL
Chalk. Lewes.

Fig. 1.— RHYNCHONELLA PLICATILIS.
1*a*.— The same species, partly open.
2.— RHYNCHONELLA SUBPLICATA.
2*a*.— Front view of the same.
3.— TEREBRATULA SEMIGLOBOSA; side view.

3*a*.— The same species, seen from above.
4.— TEREBRATULA SUBROTUNDA.

FOSSIL SHELLS OF THE BRACHIOPODOUS MOLLUSCA.—These are bivalve shells, of which nearly five hundred species are found in the British strata. They occur in incredible numbers in the ancient rocks, to which several genera are restricted; while some continue through all the formations, and inhabit the present seas; but the existing genera are few.

TEREBRATULA.

TEREBRATULA (*bored, alluding to the perforated beak*), *Lign.* 125.—The common species of this genus must be familiar to all who have ever looked into a quarry of Chalk, or of Shanklin sand, in the south-east of England. They have been humorously called the *Fossil Aristocracy*, from the incalculable antiquity of their lineage.

The species are very numerous; more than 300 extinct forms have been determined.[353] Those figured in *Lign.* 125 are from the White Chalk, and are beautifully preserved; even vestiges of the colour occasionally remain. In a living state, the animal is fixed to foreign bodies by a byssus, or peduncle, which passes through the opening in the beak, or arched extremity, of the shells,[354] The most interesting circumstance relating to these mollusca, is the respiratory apparatus, which consists of two long ciliated tubes, spirally coiled, united at their base, and supported by slender calcareous processes, which are often preserved in the fossils. Thus, in specimens from the soft chalk, the calcareous earth may be removed from the interior of the shell, and the appendages exposed, as in the examples, *Lign.*

126, *figs.* 1, 2; and in the shells that are empty, these processes occasionally remain distinct, or are coated by a thin pellicle of calcareous spar, or pyrites.

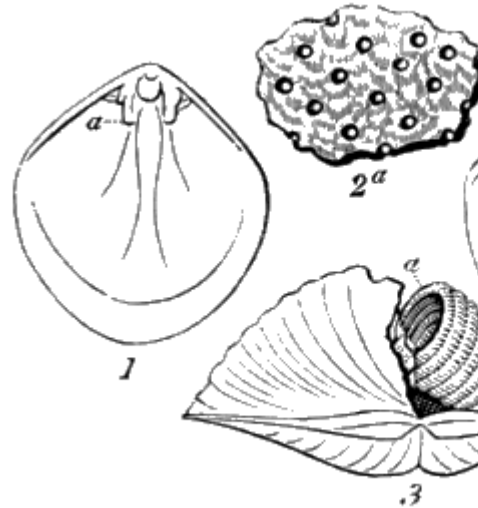
[353] See Catalogue of *Terebratulidæ*, published for the British Museum.

[354] In the British Museum (Eastern Zoological Gallery, case table A) there are between thirty and forty recent terebratulæ (*T. australis*, Quoy, a plaited species, much resembling *T. fimbria* of the Inf. Oolite, Cheltenham) attached with their byssi to a block of stone, from Port Jackson, where it was found by Mr. Jukes just below low-water.

In the smooth *Terebratulæ*, the laminations of the shell are full of minute perforations, which may be seen by a lens of moderate power; the appearance of this structure, when highly magnified, is shown *fig.* 2a, *Lign.* 126.[355] The Rhynchonellæ (as *Lign.* 125, *figs.* 1, 2,) do not possess this organization.

[355] An interesting Memoir on the Microscopal Examination of Shells has recently been communicated to the Royal Society by Dr. Carpenter.

Several species of Terebratula are found both living and fossil, *e.g. Terebratula vitrea*, living in the Mediterranean, fossil in Sicily,—*T. caput-serpentis*, recent in the British seas, fossil in the Crag,—and *T. lenticularis*, both recent and fossil in New Zealand.



LIGN. 126. TEREBRATULA AND

Fig. 1 and 2. Upper and under valve of TEREBRATULA CARNEA. *Chalk*
— of the *brachia*.
2*a*.— Portion of the shell of *Terebratula carnea*, magnified to e
3.— SPIRIFER TRIGONALIS, with part of the upper valve remc
Conch.) *Mountain Limestone.*

SPIRIFER. PENTAMERUS.

SPIRIFER (*containing spiral processes*). *Lign.* 126.— In the Silurian, Devonian, and Carboniferous limestones there is a profusion of several genera of *Brachiopoda*, whose peculiar forms render them easily recognisable. Among these, the Spirifers are the most interesting, on account of their spiral calcareous processes, which in the recent state supported the ciliated *brachia*, being often preserved. A specimen, in which part of the upper valve of the shell has been removed, and one of the spires exposed, is figured *Lign.* 126, *fig.* 3. (*Wond.* pp. 735, 736).[356]

[356] See a Memoir on the Anatomy of the

Brachiopoda, by Professor Owen. Zoological Trans, vol. i. p. 145, *et seq.*

All these genera are extinct; they prevail in the oldest fossiliferous rocks, and gradually disappear as we ascend to the newer formations; the last trace of their existence is in the Lias, in which one species has been found. But the *Terebratulæ* abound in the Lias, Oolite, Chalk, &c., occur in the tertiary formations, and several living species inhabit the seas around Australia and New Zealand. (See *ante* p. 390.)

RHYNCHONELLA, *Fischer*. The "*plaited*" *Terebratulæ* differ from the typical species (*e.g. T. australis*, caput-serpentis, vitrea, &c.) more than even the Spirifers differ, and must be regarded as forming a distinct *family*, RHYNCHONELLIDÆ, which will include *Pentamerus*. The shell is not punctate; the arms are spiral, supported only at their origins by shelly processes; the larger valve is *beaked* acutely, and has a notch within the beak through which the pedicle passes; sometimes the notch is converted into a foramen, by two little plates, (*deltidium*,) as in *Terebratula*. The form of the Rhynchonellæ is tetrahedral. *Lign.* 125.

PENTAMERUS, *Ly.* p. 352.—With the Spirifers, and other Brachiopoda of the Silurian System, some bivalves which, in their general figure, resemble certain species of Terebratulæ, frequently occur. These shells differ in their internal structure from all other genera, in having a septum, or plate, by which their cavity is divided into four chambers; and in one valve the septum itself contains a cell, thus making five chambers, whence the name *Pentamerus* (*five-celled*). The casts of these shells often have fissures, produced by the decomposition of the septa; and

occasionally these cavities are occupied by calcareous spar. Specimens of this kind commonly split into two parts, in one of which two, and in the other three, chambers may be detected; the fifth chamber is the canal of the peduncle. Four species are known, and all belong to the Silurian rocks.

ORTHIS, LEPTÆNA, and PRODUCTA form a third family, with horizontal spiral arms, unsupported by shelly processes. *Davidsonia* is a Leptæna *attached* by the ventral valve, and the only genus in this family which is fixed by *the shell itself*.

CALCEOLA. a genus of Brachiopoda; the shell of an inverted pyramidal form, the upper valve nearly flat; found in the Devonian strata of the Eifel, and in Devonshire.

CRANIA, *Ly. fig.* 205. These are small brachiopodous shells, attached to other bodies; very frequently to the Echinites of the chalk. The free valve is commonly wanting, but I have found specimens dispersed in the rock. In many of the quarries in Kent and Sussex, the helmet Echinites bear groups of these shells. *Ly. fig.* 13.

ORBICULA. This genus resembles Crania in form, the upper valve being like a limpet, whilst the attached valve is flat; it differs, however, from Crania in being horny and flexible, and is fixed to rocks on the bed of the sea, by a muscular pedicle passing out through a small fissure.

Species of Orbicula are found in strata of all ages, from the Lower Silurian to the Tertiary, and several are now living in tropical seas.

OBOLUS. *Eichwald.* In the Lower Silurian (*Obolite*

grit) of Sweden and Russia, is a Lingula, with a hinge and a notch for the pedicle; it has not hitherto been found in Britain.

LINGULA. HIPPURITES.

LINGULA. *Ly*. p. 353, *fig*. 412.—The Brachiopoda referred to this genus have a long peduncle, and their respiratory apparatus has no calcareous support; the recent species burrow in the sand, being usually inhabitants of shallow waters. The *Lingulæ* aære readily distinguished from the Terebratulæ by their imperforate, equivalved shells. One species is found in the Aymestry limestone, and several have been collected from the Mountain limestone, Oolite, and Shanklin sand.

With reference to the species of Brachiopoda, particularly of the Terebratulæ, which inhabit the depths of the ocean, Professor Owen observes, that "both the respiration and nutrition of animals, which exist beneath a pressure of from sixty to ninety fathoms of sea-water, are subjects suggestive of interesting reflections, and lead us to contemplate with less surprise the great strength and complexity of some of the minutest parts of the frame of these diminutive creatures. In the unbroken stillness which pervades those abysses, the existence of these animals must depend on their power of exciting a perpetual current around them, in order to dissipate the water laden with their effete particles, and to bring within the reach of their prehensile organs the animalcules adapted for their sustenance."

HIPPURITES. This genus belongs to a group of fossil shells whose characters are somewhat

problematical, some conchologists referring them to the ordinary bivalves, and others to the Brachiopoda. Although *Hippurites* have not been discovered in the British strata, I am induced to notice them in this place, in consequence of their great abundance in the Cretaceous deposits of the South of France, and in the Oolite of the Pyrenees; and also to illustrate the nature of a nearly related genus, *Sphærulites*, of which one or more species occur in the Sussex Chalk.

The Hippurite is of an elongated conical form, and fixed by its base; it has internally a deep lateral channel, formed by two obtuse longitudinal ridges. The base is sometimes partitioned off by transverse septa, forming cells or cavities, as in the Euomphalus. The aperture, or opening, is closed by an operculum, or upper valve. The substance of the shell is cellular, and very thick, and when fractured much resembles that of the lamelliferous corals: the laminæ are sometimes separated into cells, or cavities, like the Spondyli. These shells often attain considerable magnitude, and in certain districts of the Pyrenees, where they abound, are called "*petrified horns*" by the inhabitants. It is remarkable, that, while in the Chalk of the South of France, Spain, Portugal, and Greece shells of this genus so prevail, as to be considered the characteristic fossils of the formation, in the North of France they are very rare, and in England have not hitherto been discovered. [357]

[357] As marking the rapid progress of Palæontology in this country, it may be noticed that the *only fossil* figured in the first edition of the Enclycopædia Britannica, in illustration of the article, "*Petrifaction*," is one of these supposed petrified horns, described by the Abbé Fortis.

FOSSIL SHELLS OF THE LAMELLIBRANCHIA.—These are bivalve shells, the animals of which differ from the preceding class, as we have already stated, in performing respiration by means of lamellated gills. The valves are united by a strong substance, termed the ligament, which, by its elasticity, admits of the shells being opened to a considerable extent; and they are closed by powerful, short, thick muscles, called adductors. The shells of some of the genera, as the Oyster and Scallop, have but one muscle, (*monomyaria*); others, as the Cockle, or Cardium, and Venus, have two, (*dimyaria*); and by these characters the class is arranged in two groups.

MONOMYARIA: *Bivalve Shells, with one muscular impression.*

FOSSIL OYSTERS.

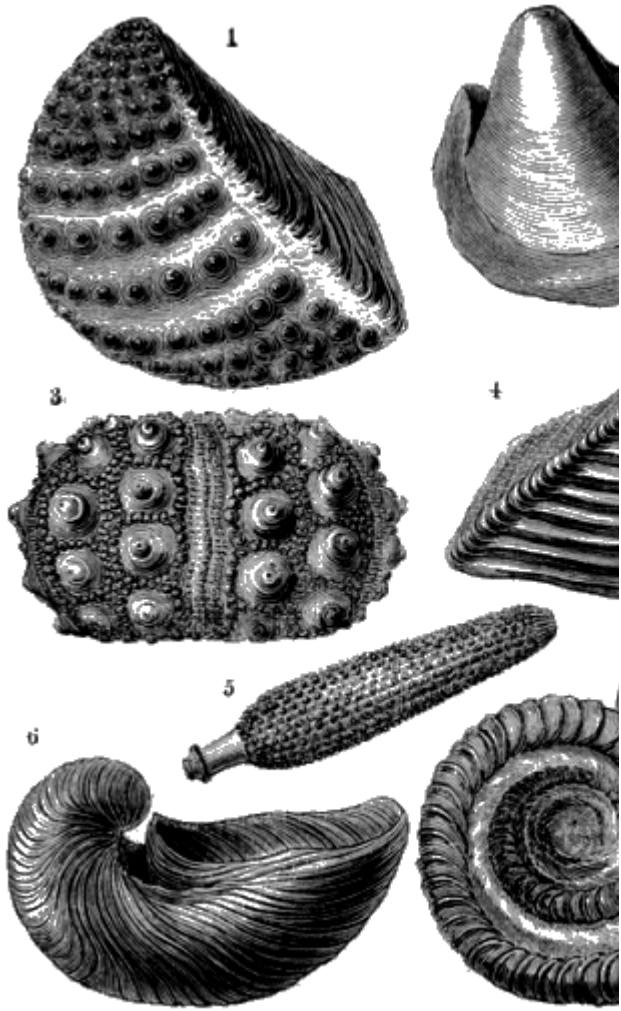
OSTREA, *Lign.* 120.—The Oyster is well known to possess no power of locomotion; it is attached to rocks, pebbles, and other bodies, and forms extensive beds, consisting of numerous individuals, of all sizes. There are many fossil species; the British strata yield between forty and fifty. In some localities. Oysters are found in thick beds, of great extent, apparently on the spots they occupied when living. One of the most interesting localities I am acquainted with, is Sundridge Park, near Bromley, in Kent, where a hard conglomerate, entirely made up of oyster-shells, and the shingle that formed their native bed, is quarried. This stone is much employed for ornamental rock-work, and several walls in and near Bromley are constructed of it: these display the fossils, some with the valves closed, others open, others detached, and the whole grouped as if artificially imbedded to

expose the characters of the shells. These oyster-beds belong to the tertiary strata of the London basin; they extend to Plumstead, and other places in the vicinity; and in some localities, the oysters are associated with other bivalves, called *Pectunculi*. In the tertiary clays near Woolwich and Bexley, fossil oyster-shells abound. In the neighbourhood of Reading, in Berkshire, an extensive layer of fossil oysters occupies the same geological position, namely, the lowermost sands and clays of the London basin. Wherever the strata around London are perforated to a sufficient depth, this oyster-bed is reached. Very recently an Artesian well was bored at Hanwell, in Middlesex, and at the depth of two hundred and eighty feet this stratum of sand with oyster-shells was found. At Headley, near Reigate, in Surrey, there is a similar deposit. These oysters very closely resemble the edible species.

The White Chalk contains several species of Ostrea, but I believe no beds of these shells have been found in it; on the contrary, the shells are diffused promiscuously through the strata. I have collected a few groups of from thirty to forty shells, evidently the young or fry of the species (*O. semiplana*) figured *Lign.* 120. This specimen is an interesting example of the petrifactive process which the mollusca have occasionally undergone; the soft parts of the oyster are transmuted into flint, and the shell is changed into carbonate of lime, having a crystalline structure. Both valves were perfect when discovered, but I chiselled off the greater part of one shell to expose the silicified body of the animal.

A small oyster, called *Ostrea vesicularis*, is a characteristic shell of the chalk; one valve is convex, the other flat; it is abundant in the Chalk of Norfolk,

and also in the Firestone of some localities: it is figured *Ly*. p. 212. Another small species, having the margin plicated (*O. plicata*), is also frequent in the Chalk. A large shell, with the margins deeply indented by angular folds, resembling the recent cockscomb oyster, is abundant in the Chalk Marl and Firestone; particularly near Dover, and around Selbourne in Hampshire, where it attracted the notice of WHITE, by its resemblance to the living "Cockscomb Oyster" of the West Indies; it is named *Ostrea carinata*, and figured *Ly*. p. 212, *fig.* 204. One other species may be noticed, the Ostrea deltoidea, which has been found in every locality of the Kimmeridge Clay in England and France. It is a very flat species, and of a triangular form; the specific name is derived from a supposed resemblance to the Greek letter Δ, *delta*. I believe that in England no shells of this genus have been observed in strata older than the Lias.



LIGN. 127. SHELLS AND ECHINITE FROM THE OOLITE

Fig. 1.— TRIGONIA CLAVELLATA. Oxford Cloy, *near Weymouth*.

2.— TRIGONIA GIBBOSA; a limestone cast. *Isle of Portland.*

3.— CIDARIS BLUMENBACHII. *Oolite. Calne, Wilts.*

4.— TRIGONIA COSTATA. *Oolite. Highworth, Wilts.*

5.— Spine of the CIDARIS BLUMENBACHII.

6.— GRYPHYA INCURVA. Lias. *Cheltenham*.
7.— AMMONITES WALCOTII. Lias, *near Bath*.

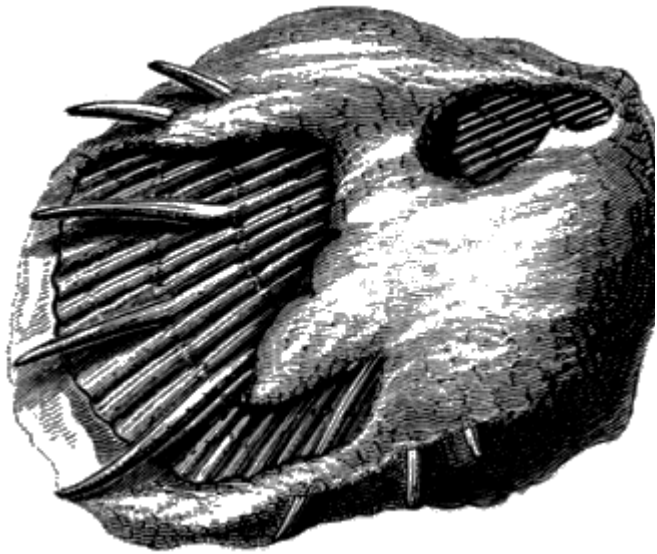
GRYPHYÆA.

GRYPHYA. *Lign.* 127, *fig.* 6.—The shells to which the term *Gryphæa*, or *Gryphites*, is applied, are related to the Oyster, but distinguished by the deep concave under valve, and its curved summit, or beak, and the almost flat, or opercular upper shell. The Gryphites are of a finer laminated structure than the oysters, and the ligament of the hinge is inserted in an elongated curved groove. There are about thirty British fossil species, none of which have been noticed below the Lias, in which formation one very remarkable species is so abundant as to be considered characteristic of the Liassic deposits. It is so faithfully represented, *Lign.* 127, *fig.* 6, that description is unnecessary. In the upper argillaceous beds of the Oolite and Kimmeridge Clay, a very small gryphite, (*G. virgula*, *Ly.* p. 260) is so abundant, that it constitutes entire layers. The low cliffs on the west of Boulogne harbour, like those near Weymouth, are composed of this clay, and myriads of the gryphites are scattered on the shore, with other shells of the same deposits; these shelly beds are called *marnes à gryphées*, by the French geologists. A very large gryphite, *Gryphæa sinuata*, (*Min. Conch.* tab. 336,) is found in the Shanklin sand of the Isle of Wight, and of Kent and Sussex. At low water, in the sand along the shore under Dunnose Cliff, near Shanklin Chine, numerous specimens are always obtainable.[358]

[358] The name *Exogyra* was applied to the Chama-shaped species of Gryphæa by the late Mr. Sowerby, and other writers; but subsequent authors have included these shells in the present genus.

SPONDYLUS. PLAGIOSTOMA.

SPONDYLUS. *Lign. 128.*—A species of this genus is so frequent in the Chalk, that it ranks with certain Terebratulæ, as characteristic of that formation. One valve is covered with long slender spines, which, in the usual examples, are destroyed by the mode of extracting them. The specimen figured shows the appearance of a shell partly cleared; the remainder of the chalk might be removed by a penknife (taking care to leave the longest spines supported by brackets of chalk), and it would then resemble the beautiful fossils figured *Min. Conch.* tab. 78, and in *Geol. S. E.* p. 125. Between the beaks there is a triangular aperture in the spinous valve, which some naturalists, with much probability, suppose was once filled up with shell, as in the recent species.



LIGN. 128. SPONDYLUS SPINOSUS. *In Chalk-flint. Lewes.*

In the cretaceous strata of North America, Dr.

Morton has discovered a Spondylus (*S. dumosus*) very nearly related to *S. spinosus*; but it differs in its general form, and has both valves beset with strong spines. I have the fragment of a large bivalve from the Kentish Rag (Mr. Bensted's quarry), which has the peculiar structure of the Water-clam (*Spondylus varius* of Mr. Broderip); namely, hollow interspaces formed by shelly layers or partitions, which were secreted by the posterior part of the mantle, or investing integument of the animal, as it gradually receded from that part of the shell. In the recent Water-clam the cells are full of fluid.[359]

[359] See Penny Cyclop. Art, *Spondylidæ*.

PLAGIOSTOMA, Llhwyd, 1699. This genus, adopted by Mr. Sowerby in the Mineral Conchology, is scarcely distinguishable from *Lima* of Bruguiere (1791). Most of the recent species are ornamented with small asperities, from which the name *lima* (file) is derived; they are symmetrical shells attached by a byssus.

Several smooth species of this genus are found in the Chalk,[360] Oolite, and Lias. A very large species (*P. giganteum*), sometimes ten inches in diameter, abounds in the Lias (*Ly.* p. 274). It is somewhat depressed in form, with the surface slightly striated; each valve has a pointed beak, with two lateral expansions, or ears, as they are termed by conchologists.

[360] See Foss. South Downs,, plate xxvi.

PLICATULA, is another genus of this family, of which there are three British fossil species. A delicate shell, with slender depressed spines (*P. inflata. Foss. South D.* pl. xxvi.), occurs in the Chalk Marl. The

recent species are natives of the seas of warm climates.

PECTEN.—The common scallop-shell will serve as a type of this genus. The animals of these shells, unlike the oysters, have the power of locomotion, and when in the water, may be seen moving with rapidity, and flapping their shells to and fro with great activity. Numerous species are found fossil. In the Pliocene, and other marine tertiary deposits, Pectens abound; in the White Chalk there are several elegant forms (see *Foss. South D.* plate xxv.); many kinds in the Oolite and Lias; and several in the Devonian strata.

A large Mediterranean species (*Pecten Jacobæus*, *Ly.* p. 152) occurs in the Pliocene strata of Palermo, in every stage of growth, and as perfect as if recent. The Chalk and Shanklin sand contain a small inequivalved Pecten, the lower valve of which is convex, and pentangular, the upper flat, and both strongly ribbed, or pectinated; it is named *Pecten quinquecostatus* (*Foss. South D.* pl. xxvi. *Ly.* p. 212); and in the cretaceous strata of North America a variety of this species is found.

In the Chalk Marl a large and beautiful Pecten (*P. Beaveri. Min. Conch.* tab. 158) is very common, and I have obtained from Hamsey and Southerham examples in the most perfect state of preservation; it is a characteristic shell of the Chalk Marl of England (*Foss. South D.* plate XXV. fig. 11).



LIGN. 129 INOCERAMUS CUVIERI. *Chalk. Lewe*

Fig. 1.— Beak and hinge of an INOCERAMUS.
a. The hinge line.
2.— Two valves of I. CUVIERI, displaced,
and both showing the external surface.

INOCERAMUS.

INOCERAMUS. *Lign.* 129.—This name, which refers to the fibrous structure of the shell, has been

given to a fossil genus, of which there are about thirty species in the cretaceous and oolitic formations; and very recently four or five species have been discovered in the Silurian strata of Ireland.[361] These shells are chiefly characterized by their hinge (see *Lign.* 129, *fig.* 1*a*.), and by the fibrous structure of their constituent substance, which closely resembles that of the recent *Pinna*;[362] and under the microscope is found, like that shell, to consist of prismatic cells, filled with carbonate of lime.[363] The species vary in size from an inch to three or four feet in diameter. The shell, in consequence of the vertical arrangement of the fibres, readily breaks to pieces, and it is often extremely difficult to extricate a specimen with the hinge and beaks tolerably entire. That they were equally brittle when recent is evident from the numerous fragments diffused through the chalk and flint, and occasionally imbedded in pyrites.[364] The form of the hinge is shown in *Lign.* 129, *fig.* 1: in the lower specimen two valves of the same individual are seen displaced, one lying over the other. The usual chalk species are figured *Foss. South D.* pl. xxvii. and in *Min. Conch.*

[361] The term Inoceramus is restricted by the French geologists to the beaked and laminated species of the Galt; and the chalk Inocerami are arranged under the name *Catillus*.

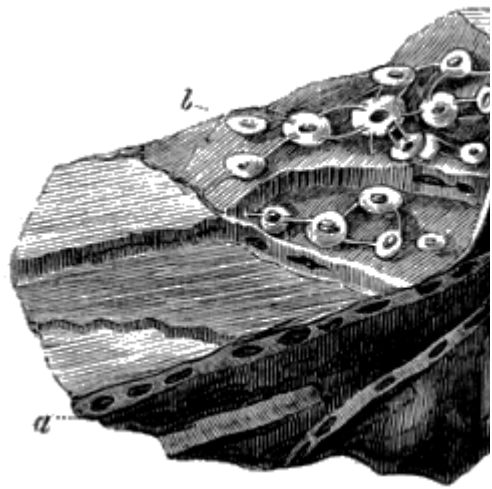
[362] *Perna* and all the Aviculidæ have the same structure, Inoceramus scarcely differs from Perna.

[363] Dr. Carpenter on the Microscopical Structure of Shells. To detect this structure, the shell should be immersed in diluted hydrochloric acid, and when partially

dissolved, the cells will be apparent.

[364] It was many years before I succeeded in obtaining a specimen with the hinge perfect; and M. Brongniart, unable to obtain one from the chalk of France, gave the figure of this genus from my Foss. South D. pl. xxvii. in the Géog. Min. Env. de Paris.

In the Galt, or Folkstone-marl, two small species of this genus are to be found in every locality I have visited. They were first figured and described by Mr. Parkinson, under the name of *Inoceramus sulcatus*, and *I. concentricus* (*Wond.* p. 330, fig. 1 and 3). In most examples the shell is in the state of a white, friable earth, and readily decomposes, leaving patches of iridescent nacre on the casts; but I have seen examples which prove that the originals were of a fibrous structure, like the Inocerami of the Chalk.



LIGN. 130. FLINT, WITH FRAGMENTS OF INO
Chalk. Lewes.

a. Marks the section of a fragment of shell, with numerous cavities

Cliona Conybearei.

b. Portion of shell partially decomposed, and exposing siliceous, glob which are flint casts of the hollows left by the Cliona.

The shells of the Inocerami, like those of the oyster, and other living mollusca, were exposed to the attacks of some parasite, and perhaps of some Annelid, as the *Nereis*. The shells are often cellular from this cause, and the cavities are found either hollow, or filled with chalk, or, as in the example *Lign.* 130, with flint. In the latter case, upon the decomposition of the shell, the siliceous casts remain in relief on the surface of the flint, as in *Lign.* 130, *b*. Such specimens are common in the broken flints of the South Downs, and in the shingle on the sea-shore of chalk districts; and their origin would be difficult to understand without this explanation.[365]

[365] The Rev. W. Conybeare first ascertained the origin of these fossils, and figured and described them in an elegant Memoir, published in Geol. Trans, vol. ii. first series. Mr. Morris proposes the name of *Clionites* for the fossil bodies derived from the depredations of the Cliona on the Inocerami and other shells. See Annals Nat. Hist. 1851, and my Pictorial Atlas of Organic Remains.

AVICULA. *Lyell*, p. 274.—Above fifty species of this genus of shells have been found in the British strata; their general character will be readily understood by reference to the pearl-oyster, (*Avicula margaritifera*,) which is so largely imported for the manufacture of mother-of-pearl ornaments. A remarkable species is found in the Lias, called, from the great disproportion in the size of the shells, *Avicula inæquivalvis*, (*Lyell*, p. 274.) The recent species are inhabitants of warm climates.

Our limits will not admit of further notice of the *Monomyaria*, and we proceed to the second division of the plated-gilled mollusca.

DIMYARIA: *Bivalve Shells, with two muscular imprints*.

The conchifera, or bivalve shells, of this group, found fossil, are more than double in number those of the preceding; nearly eight hundred species are known in the rocks of Great Britain, of which by far the greater number is marine. But we must restrict our notice of this division to a few genera, that more space may be devoted to that important class, the Cephalopodous Mollusca.

The *Cardium*, *Venus*, and Mussel shells, are familiar examples of the *Dimyaria*. The conglomerates, now forming in the British Channel, from accumulations of the recent species of Cockle (*C. edule*), have been previously noticed; see *Lign.* 124, p. 386. In the strata of England there are upwards of thirty species: the Crag contains several, particularly a large and delicate shell, the *Cardium Parkinsoni* (*Min. Conch.* tab. 49). Others are peculiar to the London clay, as the *Cardium semigranulatum*, a beautiful shell, having the surface smooth, except on the posterior side, which is covered with strong ridges, beset with minute granules; it is found in many localities (*Min. Conch.* tab. 144). Among the silicified shells of the Shanklin sand of Devonshire, an elegant Cardium, *C. Hillanum*, (*Min. Conch.* tab. 14,) occurs. But one species is known in the formations below the Lias: the *Cardium striatum*, (*Murch. Sil. Syst.* tab. 6, *fig.* 2,) found in the Aymestry limestone.

VENERICARDIA. *Ly.* p. 199.—These shells are abundant in the tertiary strata; one large species, *V. planicosta*, (*Ly.* p. 199, *fig.* 171,) is found in immense quantities in the clay and sand at Bracklesham Bay, in Sussex, from the young to the adult state; some examples are very large, and perfect. In the sand at Grignon, near Paris, the same shell is abundant, possessing the usual white and delicate aspect of the fossils of that celebrated locality of the *Calcaire grossier*. Only one species has been noticed in the British secondary strata.

PECTUNCULUS. *Wond.* p. 244, *fig.* 8.—In the London clay at Bracklesham Bay, Highgate, Hordwell Cliff, and in the arenaceous limestone of Bognor rocks, an immense number of the bivalve shells, called *Pectunculi* (*little pectens*), occur. Some of the French marine tertiary strata also abound in the same, and other species of this genus. In the above-mentioned Sussex localities, these shells are so numerous, as to be the most frequent fossils that come under the notice of the collector. They are readily known from their associates by their rounded equivalve shells, and the single arched row of teeth along the hinge, resembling the common *Arca*.[366] (See *Min. Conch.* tab. 27). At Plumstead, near Woolwich, a smaller species is found; and also occasionally with the oysters at Bromley.

[366] The species so abundant at Bognor, is *P. brevirostris*, *Min. Conch.* tab. 472. I have seen a block of the limestone, in which, spread over an area of a foot square, there were upwards of fifty specimens lying in relief.

NUCULA.—Several species of a small elegant bivalve, related to the preceding, but distinguished by having two rows of teeth on the hinge, diverging

from an interspace between the beaks, are found in the Crag and other tertiary deposits (*Min. Conch.* tab. 180, 192). Two species occur in the Galt (*Foss. South D.* pl. xix. *fig.* 5, 6, 9), at Ringmer, Folkstone, Bletchingley, &c., sometimes with the shell perfect, but generally in the state of casts composed of indurated clay, and having impressions of the muscles and of the two rows of hinge-teeth. The shell of one species is marked with fine transverse grooves, or striæ (*N. pectinata*); the other is of a flattened ovate form, and the surface smooth (*N. ovata*).

The most beautiful species of Nucula are the *N. bivirgata* of the Galt of Folkstone, and *F. Cobboldiæ* of the Norwich Crag.

The species of *Nucula* with the posterior side produced into a long beak have been separated under the name *Leda*; they have a pallial sinus, indicating a siphon to the mantle;—

e.g.	*Nucula*	*ovum*	Alum Shale.
	—	*claviformis*	Lias.
	—	*attenuata*	Coal Shale.
	—	*arctica*	Norwich Crag.

PINNA. MYTILUS. MODIOLA.

PINNA.—The common large *Pinna*, of the Mediterranean, is well known, and differs so entirely from other shells, as to be readily distinguished. There are about fifteen or sixteen British fossil species. The earliest appearance of this genus is in the Carboniferous Limestone of Derbyshire (PHIL. YORK. tab. 6), in which there are two species. The Lias contains one species; the Oolite eight; the Cretaceous formation four; and the London clay two.

One of the tertiary species, *Pinna affinis* (*Min. Conch.* tab. 313), occurs in considerable numbers in the Bognor rocks, associated with Pectunculi; it varies in length from one to six or seven inches. A beautiful and delicate species is found in the *Calcaire grossier* of Grignon. Shells of this genus are very rare in the White Chalk, most of the supposed *Pinnæ* being imperfect examples of *Inocerami*; but I have seen specimens from Norfolk (collected by the late Mr. Woodward), and one from Sussex, in the cabinet of the Marquess of Northampton.[367]

[367] Dr. Lee has recently discovered in the Kimmeridge Clay on his estate at Hartwell, Bucks, a species of Pinna not previously observed in England. Professor Forbes informs me that it resembles *Pinna conica* (of Röemer), and is related to *P. lanceolata* of Sowerby, but appears to be distinct from both.

MYTILUS, OR MUSSEL.—There have been found about twenty species of this well-known genus of marine shells in the British strata. They are sparingly distributed through the several formations, from the Silurian to the newer Tertiary. One species (*Mytilus Lyellii*, *Wond.* p. 405, fig. 2) occurs in the Wealden, associated with fresh-water shells.

Of the genus termed MODIOLA, which comprises those mussels that have a rounded anterior termination, nearly forty British species have been discovered; ranging through the fossiliferous strata, from the Silurian to the Crag. A beautiful species (*Modiola elegans. Min. Conch.* tab. 9), with the shell generally retaining its pearly coat, is found in the London Clay, and in the limestone of Bognor.

An undescribed striated *Modiola* (which may be

named *M. striata*, since the striæ are peculiar), occurs in the Kimmeridge Clay, at Hartwell.

Those species of Modiola, which excavate hollows in stones, and inhabit them, are arranged in a genus termed *Lithodomus*. The occurrence of these shells in the remaining erect pillars of the Temple of Jupiter Serapis (*Wond.* p. 106), at Puzzuoli, has afforded important and unequivocal evidence of the physical mutations which that part of Italy has undergone. Two species of Lithodomi have been found, by Mr, Lonsdale, in the Oolite.

PHOLADOMYA. *Ly.* p. 272, *fig.* 290.—This genus of shells (established by Mr. James De C. Sowerby in the Min. Conch. 1826), comprises about twenty British fossils, all of which, with but two exceptions, occur in the Lias and Oolite. They are equivalved shells, with the posterior end short, and rounded, and the anterior elongated and gaping. The surface is generally marked with ribs, or alternate elevations and depressions, diverging obliquely from the beaks to the margin. In the clay at Osmington and Radipole, near Weymouth, a large species (*P. æqualis*, *Min. Conch.* tab. 546) is abundant. The Oolite of Brora, in Scotland, contains several species. The only species found in our Chalk, is the beautiful shell (*P. decussatum*), figured *Foss. South D.* tab. XXV. *fig.* 3, and first discovered by me, in 1820, in a bed of Chalk Marl, which at that time was exposed at low-water, at the base of the cliff at Brighton, near the present entrance to the Chain-pier. The same species has since been found at Clayton, Hamsey, Southbourne, and other localities of the Marl.

FOSSIL PHOLADES.

PHOLAS. *Lign.* 166, *fig.* 5, 6.—The common boring

bivalve called Pholas, must have attracted the attention of every stroller by the sea-shore, from the numerous perforations in blocks of chalk, and other limestones, occasioned by its operations. Some species burrow in wood, and often commit serious ravages in piles and other submarine works constructed of timber. In the earlier ages of our planet we find evidence of the existence of the same kind of living instruments for the disintegration of floating wood, and the reduction of masses of rock into detritus. But no traces of these shells have been found in strata below the Oolite. One species occurs in the Coral Rag, another in the Kimmeridge Clay; two in the Galt and Greensand; and three or four in the tertiary deposits. In the Crag, blocks of stone are occasionally found with the shells of *Pholades* occupying the perforations they originally formed and inhabited. But all the specimens I have observed in the Galt, Greensand, and Oolite were *xylophagous* (*wood-eating*) species. In the Shanklin Sand, masses of fossil wood, literally honey-combed by the perforations of Pholades, are frequent; but the shells themselves are rare. Mr. Sowerby has figured a beautiful specimen of silicified wood, from Sandgate, with numerous shells of this genus (*Pholas priscus. Min. Conch.* tab. 581). *Lign.* 166, *fig.* 5, represents a fragment of fossil wood, with three shells *in situ*; *a*, a shell seen longitudinally; and below, the rounded anterior extremities of two other shells are exposed.

Masses of wood perforated by Pholades, from which all traces of the shells have disappeared, have given rise to some curious fossil remains, which are often very enigmatical to the young collector. In the Kentish Rag, as for example, in Mr. Bensted's quarry, near Maidstone, large blocks of stone are found, covered with groups of subcylindrical mammillary

projections, which are obtuse or rounded at the apex. In some examples the interstices between these bodies are free; in others they are occupied by a reddish brown, friable substance, presenting obscure indications of ligneous structure: and rarely, distinct woody fibres may be observed, the direction of which is transverse, or nearly at right angles, to the mammillated projections. These blocks are, in truth, the stony casts of cavities formed by Pholades, in masses of wood, both the vegetable structure, and the shells, having perished.

In the White Chalk specimens of this kind are occasionally found.

A remarkable fact, relating to some of the specimens from the Iguanodon quarry, remains to be mentioned. Upon breaking off the projections, to ascertain if any traces of the shells of the Pholades remained, we discovered in several, near the apex, a univalve shell, a species of *Nerita*. *Lign.* 166, *fig.* 6, represents a fragment of stone with two of the casts, which have been broken, and in each, at *a*, a univalve is imbedded. At *b*, the ligneous structure of the original wood is visible. The only hypothesis that will account for the appearance of these univalves in their present position, is that of supposing that the Nerites crawled into the cavities made in the mass of timber, after the shells of the Pholades had been removed; and that the wood became imbedded in a sand-bank, and the univalves enclosed in the cavities; the ligneous structure in a great measure perished, and the stony casts of the perforations of the borers, with the imprisoned univalves, remained. The Nerites, as shown in the example figured, do not occupy any particular position in the tubes; one has the apex towards the end of the cavity, and the other

lies in a transverse direction.[368]

[368] In a fragment of a perforated column, from Puzzuoli, in my possession, by favour of Sir Woodbine Parish, there were numerous living univalves in the cavities made and previously inhabited by the lithodomi.

TEREDO.

TEREDO. *Ly.* p. 24.—It will be convenient to notice in this place another genus of boring shells, whose fossil remains are far more abundant than those of the Pholas. The *Teredo navalis*, or Ship-worm, which is the most vermiform of all the mollusca, forms tortuous cylindrical hollows in wood; and in some climates commits the most extensive injuries to ships, the piles of harbours, bridges, and other submarine works formed of timber. A reference to the illustration given by Sir C. Lyell will render detailed description unnecessary. The *Teredo* is furnished at one extremity with testaceous valves, by which it bores its way into the wood, while from the surface of its soft body a calcareous matter is secreted, which lines with a shelly covering the hollows or channels formed by the animal in its progress. The fossil species differ from the recent in the valves being united to the calcareous tube. Wood perforated by *Teredines*, and occupied by their shelly tubes, occurs in almost every locality of the London Clay. Those specimens in which the wood is petrified, and the cavities of the tubes are filled with calcareous spar of various colours, furnish beautiful sections, when cut and polished (*Pict. Atlas*, pl. viii. *fig.* 8, 9). When the canal in the Regent's Park was being formed, large blocks of perforated calcareous wood were discovered, having the ligneous structure well

preserved, and the tubes of the Teredines occupied by yellow, grey, and brown spar, forming specimens of great beauty and interest. Wood, with Teredines, or some analogous boring mollusks, occurs sparingly in the chalk of this country; but in the cretaceous strata at Maestricht, large masses are frequently found.[369] Fossil wood may occasionally be observed with perforations that have been made by other kinds of boring shells; but the preceding remarks will suffice to convey an idea of the nature and origin of such appearances.[370]

[369] In the British Museum there is a mass of silicified wood from the Upper Greensand of Blackdown, perforated by a Teredo, whose valves remain in the burrows.

[370] Other genera of boring shells also occur fossil, as Fistulana, Gastrochæna (*Min. Conch.* tab. 526), Saxicava (*Min. Conch.* tab. 466).

TRIGONIA. *Lign.* 127, *fig.* 1, 2, 4.—These bivalves are related to the *Arcadeæ* and *Nuculæ*, but distinguished by the peculiar character of the hinge; the right valve has two large oblong teeth, which diverge from the umbo, and are strongly furrowed, and fit into two corresponding grooved cavities, in the opposite, or left valve. These shells are very thick and nacreous; they abound in certain strata of the Oolite and lower Cretaceous formation, but have not been observed in any deposits of this country older than the Lias; there are nearly thirty British species. Two living species of Trigonia (*Trigonia margaritacea* and *T. Jukesii*) are known, both inhabitants of the seas of New Holland, where they are associated with Terebratulæ. Some of the argillaceous beds of the Oolite, as the Oxford and Kimmeridge clays, abound

in Trigoniæ; Osmington and Radipole, near Weymouth, are celebrated localities for these fossil shells, which are found there in great perfection; and on the French coast, where similar strata appear, the Trigoniæ are equally abundant. Under the cliffs, near Boulogne harbour, the shore is strewn with them. Three common species are figured in *Lign.* 127. The casts of most of the species are smooth, as in *fig.* 2; and the collector should, therefore, search for impressions of the outer surface, when the shell is absent, as is generally the case in the Portland Oolite and Shanklin Sand, in which Trigoniæ are very numerous. Near Highworth, in Wiltshire, very fine and large examples of *Trigonia costata*, *fig.* 4, occur, with the shell preserved. The impressions of the large, oblong, diverging teeth of the hinge, are usually so strongly marked in the casts, as to render it easy to identify the shells of this genus. The quarries of the Portland Oolite at Swindon, Wilts, teem with casts of Trigoniæ, collocated with Ammonites. In the Isle of Portland they are also very numerous, some beds of stone being so friable, from the numerous cavities left by the removal of the substance of the shells, as to be unfit for paving, or other economical purposes. Very sharp casts may be obtained from this rock by merely breaking the stone to pieces. In the Whetstone of Blackdown, Devon, beautiful silicified Trigoniæ are occasionally found. Tisbury, in Wiltshire, yields very fine specimens, and in some examples, Mr. G. B. Sowerby has detected remains of the ligament.

FOSSIL FRESH-WATER BIVALVES.

FOSSIL FRESH-WATER BIVALVES.

The animals of the shells hitherto described are,

with scarcely any exception, inhabitants of the sea; and the marine origin of the strata in which they occur, may consequently be inferred, with but little probability of error. I now propose noticing the fossil remains of those bivalves which inhabit rivers, lakes, streams, and pools of fresh water. The marine, or fresh-water, character of fossil shells, is inferred from their resemblance to the recent mollusca, whose habits are known; for the shells alone present no unequivocal marks, by which even the experienced conchologist can pronounce whether an extinct form belonged to a marine or to a fluviatile mollusk, although certain characters may admit of an approximative inference. Thus, for instance, as none of the known living fresh-water bivalves belong to the previous division, the *Monomyaria*, the presence in a stratum of numerous shells with but one muscular impression, would afford a fair presumption of the marine origin of such, deposit. The remains with which the shells are associated and the mineralogical characters of the strata in which they occur, would, of course, afford important corroborative evidence.[371]

[371] See Sir C. Lyell on the distinction between fresh-water and marine deposits. *Ly.* p. 27, *et seq.*

The living fresh-water bivalves comprise but a few genera and species; and those which have been found fossil in the British strata belong to but four or five genera. Their distribution is restricted to strata of undoubted fluviatile origin, and to those local intercalations of fresh-water and land productions in marine deposits, which occur in some of the secondary, and in many of the tertiary formations.

UNIO. *Ly.* p. 28.—The river Mussels, or *Unionidæ*,

have a solid, pearly shell, with two principal and two lateral teeth on the hinge; and their umbones, or bosses, are generally smooth, or longitudinally undulated. Those which have no cardinal teeth are arranged under the genus *Anodon*: but it is not necessary for our present purpose, to enter into minute conchological distinctions. In number, variety, and beauty, the species which inhabit the large rivers of North America present a striking contrast with the few and homely British fresh-water mussels; nor have we, in a fossil state, any shells of this family at all comparable with those living types. [372] The earliest fossil Mollusca referred to the genus *Unio* appear in certain layers of clay and argillaceous ironstone belonging to the Carboniferous system of Derbyshire, Coalbrook Dale, &c. (*Min. Conch.* vol. i. tab. 33). In the former county, these strata are termed *mussel-band*;[373] and some beds constitute a compact shell-limestone, which admits of being manufactured into vases, &c., and takes a good polish; the sections of the shells in this marble are white, on a dark ground. There is, however, considerable doubt whether any of the Carboniferous shells really belong to the genus *Unio*; some geologists refer them to *Cardinia*, a group of sea-shells found especially in the Lias.

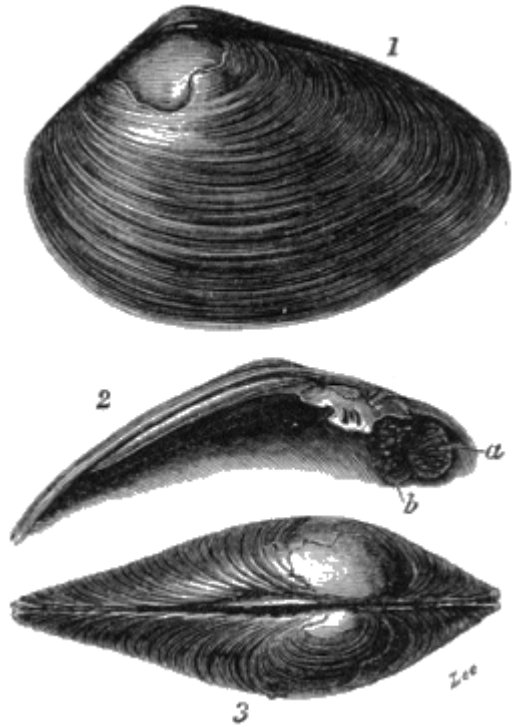
[372] See American Journal of Science, vol. xlvii. p. 402, "Unionidæ."

[373] "A solid stratum of ironstone, which extends from Tupton Moor to Staveley." Martin's Petrificata Derbiensia, pl. xxvii.

The earliest undoubted shells of this genus from the British strata, are, I believe, those first discovered by me in the strata of Tilgate Forest, (*Foss. South D.* p. 45, and *Foss. Tilg. For.* p. 57), and subsequently

found in numerous localities of the Wealden.[374]

[374] They are figured in Geol. S. E. p. 250; and in Dr. Fitton's Memoir, Geol. Trans, vol. iv. pl. 21.



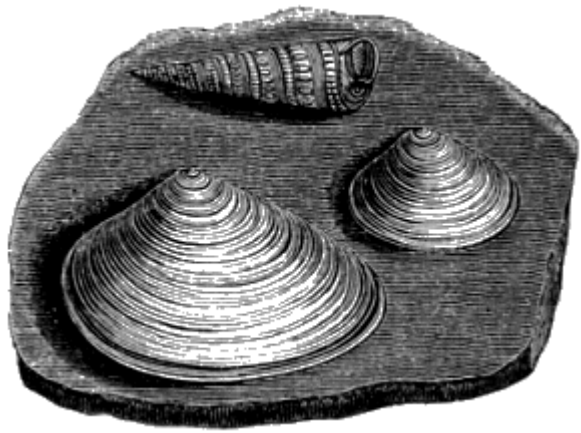
LIGN. 131. UNIO VALDENSIS. ($^1/_3$ *nat.*)
Wealden; Isle of Wight.

In 1844 I discovered a large species in the Wealden at Brook Point. I have named it *Unio Valdensis*.[375] I have collected and obtained nearly fifty specimens; they present two varieties, the one contracted and narrow, the other broader and deeper; this difference is probably sexual; the wide and deep shells may be the females; for in the living

American Uniones the same characters are observed. Some examples are remarkably well preserved; the ligament remaining in a carbonized state, and the body of the mollusk in the condition of molluskite; even a tint of the original tawny reddish colour of the shell is present. The same species has been found in the Wealden strata, near Tunbridge Wells, by Mr. Barlow, C. E.

> [375] *Unio Valdensis* resembles in form the Mexican species, U. Panacöensis (River Panaco), but is probably more nearly allied to an unnamed Australian species of which Mr. G, Sowerby has numerous examples.

I shall reserve my remarks upon the important aid these fossils afforded in the determination of the fluviatile origin of the Wealden, for our *Excursion to Tilgate Forest.*



LIGN. 132. CYCLAS AND MELANOPSIS. *Wealden; Sussex.*

CYCLAS. *Wond.* p. 404. *Ly.* p. 28.—Another genus of fresh-water bivalves is termed *Cyclas*, of which there are ten species in the Wealden formation: and,

with the exception of four or five recent forms, which occur in the tertiary fresh-water strata, none others have been found in England.[376] The shells of the genus Cyclas are oval, transverse, equivalved bivalves, with the hinge-teeth very small: the substance of the shell is thin and fragile; the figures in *Wond.* and *Ly.* accurately represent the appearance of the fossil *Cyclades* of the Wealden, and tertiary strata. Entire layers of two or three species of these shells occur in the argillaceous deposits of the Wealden, generally in a friable state, but from among the masses of crushed shells, perfect specimens may be obtained, and sometimes with the remains of the epidermis and ligament. The hard stone, termed calciferous grit, in the neighbourhood of Hastings, Tilgate Forest, Horsham, and other places in the Weald of Sussex, abounds in casts of the same species, associated with the *Uniones*, previously described. In the cliffs on the southern shores of the Isle of Wight where the Wealden beds emerge, and also in the Isle of Purbeck, these shells are equally abundant. Together with the *Uniones*, they occasionally appear in the limestone, called Sussex Marble; and in the Isle of Purbeck there are beds of limestone wholly composed of bivalves belonging to these two genera, and presenting, in polished slabs, markings formed by sections of the enclosed shells.

[376] *Cyrena*, is a genus so nearly related to Cyclas, that it is difficult to distinguish them, and it will be convenient to retain only the former name.

FOSSIL PTEROPODA.

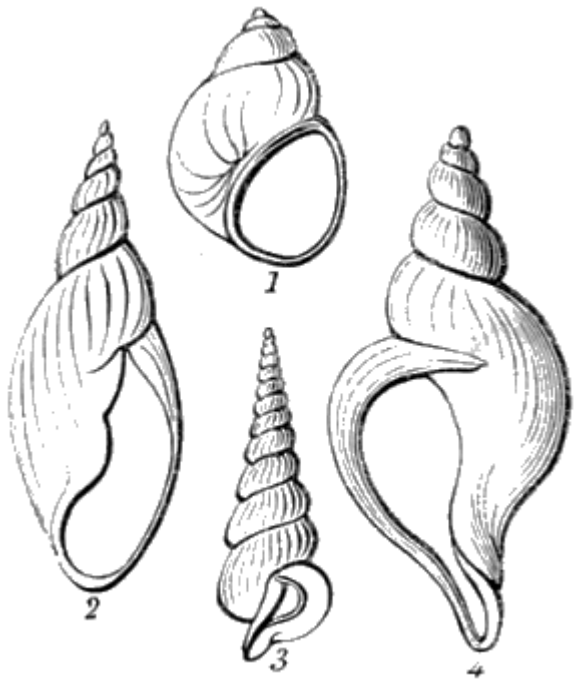
PTEROPODA. GASTEROPODA.

In the Ludlow strata there are found small fragile

elongated conical shells without chambers, which are supposed by Professor E. Forbes to be identical with a recent genus of pteropodous mollusca, common in the Mediterranean, called Creseis. They seldom exceed two inches in length.

Of another genus, named Conularia, six Species have been discovered in the Silurian formation.[377]

[377] See Geol. Trans, second series, vol. vi, p. 325.



LIGN. 133. FOSSIL SHELLS OF GASTEROPODA.

Fig. 1.— PALUDINA fluviorum. *Wealden.*

2.— LIMNÆA LONGISCATA. *Tertiary. Isle of Wight.*

3.— CERITHIUM LAPIDORUM. *Tertiary, Grignon.*

4.— FUSUS CONTRARIUS. Crag. Essex.

FOSSIL SHELLS OF GASTEROPODA.

The univalve shells, as we have previously explained, are the calcareous cases, or coverings, of a more highly organized class of molluscous animals, than the inhabitants of the bivalves (see p. 366.), for they possess a head and mouth with jaws, eyes, and feelers; and while the *Acephala*, with but few exceptions, are incapable of locomotion, the *Encephala* are almost all of them furnished with organs of progression, and can creep, climb, and swim, or float on the surface of the water. Their shells are for the most part formed of one valve, hence the name of *univalve*; but in some species it is composed of several pieces. The most simple form of shell is that of the hollow cone, of which the *Patella*, or limpet, affords an example; and in the more complicated modifications, the cone is twisted, or convoluted spirally, either in the same plane as in the *Planorbis* of our rivers, or obliquely, as in by far the greater number of species. The direction of the spire is generally from left to right, the aperture being dextral to the observer when the shell is placed with its apex uppermost, as in *Lign.* 133, *figs.* 1, 2, 3; but in a few species the spire turns in the opposite manner, and the mouth or aperture is to the left, or sinistral, as in *Lign.* 133, *fig.* 4. In consequence of the form of the aperture of the shell, the entire or notched condition of its margin, and the presence or absence of a canal or siphon always having relation to the soft parts of the animal, these characters afford data by which the genera and species of the shells may be determined, and information obtained as to the structure and economy of the originals.

The Gasteropoda generally creep by means of a fleshy disk, or foot, which is situated under the belly. Some kinds are terrestrial, others inhabit trees, many live in rivers and streams, others in stagnant and brackish waters; but the greater number are denizens of the sea.

FOSSIL GASTEROPODA.

The Common Snail, River Snail, and Periwinkle, are instances of terrestrial, fluviatile, and marine forms. The organs of respiration are situated in the last whorl of the shell; and in some genera the border of the mantle, or integument surrounding the body, is prolonged into a siphon, by which the water is freely admitted, without the head or foot being protruded: in these mollusks the shell has a corresponding channel to receive the siphon, as in the Whelk, or Buccinum, and in the fossil shell *Lign.* 133, *fig.* 4. The Gasteropoda are generally provided with an operculum, or movable valve, by which the aperture is closed and defended when the animal retreats within its shell. In some species the operculum is a mere horny pellicle; in others it is a solid calcareous plate of considerable relative thickness. These mollusca, as is but too well known of the terrestrial species, consume large quantities of food. Some are herbivorous, and others carnivorous; many prey on living, and others on decaying animal and vegetable substances.[378] As in a fossil state the shells alone remain to afford any clue as to the structure and economy of the originals, characters have been sought for, by which the fluviatile or marine nature, and the carnivorous or herbivorous habits of the living mollusca may be determined. As a general rule, it will be found, that the shells of terrestrial and fresh-water Gasteropoda have the

aperture entire, as in the Garden Snail, and in the fossil shell, *Lign.* 133, *fig.* 1; and that a large proportion of the marine species have the opening notched or channelled, as in the Whelk, and *Lign.* 133, *figs.* 3, 4; and most of the species with entire apertures are herbivorous. But these inferences must be regarded in a very general sense, and it will require corroborative evidence to establish the marine or fresh-water nature of those fossil shells which do not bear a close analogy to known living species.[379]

> [378] "All *Gasteropoda* commence life under the same form, both of shell and animal, namely, a very simple helicoid shell, and an animal furnished with two ciliated wings or lobes, by which it can swim freely through the fluid in which it is contained. At this stage of existence the animal corresponds to the permanent state of the *Pteropod*, and the form is alike, whether it be afterwards a shelled or a shell-less species."—Prof. E. Forbes, Edin. Philos. Journal, vol. xxxvi. p. 326.
>
> The well known Tiger Cowry (*Cyprcea tigris*) in its earliest stage has a minute helicoid (snail-like) shell.
>
> [379] See *Ly.* p. 30.

The various conditions in which the remains of univalve shells occur in the mineral kingdom have already been so fully explained, that but a few additional remarks on that subject are required (see p. 382.).

The Gasteropoda are found to progressively diminish in number with the antiquity of the deposits, and it was once supposed that this type of molluscous organization was not contemporaneous

with the ancient Cephalopoda. My discovery of several genera associated with Ammonites in the chalk (see *Foss. South D.* pl. xviii, xix) first tended to invalidate this hypothesis; and the subsequent researches of Dr. Fitton, Professor Phillips, and other geologists have shown that the presence or absence of Gasteropoda in a stratum may generally be ascribed to the circumstance of the deposit having been formed in shallow, or in deep water. Thus when simple univalves largely predominate under circumstances that indicate they were imbedded in their native habitats, it may be safely concluded that the rock is of littoral formation; or, in other words, was deposited in shallow water, near the sea-shore; and, on the contrary, when Nautili, Ammonites, and the shells of other mollusca known to live in deep waters abound in a formation, it may be presumed that the strata were formed in the tranquil depths of the ocean. The number of described species from the British strata is nearly eight hundred; and these are distributed throughout the sedimentary formations, from the Silurian to the newest Tertiary; the latter containing by far the greater proportion.

FOSSIL FRESH-WATER UNIVALVES.

FRESH-WATER UNIVALVES.—The fossil shells of Gasteropoda that are undoubtedly fluviatile, comprise but few genera and species, and are confined to those deposits, which, from the corroborative proofs afforded by other organic remains, are unquestionably of fresh-water origin. Such are the intercalated beds of clay and limestone in the London and Paris basins, the Wealden formation, and certain strata in the Carboniferous system. The most numerous specimens are principally referable to the common fluviatile

genera, *Paludina*, *Limnæa*, *Planorbis*, and *Melanopsis* (see *Ly.* p. 29).

PALUDINA. *Lign. 133, fig. 1.* (*Wond.* p. 401, *Ly.* p. 29.)—This common river shell is of a conoidal form, and the whorls of the spire, and the aperture, are rounded. Eleven British species are known. In the tertiary fresh-water beds of Headon Hill, at Alum Bay, Paludinæ with the shells perfect, and of a dull white colour, are abundant; and also in the limestone at Shalcombe, in the Isle of Wight, in the state of casts. In both these localities the Paludinæ are associated with other fresh-water shells. But the grand deposit of shells of this genus is the Wealden formation; throughout which there are extensive beds of marble, coarse limestone, and clays, almost wholly composed of Paludinæ, and minute fresh-water Crustaceans, of the genus *Cypris*, which will be described in a subsequent chapter. The compact paludina-limestone of Sussex, called Petworth or Sussex marble, is principally made up of one species, the *P. fluviorum*, *Lign.* 133, *fig.* 1, and is an aggregation of Paludinæ, held together by crystallized carbonate of lime; the cavities of the shells, and their interstices, being often filled with white calcareous spar. A polished slab, displaying sections of the enclosed shells, is figured in *Wond.* p. 402. Upon examining slices of this marble with the microscope, the cavities of the shells are found to contain myriads of the cases of Cyprides.[380] The Wealden limestone of the Isle of Purbeck, *Lign.* 134, known as Purbeck marble, is, in like manner, composed of Paludinæ, but of a much smaller species. Both these marbles were in great repute with the architects of the middle ages, and there are but few of our cathedrals and ancient churches which do not still contain examples, either in their columns,

monuments, or pavements, of one or both varieties. The polished marble columns of Chichester Cathedral, and those of the Temple Church, in London, are of Purbeck marble; in other words, they are composed of the petrified shells of snails, that lived and died in a river, flowing through a country inhabited by the Iguanodon and other colossal reptiles, all of which have long since become extinct. With the exception of the *mussel-band* limestone of the Carboniferous system, previously described, these are the only British fresh-water marbles[381] There are four species of Paludina in the Wealden, and four in the Tertiary strata of Hants.

[380] For a particular account of this marble, see Geol. S. E. pp. 182-187.

[381] The collector may obtain specimens, and polished slabs of these limestones, of Mr. Martin, mason, Lewes, Sussex.



LIGN. 134.
POLISHED SLAB OF PURBECK MARBLE.

LIMNÆA. *Lign.* 133, *fig.* 2.—Several species of these fresh-water mollusks inhabit our lakes and ponds, and may be known by their pointed spire, elongated oval body, and delicate thin shell: on the inner lip of the aperture there is an oblique fold. Fossil shells of this genus are found with Paludinæ in

the fresh-water tertiary deposits. Headon Hill and other localities in the Isle of Wight abound in these shells; and in the limestone of Calbourn beautiful casts are very numerous. The Paris basin yields several species; and there are six species in the Isle of Wight Tertiary; I have not observed any decided examples in the Wealden. In the sands and clays the shells are well preserved; in the limestones the casts only remain. Shells of another genus of fresh-water spiral univalves, termed *Bulimus* (*Ly.* p. 30), are found associated with the above. A large species (*B. ellipticus*, *Min. Conch.* tab. 337), occurs in the limestone at Binstead, near Ryde, and at Calbourn; I have collected specimens two inches long from the former locality; they are generally in the state of casts, with a white friable coating of the shell.[382]

[382] A very large species of *Limnæa* from Bavaria (labelled *L. maxima*) is in the British Museum. It is a cast six and a half inches long, and is placed with the recent shells. Prof. E. Forbes has discovered a Limneïd (*Physa*) in the Purbeck strata.

PLANORBIS. *Ly.* p. 29. *Wond.* p. 400.—The shells of this genus are also numerous in our rivers and lakes, and may be distinguished by their discoidal form, the shell being coiled up in a nearly vertical plane. There are about twenty living species; and sixteen are enumerated as fossil in the British tertiary; five occur in the Isle of Wight basin, in the localities of the fresh-water genera already mentioned; Headon Hill, in particular, yields shells of this genus in great abundance and perfection.

MELANOPSIS. *Ly.* p. 29.—These are spiral univalves, the appearance of which will be better understood by the figures, than by any description. I

allude to this genus because a small species is very numerous, with the other fresh-water shells, at Headon Hill; and two or more species are found in the argillaceous strata of the Wealden (see *Geol. S. E.* p. 249, and *Lign.* 132).

FOSSIL MARINE UNIVALVES.

MARINE UNIVALVES.—Of the fossil marine Gasteropoda there are no less than eighty genera in the strata of the British Islands, and the species amount to several hundreds. To distinguish the species and genera, reference must, of course, be made to works expressly devoted to fossil conchology, as Sowerby's *Mineral Conchology*, and *Genera of Fossil Shells*; or to the works of French authors, particularly those of Lamarck, edited by M. Deshayes, and of M. Blainville. The *Penny Cyclopedia* contains admirable notices of fossil shells, under the respective heads of the classes, orders, and genera, of the recent Mollusca.

BUCCINUM, of which the common Whelk is an example.—FUSUS, *Lign.* 133, *fig.* 4. *Wond.* p. 244.—PLEUROTOMA, *Ly.* p. 31. *Wond.* p. 244.—CERITHIUM, *Lign.* 133, *fig.* 3. *Wond.* p. 244.—ANCILLA, *Wond.* p. 244. *Ly.* p. 31.—VOLUTA, *Ly.* p. 202, *fig.* 180.—MUREX, *Ly.* p. 164.—ROSTELLARIA, *Ly.* p. 201.—To the eight genera here enumerated a very large number of the marine simple univalve shells belong; and they are principally found in Tertiary strata.

The animals of these shells are characterized by their respiratory organs, which are formed of one or two pectiniform gills, with a tube or siphon more or less elongated, for the free admission of sea-water to the branchial apparatus. This organization is

indicated in the shell, either by a notch, or by a prolonged tubular canal. All the species are, with scarcely any exceptions, inhabitants of the sea, and carnivorous.

I have selected for illustration of the genus *Fusus*, a celebrated shell of the Crag, known among collectors as the "*Esssex reversed Whelk*," *Lign.* 133, *fig.* 4; the spire is twisted in the opposite direction to the usual mode, and the mouth is consequently to the left of the observer; the same species occurs with the spire in the common direction. The shells of the genus *Pleurotoma* are distinguished by an incision, or notch, in the side of the right or outer lip; and those of *Cerithium*, by the form of the mouth, see *Lign.* 133, *fig.* 3. The latter is a very numerous genus, and more than two hundred fossil species are enumerated; it contains many elegant forms. The Tertiary strata at Grignon are particularly rich in these fossils; the shells are of a pearly whiteness, and as perfect as when recent. Some Cerithia are of considerable size; the *C. giganteum* is from ten to fourteen inches in length. The genus POTAMIDES comprehends shells closely resembling the Cerithia in form, but which are inhabitants of fresh-water.[383] This is an instance of the difficulty which sometimes exists of arriving at certain conclusions as to the habits of the mollusks, from their testaceous coverings alone.

> [383] Mr. Woodward informs me that they can only be distinguished when *fossil*, by the absence of *varices*, or "periodic mouths." The recent species are known to be inhabitants of fresh-water, by their dark epidermis, corroded points, and horny multi-spiral *opercula*.

The Plastic Clay beds at Castle Hill, Newhaven, and in the vicinity of Woolwich, abound in two

species of shells, which were originally described by Mr. Sowerby, as *Cerithia* (viz. *C. funatum* and *C. melanoides*),[384] but are now referred to the fresh-water genus, Melania; by some conchologists to *Potamides*. At Castle Hill they are accompanied by fresh-water bivalves, and leaves of dicotyledonous plants.

[384] Foss. South Downs, tab. xvii. figs. 3, 4.

Of the genus *Rostellaria*, there is a remarkable species in the London Clay, called *R. macroptera*, from the large wing-like expansion of its outer lip, in adult specimens; see *Ly.* p. 201. An elegant Rostellaria is found in the Galt, at Folkstone,[385] (*Foss. South D.* tab. xix. figs. 12, 14,) and other localities; and also in the Chalk Marl.

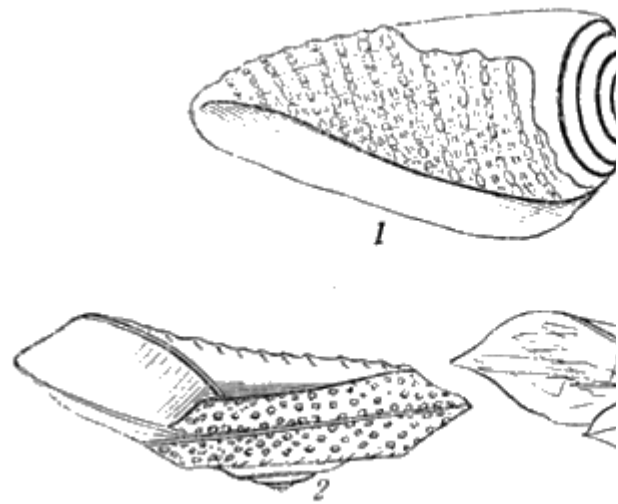
[385] "This shell belongs to the recent genus, *Aporrhaïs*, and is related to Cerithium, not to Strombus."—*Mr. Woodward.*

Casts of a large ventricose, globular univalve, called DOLIUM,[386] have been found in the Chalk Marl, at Clayton, near Hurstpierpoint, in Sussex. This species is distinguished by its transverse tuberculated bands; it is a very rare production of the lower chalk of Sussex (*Min. Conch.* tab. 326). Turbinated shells related to *Trochus*, and belonging to several genera, occur in the Cretaceous deposits. As is the case generally with the univalves of this formation, but slight traces of the shells remain; the thin internal nacreous lining is sometimes found adhering to the cast.

[386] This Chalk fossil is not a *Dolium*: it is probably related to *Ringinella incrassata* (Geol.

Suss. t. xix. *fig.* 3), one of the *Tornatellidæ*, a family largely developed in the chalk.

In the Chalk of Touraine, species of the genera *Conus* (*Lign.* 135, *fig.* 1) and *Solarium* (*Lign.* 135, *fig.* 2) are found with the shells preserved. The specimens figured, *Lign.* 135, are selected to familiarize the student with the difference so commonly observable, between the outer surface of the casts, and that of the shells: in both these fossils the shells are marked externally with lines and tubercles; but the casts present only the smooth surface of the interior of the shell in which they were moulded.



LIGN. 135. UNIVALVES, FROM THE CHALK OF

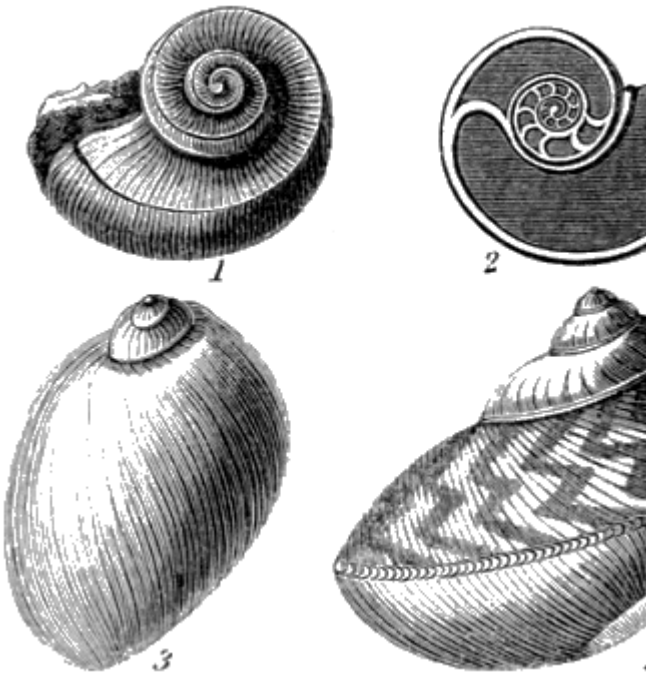
Fig. 1.— CONUS TUBERCULATUS, with part of the shell remaining attac
2.— SOLARIUM ORNATUM, with the shell.
2ª.— Specimen of the same species, deprived of the shell.

In the most ancient fossiliferous formations, the Carboniferous; Devonian, and Silurian, many species and genera of Gasteropoda have been discovered.

Professor Phillips enumerates more than ninety in the mountain limestone of Yorkshire (*Phil. York.*), belonging to the genera *Turbo*, *Pleurotomaria*, *Natica*, *Euomphalus*, *Loxonema*, *Macrocheilus*, *Platyceras*, and *Metoptoma*. Thirty-four species from the Silurian rocks are figured and described in *Murch. Sil. Syst.* p. 706.

The *Natica*, *Lign.* 136, *fig.* 3, sometimes attains thrice the size represented, and has been found in many localities in England and Ireland.

PLEUROTOMARIA. *Lign.* 136, *fig.* 4.—This is an extinct genus, distinguished from Trochus by a fissure on the right lip, the position of which is indicated by the band along the back of the whorl in *Lign.* 136; several species occur in the Mountain Limestone; the markings of the original shell are sometimes preserved, as in the example delineated This genus is common in the Oolite; a splendid species, with the shell entire, is found in the Kimmeridge Clay, at Hartwell; limestone casts of the same species are abundant in the Portland stone at Swindon, in Wiltshire.



LIGN. 136. UNIVALVES FROM THE MOUNTAIN LIMES

Fig. 1.— EUOMPHALUS PENTANGULATUS; Upper surface.
2.— Polished section of the same species.
3.— NATICA PLICISTRIA. *Yorkshire. Mt. L.*
4.— PLEUROTOMARIA FLAMMIGERA. (*Phil. York.*) *Mt. L.*

There are two species of this genus (formerly named *Cirrus* by Mr. Sowerby) which are of frequent occurrence in the White Chalk of England, in the state of casts, and are figured in my *Foss. South D.* tab. xviii., under the names of *Cirrus perspectivus*, and *Trochus linearis*. The Chalk Marl of Sussex yields in some localities (Hamsey, Middleham, Clayton) fine casts of Pleurotomaria, which appear to be distinct from those of the upper cretaceous strata.

EUOMPHALUS.

EUOMPHALUS.[387] *Lign.* 136, *figs.* 1, 2.—The shells of this extinct genus are deeply umbilicated, discoidal, spiral univalves, having the innermost whorls of the shell divided by imperforated partitions. The internal structure of these shells will serve to prepare the student for those more complicated forms of the testaceous apparatus presented by the Cephalopoda, which will form the subject of the next chapter. There are several recent univalves the animals of which retreat in the progress of growth from the apex of the spire, and the vacated portion is shut off by a shelly plate. In some genera a series of concave septa are thus formed; but in others (as *Magilus*) the deserted cavity is filled by a compact accretion of calcareous matter, and a solid elongated shell is produced. The *Euomphalus*, of which there are many species in the Silurian, Devonian, and Carboniferous strata, belongs to the former group. As the animal increased in size, it deserted the smaller and innermost portion of the spire, and a nacreous partition was secreted by the posterior part of the mantle, the interspace remaining hollow; as this process was repeated at different periods, several cells were successively formed. This chambered structure is shown in the specimen *Lign.* 136, *fig.* 2, in which the cells are filled with spar, but the outer cavity is occupied by limestone like that in which the shell was imbedded; a proof that no communication existed between the chamber occupied by the body of the animal, and the space from which it had withdrawn. The calcareous spar, as in the vegetable remains previously described (p. 71.), has percolated the substance of the fossil, and crystallized in the innermost cells. We shall again have occasion to refer to this interesting fact, when investigating the chambered cells of the

Cephalopoda. It may be necessary to remark, that it does not appear that the vacant interspaces in the Euomphalus served the special purpose of the air-chambers of the Nautilus and Ammonite.

[387] So named by Mr. Sowerby, in allusion to the deeply umbilicated character of the disk.



LIGN. 137.
MURCHISONIA ANGULATA.
Devonian; Eifel.

MURCHISONIA. *Lign.* 137. An elongated spiral shell, having the outer lip deeply notched, as in the Pleurotomaria (*a, Lign.* 137). There are upwards of 50 species of this genus, which are characteristic of the palæozoic rocks. They occur in the Permian, Devonian, and Lower Silurian deposits; the specimen figured is from the Devonian, or Old Red of the Eifel.

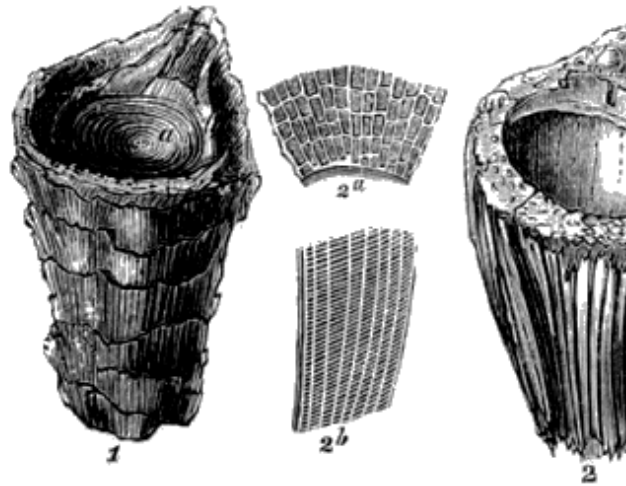
CHITON. Valves of Chitons have been found in the Magnesian limestone, near Sunderland, by Prof. King, (*Permian Fossils*, *Pal. Soc.* p. 202, pl. xvi.), and in the Silurian rocks of Ireland, by Mr. Salter, *Geol.*

Journal, vol. iii. p. 48.

SPHÆRULITES.

SPHÆRULITES.[388] *Lign.* 138.—No vestiges of a shell of this genus had been noticed in the English strata, until my discovery of some fragments in the Lewes Chalk in 1820; from the lamellated structure of these fossils, I mistook them for corals, until specimens were obtained sufficiently perfect to show the form of the originals; these were described in the *Geol. S. E.* (p. 130), under the name of Hippurites. But these fossils are more nearly related to the *Sphærulites*, which differ from the shells of the former genus in having only one internal longitudinal ridge, and in the external surface being roughened by irregularly raised plates, as in *Lign.* 138, *fig.* 1, which is a specimen from the Pyrenees, collected by M. Alex. Brongniart; the operculum is seen at *a*.

[388] This genus has been referred by some conchologists to the Bivalves, and by others to the Univalves.



LIGN. 138. SPHÆRULITES FROM THE CHALK OF FRANCE ANI

Fig. 1.— SPHÆRULITE, with its *operculum*, *a*.
2.— SPHÆRULITES MORTONI (G. A. M.), *from Lewes*: $^1/_2$ *nat.*
2*a*.— Cellular structure of *fig.* 2, in a transverse section: ×
2*b*.— Structure, as seen in a vertical section: ×

The species found in the Sussex Chalk, *Lign.* 138, *fig.* 2, is characterized by the longitudinal striæ on the outer surface. In some examples there is an external longitudinal furrow, and a corresponding internal ridge.[389]

[389] The specific name is in honour of Dr. George Morton, of Philadelphia, author of the "Synopsis of the Cretaceous Group of the United States."

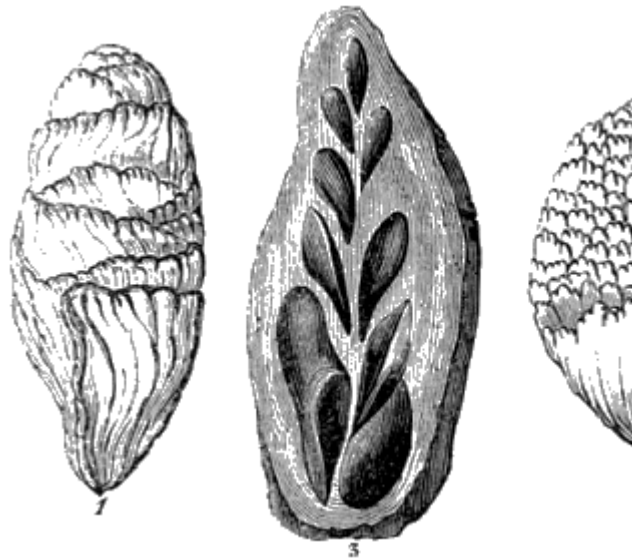
The Sphærulites sometimes occur in groups in the Sussex chalk; I had a large water-worn mass, consisting of five or six individuals, anchylosed together. Some beautiful specimens collected by the late Mr. Dixon from the Chalk, near Worthing, are now in the British Museum.[390] The structure of the Sphærulite is accurately delineated in *Lign.* 138, figs. 2*a*, 2*b*. The cavities of these shells are occasionally filled with flint, but in general with chalk, which may be entirely cleared away, as in *fig.* 2. The Hippurites of the limestone of the Pyrenees are frequently occupied by calcareous spar, and the substance of the shells is occasionally transmuted into the same mineral.

[390] Petrifactions, p. 468.

MOLLUSKITE.

MOLLUSKITE; OR THE CARBONIZED REMAINS OF THE SOFT PARTS OF MOLLUSCA.—Before proceeding to the consideration of that numerous and important

division of the mollusca the *Cephalopoda*, I will offer a few remarks on a carbonaceous substance resulting from the gelatinous matter of which the soft bodies of these animals are composed, and for which I have proposed the name of *molluskite*, to indicate its nature and origin.



LIGN. 139. COPROLITES AND MOLLUSKITE. *Chalk and Gr*

Fig. 1.— COPROLITE of a fish (*Macropoma*). *Chalk, Lewes.*

2.— COPROLITE of a fish (*Squalus*). *Chalk marl. Ramsey.*

3.— MOLLUSKITE of a *Rostellaria*. (*Mr. Bensted.*) *Kentish Rag, Maidst*

This substance is of a dark brown or black colour, and occurs either in shapeless masses, which are irregularly distributed among the shells and other organic remains, in sandstone, limestone, &c., or as casts of shells, or occupying their cavities, as in the specimen *Lign.* 139, *fig.* 3, which is a vertical section of a spiral univalve (*Rostellaria*), filled with the soft parts of the animal, converted into molluskite. Upon

analysis this substance is found to contain a large proportion of animal carbon.[391] The rocks of firestone at Southbourne, on the Sussex coast, are mottled with brown molluskite and hard amorphous concretions, consisting of carbon and phosphate of lime, mixed with sand and other extraneous matter. Casts of shells, of the genera Venus, *Arca*, &c., entirely composed of the same kind of materials, are also abundant in those rocks. The lowermost bed of Galt, at its line of junction with the Greensand beneath, at Folkstone, and in many other localities, is largely composed of similar matter, resembling in appearance the fossils called Coprolites, hereafter described. The outer chamber of the Ammonites and other shells, so abundant in the Galt, are often filled with this substance. But the most interesting deposit of molluskite is in the Kentish Rag of Mr. Bensted's quarry, near Maidstone. This phenomenon had not escaped the notice of that intelligent and accurate observer, who liberally placed at my disposal numerous shells, particularly of *Trigoniæ* and *Terebratulæ*, which were filled with molluskite, and large slabs of the sandstone, full of concretionary and amorphous masses of the same. The latter, Mr. Bensted suggested, may have been derived from the soft bodies of the dead Mollusks, which, having become disengaged from their shells and aggregated together, had floated in the sea, until they became enveloped in the sand and mud, which have gradually consolidated into the arenaceous stone termed Kentish Rag, In illustration of this opinion, Mr. Bensted directed my attention to the following remarkable fact, related in the *American Journal of Science*:—In the year 1836, a fatal epidemic prevailed among the shell-fish of the Muskingum River, in the state of Ohio. It commenced in April,

and continued until June, destroying millions of the mollusca that inhabited the beds of the tributary streams, and the river. As the animals died, the valves of the shells opened, and, decomposition commencing, the muscular adhesions gave way, and the fleshy portions rose to the surface of the water, leaving the shells in the bed of the river. As masses of the dead bodies floated down the current, the headlands of islands, piles of drifted wood, and the shores of the river, in many places, were covered with them; and the air in the vicinity was tainted with the putrid effluvium exhaling from these accumulations of decomposing animal matter. The cause of the epidemic was unknown.

> [391] Some of this *molluskite* has, at my request, been analyzed by Mr. Rigg, who obliged me with the following remarks:—"After removing the lime by means of hydrochloric acid from ten grains of this substance, there remained 1.2 grain of dark powder, which gave, by analysis with oxide of copper, .16 of a cubic inch of carbonic acid, and a small portion of nitrogen. On subjecting to the same kind of analysis two grains of the darker body, without previously acting upon it by any acid, .054 of a cubic inch of carbonic acid was obtained; so that from these results there is no doubt but the darker portion of the molluskite contains about .35 per cent, of its weight of carbon in an organized state."

"Now nearly the whole of the shells in the beds of Kentish Rag," Mr. Bensted remarks, "have their shells open, as if they were dead before their envelopment in the deposit. And, from the large quantity of water-worn fragments of wood perforated by Pholades imbedded with them, it seems probable that this stratum had originally been a sand-bank covered

with drifted wood and shells, thus presenting a very analogous condition to the phenomenon above described." The gelatinous bodies of the *Trigoniæ*, *Ostreæ*, *Rostellariæ*, *Terebratulæ*, &c., detached from their shells, may have been intermingled with the drifted wood in a sand-bank; while, in some instances, the animal matter would remain in the shells, be converted into molluskite, and retain the form of the original, as in the spiral univalve, represented in section, *Lign.* 139, *fig.* 3.

A microscopical examination of the Maidstone molluskite detects, with a low power, innumerable portions of the nacreous laminæ of shells, intermingled with the carbonaceous matter, many siliceous spicula of Sponges, minute spines of Echinoderms, and fragments of Corals; these extraneous bodies probably became entangled among the floating animal matter. A large proportion of the shelly laminæ, examined with a high power, displays the peculiar structure of the *Terebratulæ* (see *Lign.* 126, *fig.* 2[a]), of which several species are abundant in the Kentish Rag.

The dark masses and veins so common in the Sussex and Purbeck marbles are produced by molluskite. If at the period of their envelopment the shells were empty, they became filled either with grey marl and limestone, or with white calcareous spar; but if they enclosed the bodies of the Mollusks, the soft mass was changed into carbonaceous matter; and in polished sections of the marble, the *molluskite* appears either in black or dark brown spots, or fills up the cavities of the shells. The dark blotches and veins observable in the fine pillars of Purbeck marble in the Temple Church, London, are produced by

molluskite; and the most beautiful slabs of Sussex marble owe their appearance to the contrast produced by this black substance in contact with white calcareous spar.[392]

[392] See a "Memoir on the Carbonized Remains of Mollusca," by the author. Read before the Geological Society of London, February, 1843; and published in the American Journal of Science.

Carbon, resulting from animal remains, is of frequent occurrence in many strata; and the fetid emanations from certain limestones, upon being broken or rubbed, are attributable to the evolution of sulphuretted hydrogen, from the animal matter which they contain.

GEOLOGICAL DISTRIBUTION OF SHELLS.

GEOLOGICAL DISTRIBUTION OF THE BIVALVE AND UNIVALVE MOLLUSCA.—If the more rare and splendid organic remains may be regarded as the "Medals of Creation," the fossil testaceous mollusca, from their durability, numbers and variety, may be considered as the current coin of Geology. Occurring in the most ancient fossiliferous strata in small numbers, and of peculiar types,—becoming more abundant and varied in the secondary formations,—and increasing prodigiously, both numerically and specifically, in the tertiary, these relics are of inestimable value in the identification of a stratum in distant regions, and in the determination of the relative age of a series of deposits. To the solution of the former problem the sagacity of the late Dr. William Smith first suggested their applicability;[393] while the idea, so happily conceived, and so

philosophically candied out, by Sir C. Lyell, of arranging that heretofore chaotic mass of deposits, termed the Tertiary, into groups, by the relative number of recent and extinct species of shells, demonstrated the important aid to be derived from this class of organic remains, in the determination of some of the most difficult questions in geological science.

[393] See an interesting memoir of Dr, Smith, from the pen of his distinguished nephew, Professor Phillips.

Many useful tables have been constructed by Professor Phillips,[394] Sir C. Lyell, M. Deshayes, M. D'Orbigny, Prof. E. Forbes, and other eminent observers, to illustrate the geological distribution, in the several formations, of the genera and species of fossil shells hitherto described. To the English student, Mr. Morris's "Catalogue of British Fossils," of which an enlarged edition is in the press, will be the most valuable for reference. In the works which we have especially recommended for reference (*ante*, p. 10.), figures are given of some of the characteristic shells from each formation, as follow; commencing with the most ancient deposits.

[394] A Treatise on Geology; and Art. *Geology*, Encyclopæd. Metropolitana.

SILURIAN SYSTEM. *Ly.* p. 350.

Orthis orbicularis; *Ly.* fig. 409.
——— grandis;—fig. 427.
Terebratula navicula;—fig. 410.
————— Wilsoni;—fig. 413.
Pentamerus Knightii;—fig, 411.
————— lævis;—fig. 426.
Atrypa reticularis; fig. 414. *Wond.* p. 786.

Lingula Lewisii; *Ly.* fig. 412.
Strophomena depressa;—fig. 421.

DEVONIAN SYSTEM. *Ly.* p. 342.

Calceola sandalina; *Ly.* fig. 403.
Stringocephalus Burtini;—fig. 404.
Megalodon cucullatus;—fig. 405.

"THE SILURIAN SYSTEM," by Sir R. I. Murchison, a splendid work on the rocks and fossils of the above formations, contains numerous figures of the shells peculiar to each group of strata; and many other species are delineated in the Memoir on the Devonian deposits of Devonshire and Cornwall, by Sedgwick and Murchison, *Geol. Trans. New Series*, vol. v. plates lii-lvii. A Memoir on the Palæozoic Rocks of Germany and Belgium, by the same distinguished geologists, is also accompanied by many figures of fossil shells belonging to the same geological epochs. *Geol. Trans. New Series*, vol. vi.

See also Prof. M'Coy's "Silurian Fossils of Ireland," and his Description of the British Palæozoic Fossils in the Woodwardian Museum at Cambridge, in Prof. Sedgwick's "SYNOPSIS OF THE CLASSIFICATION OF THE BRITISH PALÆOZOIC ROCKS," of which two Parts are already published.

CARBONIFEROUS SYSTEM. *Ly.* 308. *Wond.* p. 736.

Producta punctata; *Wond.* p. 736.
——— Martini; *Ly.* fig. 390.
Pleurotomaria flammigera; *Lign.* 136, fig. 4.
Euomphalus pentangulatus; *Lign.* 136, fig. 1.
Natica plicistria; *Lign.* 136, fig. 3.
Spirifera trigonalis; *Wond.* p. 736.
——— triangularis; *Wond.* p. 736.

———— glabra; *Ly.* p. 389.
Serpula carbonaria; *Ly.* fig. 375.
Avicula papyracea;—fig. 378.

For the shells of the Mountain Limestone, reference should be made to the second vol. of Prof. Phillips's "Geology of Yorkshire;" to Prof. M'Coy's "Carboniferous Limestone Fossils of Ireland;" and to Prof, de Konick's "Anim. Foss. Belg." The fossils of other portions of the Carboniferous System are illustrated in Phillips's "Palæozoic Fossils of Devon;"[395] and in Prestwich's Memoir on Coalbrook Dale (*Geol. Trans.*).

[395] To prevent confusion, it may be necessary to state that Professor Phillips, in the work referred to, terms the Silurian strata the "*lower palæozoic*" and the mountain limestone, the "*upper palæozoic*"

MAGNESIAN LIMESTONE AND TRIAS. *Ly.* p. 301.

Producta calva; *Ly.* p. 203, fig. 337.
Spirifera undulata;—fig. 338. } Permian.

Posidonia minuta;—p. 288, fig. 321.
Avicula socialis;—fig. 322. } Triassic

Prof. King's elaborate Monograph on the Permian Fossils (published by the Palæontographical Society) should be consulted by the student.

LIAS. *Ly.* p. 273.

Pleurotomaria Anglica; *Ly.* p. 39.
Avicula inæquivalvis; *Ly.* fig. 302.
Plagiostoma giganteum; *Ly.* fig. 303.
Gryphæa incurva; *Lign.* 127.

OOLITE. *Ly.* p. 257.

Gryphæa virgula; *Ly.* fig. 268.
Ostrea deltoidea (Kimmeridge Clay);—fig. 269.
Trigonia gibbosa;—fig. 270.
——— clavellata; *Lign.* 127.
——— costata; *Lign.* 127.
Nerinæa Goodhallii; *Ly.* fig. 274.
Diceras arietinum;—fig. 275.
Pleurotomaria;—fig. 299.
Terebratula spinosa;—fig. 297.
———— digona;—fig. 283.
Ostrea Marshii;—fig. 300.
Phasianella Heddingtonensis;—fig. 58.

Many of the characteristic shells of the Oolite and Kimmeridge Clay, are figured in Plates XXII. and XXIII. of Dr. Fitton's Memoir on the Strata below the Chalk; *Geol. Trans. New Series*, vol. iv.

The fossil shells of the Great Oolite are figured and described by Messrs. Morris and Lycett, in the Memoirs of the Palæontographical Society; and valuable Papers on the Brachiopods of the Oolite and Lias, by Mr. Davidson, have been published by the same Society.

WEALDEN AND PURBECK. *Wond.* vol. i. *Geol. S. E.*, *Foss. Tilg. For.*, and *Ly.* p. 225.

Melanopsis; *Wond.* pp. 401 and 404.
Cyclas;—p. 404.
Paludina Sussexiensis;—p. 401.
Neritina Fittoni;—p. 401.
Mytilus Lyellii;—p. 405.
Unio antiquus; *Geol. S. E.* p. 250, fig. 1.
—— compressus;—fig. 2.
—— aduncus;—fig. 3.
—— porrectus;—fig. 4.
Valdensis;—*Min. Conch.* pl. 646, and *Lign.* 131.

Corbula alata; *Ly.* p. 229.
Ostrea distorta;—p. 232.

The shells of the Wealden are also figured by Dr. Fitton, *Geol. Trans. New Series*, vol. iv. Pl. XXI.

CHALK FORMATION.

I.—SHANKLIN, OR LOWER GREENSAND. *Ly.* p. 219.

Dr. Fitton's Memoir, previously quoted, contains numerous figures of the characteristic shells of this division of the Chalk, particularly of the species which abound in the celebrated Whetstone of Devonshire. *Geol. Trans. New Series*, vol. iv. Pl. XIII-XVIII. See also Prof. E. Forbes's Catalogue of Lower Greensand Fossils, in the Quart. Geol. Journal, vol. i.

II.—GALT AND UPPER GREENSAND. *Wond.* p. 307; *Ly.* p. 218.

Inoceramus concentricus; *Wond.* p. 330, fig. 1.
———— sulcatus;—fig. 3.
Terebratula lyra; *Ly.* fig. 219.
Pecten quinquecostatus;—fig. 203.
Ostrea carinata;—fig. 204.

In Plates XI. and XII. of Dr. Fitton's Memoir, there are figures of more than twenty characteristic shells of this division of the Chalk.

III.—WHITE CHALK. *Ly.* p. 211, *Foss. South D.*, *Geol. S. E.*

Some cretaceous species are delineated in *Lign.* 125, 126, 128, 129, 130, 138; and Sir C. Lyell figures other species; but I must refer the student to the *Foss. South D.*, *Geol. S. E.*, and Dixon's *Fossils of Sussex*, as accessible works containing numerous figures of the fossil shells of the Chalk. Accurate descriptions and representations of all the British chalk shells, however, are still much required. Mr. Davidson has done much towards the illustration of our Cretaceous Brachiopods; and the shells of the Cretaceous strata of the United States are figured and described in

an elegant work by Dr. Morton, of Philadelphia.

TERTIARY FORMATIONS.

I.—EOCENE. *Ly.* p. 174; *Wond.* p. 226.
II.—MIOCENE. *Ly.* p. 168.
III.—PLIOCENE. *Ly.* p. 161.

The specimens figured by Sir C. Lyell have been so carefully selected, and are so well engraven, as to present a *coup-d'œil* of the most characteristic shells of the three grand divisions of the Tertiary Deposits.

I have reserved for especial mention in this place, the work, which will afford the student of British fossil Conchology the most important aid in the identification of specimens, namely, the "*Mineral Conchology of Great Britain*," by the late eminent naturalist, Mr. JAMES SOWERBY, and continued by his son, Mr. James De Carle Sowerby; in six volumes 8vo., with several hundred coloured plates. Unfortunately, this work has long been discontinued; and the rapid progress of discovery, and the numerous foreign publications on every department of fossil conchology, almost forbid the hope that it will be resumed by the present proprietor. Although the high price of this work places it beyond the reach of many individuals, it will be found in most libraries of Natural History.

ON COLLECTING FOSSIL SHELLS.

ON THE COLLECTION AND ARRANGEMENT OF FOSSIL SHELLS.—The instructions already given for the collection of corals, echinoderms, &c., will have familiarized the student with the methods generally adopted, and render it unnecessary to enter into much detail. The shells in arenaceous deposits,

particularly in those of the Tertiary formations, are commonly so perfect, as merely to require careful removal: those in the clays are more fragile, and must be extracted with great caution; and, when very delicate, should be left attached to the clay or shale. The specimens extracted entire may be kept either in paper trays, lined with wadding, or fixed to pieces of card or thin board covered with paper, by thick gum-water; three or four specimens being attached in different positions, so as to expose the essential characters, as the aperture, spire, and back of the univalves, and the hinge, muscular imprints, &c. of the bivalves. Where only casts remain, search should be made for an impression of the outer surface of the shell, and a cast taken of it in wax, kneaded bread, or plaster of Paris. In indurated clays, sometimes both shells and casts may be obtained; and a specimen of each should be preserved. Mastic varnish, or solution of gum tragacanth, delicately applied to fragile shells, tends to preserve them, and improves their appearance. It is desirable to collect the same species in various states of growth; the form of the young shell (as in *Rostellaria ampla*, of Solander) often differing essentially from that of the adult. It will be found convenient to have trays or boards of different colours; and to select one tint for the shells collected from a particular formation, or deposit; for example, the newer Tertiary may be placed on yellow paper; the older, or Eocene fossils, on light-blue. It is also desirable to separate the marine from the fresh-water species.

Shells imbedded in chalk, limestone, &c., often require much labour to display their more delicate and important characters. For clearing chalk specimens, a stout penknife, and a few gravers or gouges of various sizes, will be necessary; and by a

little practice, the spines of the Spondylus (*Lign.* 128), and the beaks and hinge of Inocerami (*Lign.* 129), &c., may be readily exposed. A small stiffish brush, used with water, is also serviceable. The shells in compact stone, as those of the mountain limestone, must generally be cleared with the hammer and chisel. Common species may be broken out, and, from several examples, probably one or two will be found perfect; but choice and rare specimens should not be thus risked; they will amply repay the trouble of the less expeditious method of chiselling away the surrounding stone. Casts may be taken in gutta percha, &c.

To determine the names of the specimens that he has collected should be the next care of the student. No method will so readily initiate the young collector in fossil conchology, as the careful examination of a small series of the common species, with their names attached.[396] By the geological map,[397] the nature of the deposit in which the locality of the specimens is situated, may be ascertained; and the remarks previously advanced on the prevailing shells of each formation, will afford a general idea of the genera to which they belong; and, by referring to the figures quoted, the specific names may be determined.

[396] Such a series may be obtained, at very little cost, of dealers in objects of natural history; as, Messrs. Tennant, Sowerby, the British Natural History Society, &c. See Appendix.

[397] A Geological Map of England and Wales, coloured by Mr. Woodward, under the direction of Sir R. I. Murchison, has been published by the Society for the Diffusion of

Useful Knowledge, at the low price of 5*s.* Although on a very small scale, and therefore not to be compared for utility and convenience with that by PROF. PHILLIPS, much less with GREENOUGH'S large map, or with KNIPE'S, it will be found serviceable.

I subjoin a list of some localities of fossil shells, to direct research in places which are likely to be productive.

BRITISH LOCALITIES OF FOSSIL SHELLS.

BRITISH LOCALITIES OF FOSSIL SHELLS.

Aldborough, Suffolk. The usual shells of the Crag.

Alum Bay, Isle of Wight. Eocene tertiary; marine and fresh-water shells.

Ancliff. Great variety of minute shells of the Oolite.

Arundel, Sussex. Chalk-pits in the neighbourhood.

Atherfield, Isle of Wight, Shells of the lower beds of the Lower Greensand, in great variety and abundance.

Aylesbury, Bucks. Kimmeridge Clay: near Hartwell.

Aymestry. *Pentamerus*, and other Silurian shells.

Barnstaple, North Devon. Numerous Devonian shells.

Barton Cliff, Hants. Eocene shells in profusion.

Bedford. Lower Oolite, *Terebratulæ*, *Ostreæ*, *Myadæ*,

&c.

Binstead, near Ryde, Isle of Wight. Tertiary: in the stone-quarries, terrestrial and fresh-water shells, as *Bulimus*, *Helix*, *Limncæ*, and *Planorbis*.

Blackdown, near Collumpton, Devon. Greensand. Numerous silicified shells, of great beauty. *Trigonia*, *Venus*, *Corbula*, *Rostellaria*, &c. &c.

Bognor Rocks, Sussex. Eocene Tertiary. *Vermetus*, *Pectunculus*, *Pinna*, *Voluta*, &c.

Bolland. Numerous shells of the Mountain Limestone.

Bradford, Wilts. Numerous Oolitic shells. *Avicula.*

Bramerton Hill, near Norwich. Shells of the Norfolk Crag.

Brighton. *Strondylus*, *Terebratula*, *Ostrea*, *Pecten*, *Inoceramus*, &c. Many species in the chalk.

Bromley, Kent. Eocene Tertiary. Oyster conglomerate.

Brook-point, Isle of Wight: about one mile east of the Chine. Wealden: *Unio valdensis*, *Cyclades*, *Paludinæ*, &c.

Brora, Scotland. Oolite. *Pholadomya*, *Sanguinolaria*, &c.

Calbourn, Isle of Wight. Tertiary. Fresh-water Univalves.

Cambridge. In the Galt and Chalk-marl, the usual shells.

Castle Hill, near Newhaven, Sussex. In the Tertiary strata, on the summit of the hill. Numerous *Potamides*, *Cyclades*, and other fresh-water shells, *Ostreæ*, with pebbles.

Chardstock, Devon. The fossils of the Lower Chalk.

Cheltenham. Fine shells of the Oolite and Lias.

Chute, near Longleat, Wilts. Greensand shells, in abundance.

Clayton, near Hurst, Sussex. In Chalk-marl, many rare shells; as, *Dolium nodosum* (*Min. Conch.* tab. 326.)

Clifton. Carboniferous Limestone. *Spirifera*, *Producta*, &c.

Coalbrook Dale. Silurian and Carboniferous fossils.

Cork. In the vicinity. Carboniferous limestone shells.

Crich Hill, Derbyshire. The usual shells of the Mountain Limestone.

Cuckfield, Sussex. In the Sandstone and Grit, fresh-water shells of the Wealden.

Dudley. Profusion of shells of the Silurian strata.

Dundry, near Bristol. Beautiful shells in the Inferior Oolite.

Earlstoke, Wilts. Many shells of the Greensand.

Faringdon, Berks. The usual shells of the Oolite in the Coral Rag, &c.; and of the Greensand, in the Gravel-pits.

Folkstone, Kent. Galt. *Inoceramus*, *Arca*, *Rostellaria*, *Dentalium*, &c. Lower Greensand, *Gryphæa*, *Ostrea*, &c.

Gravesend. Beautiful shells of the White Chalk.

Hampstead Cliff, Isle of Wight. Fresh-water Tertiary shells.

Hampton Quarry, near Bath. Abounds in Oolitic shells.

Hartwell, Bucks. On the estate of Dr. Lee, beautiful shells of the Kimmeridge Clay.

Harwich Cliff, Essex. The Crag shells. *Voluta Lamberti*.

Hastings, Sussex. Fresh-water shells of the Wealden.

Headon Hill, Isle of Wight. Fresh-water Tertiary shells in profusion.

Heddington. Oysters in Kimmeridge Clay (*Ostrea deltoidea*). *Perna*, *Gervillia*, *Trigonia*, &c.

Highworth, Wilts. Very fine Trigoniæ, and other Oolitic, shells, in the stone-quarries.

Hollington, near Hastings. Wealden. Fresh-water bivalves, &c.

Holywell, near Ipswich. Shells of the Crag, abundantly.

Hordwell Cliff, Hants. The usual shells of the Eocene deposits, in immense quantity, variety, and perfection.

Horningsham, near Frome, Wilts. Oxford Clay. *Terebratula*, *Pecten*, &c. in great numbers.

Horsham, Sussex. Fresh-water shells of the Wealden, in the stone-quarries.

Humbleton Hill, Sunderland. Permian fossils.

Hythe, Kent. Greensand. *Trigonia*, *Gryphæa*, *Pecten*, &c.

Ilminster, Somerset. *Brachiopoda*, &c. Inf. Oolite and Marlstone.

Ipswich. The usual Crag shells.

Langton Green, near Tunbridge Wells. Wealden. In the sandstone quarries, *Uniones*, *Cyclades*, &c.

Leckhampton Hill, near Cheltenham. Numerous shells of the Inferior Oolite and Lias.

Lewes. *Inoceramus*, *Pecten*, and usual shells of the White Chalk and Chalk Marl.

Ludlow. *Pentamerus*, *Spirifera*, &c. and other Silurian shells.

Lyme Regis. Lias. *Plagiostoma*, *Gryphæa*, *Trochus*.

Malton. Beautiful shells of the Oolite.

Matlock, Derbyshire. The mountain limestone in the vicinity abounds in the characteristic shells *Leptæna*, *Spirifer*, &c.

Minchinhampton. Numerous shells of the Great Oolite.

Osmington, near Weymouth. Purbeck; fresh-water and marine shells: Oolite; *Trigonia*, *Gervillia*, *Perna*, *Pholadomya*, and many other genera.

Portland, Isle of. Oolite. In the stone-quarries immense numbers of the genera *Trigonia*, *Venus*, *Ostrea*, *Pecten*, &c.

Pluckley, Kent. Lower Greensand. *Trigoniæ*, *Terebratulæ*, &c.

Radipole, near Weymouth. *Trigonia*, *Pholadomya*, &c. in Oxford Clay.

Sandgate, near Margate. In the Greensand, the usual shells.

Scarborough. In the cliffs along the shore, a profusion of Oolitic and Liassic shells.

Selbourne, Hants. In the firestone, *Ostrea carinata* and other characteristic shells.

Shalfleet, Isle of Wight. In tertiary fresh-water limestone, shells of various genera, as *Bulimus*, *Helix*, *Planorbis*, &c.

Shanklin Chine. Greensand. In the cliffs along the shore, *Terebratidæ*, *Gryphites*, *Gervilliæ*, and many other shells.

Sharnbrook, Bedfordshire. The usual shells of the Cornbrash and Lower Oolite.

Sheppey, Isle of. Eocene. London Clay shells, in abundance.

South Petherton, Somerset. *Terebratulæ*, *Pholadomya*, *Ostreæ*, *Pleurotomariæ*, &c. of the Marlstone.

Stamford, Lincolnshire. Lower Oolite. Univalves and bivalves in profusion.

Stonesfield, Oxfordshire. *Trigoniæ* and other shells of the Lower Oolite.

Stubbington Cliff, near Portsmouth. Eocene shells.

Swanage. In the quarries in the vicinity, the prevailing fresh-water shells of the Purbeck limestone.

Swindon, Wilts. Oolite. The Portland limestone abounds in the usual shells of that deposit. *Trigoniæ*, *Gervilliæ*, &c.

Taunton, Somersetshire, (Pickeridge Hill, &c.) *Lima*, *Pecten*, and other Liassic shells.

Tisbury, Wilts. Beautiful *Trigoniæ*, and other shells of the Portland Oolite.

Vincent's, St., near Clifton. The rocks abound in the usual shells of the mountain limestone.

Walton, Essex. Shells of the Crag, in great variety.

Weymouth. The Oxford Clay and other strata in the vicinity contain great variety of fossil shells.

Whitecliff Bay, Isle of Wight. Eocene. Marine and fresh-water shells.

Worthing. The chalk quarries in the neighbourhood are remarkably prolific in the usual species; and

yield Sphærulites.

NOTE.—A comprehensive list of the localities for *Lower Palæozoic* shells, &c. is given by Prof. M'Coy in the second Fasciculus of the "British Palæozoic Fossils;" and in the little "Stratigraphical List," published by Mr. Tennant, reference is carefully made to the localities for the fossils of every formation.

END OF VOL. I.

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MANTELL'S

MEDALS OF CREATION.

VOL. II.



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THE

Medals of Creation;

OR,

FIRST LESSONS IN GEOLOGY,

AND

THE STUDY OF ORGANIC REMAINS.

BY

GIDEON ALGERNON MANTELL,
LL.D. F.R.S. V.P.G.S.

PRESIDENT OF THE WEST LONDON MEDICAL SOCIETY, ETC.
AUTHOR OF THE WONDERS OF GEOLOGY, ETC.



INCLINED STRATA OF MILLSTONE GRIT, CR

IN TWO VOLS.—VOL. II.

CONTAINING

Fossil Cephalopoda, Crustacea, Insects
Birds, and Mammalia

WITH NOTES OF GEOLOGICAL
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SECOND EDITION, ENTIRELY REWRITTEN.

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DESCRIPTION

OF THE

FRONTISPIECE OF VOL. II.

PLATE II.

Illustrative of the mode of developing Fossil Fishes in Chalk.

OSMEROIDES MANTELLI: A FOSSIL SMELT; from the *Chalk*, Lewes.

See page 626.

(*One-third natural size.*)

Fig. 1. — The two corresponding surfaces of a block of Chalk split asunder. The irregular oval lines, seen on each surface, are the only apparent indications that the stone contains an extraneous body.

2. In this figure the two pieces represented above are shown cemented together; care having been taken that the oval markings on each surface were accurately adjusted. The chalk has been chiselled away in the supposed longitudinal direction of the enclosed extraneous body, and part of the scaly surface of a fish has been thus brought to light. A portion of chalk has also been removed towards both ends, with the view of ascertaining the extent and direction of the fossil; and at each place indications of its presence are visible.

3. Represents the specimen completely developed. It proves to be a fish almost perfect, lying on its back, with the body uncompressed, the mouth open, the arches and opercula of the gills expanded, and the dorsal, pectoral, and ventral fins entire. The caudal fin, or tail, is imperfect. The original is nine inches long, and is one of the most extraordinary fossil fishes ever discovered. It belongs to the Salmon family, and is allied to the Osmerus, or Smelt; it is now in the British Museum. We thus perceive that the oval markings on the surface of fig. 1 were occasioned by the section of the scales covering the cylindrical body of the fish (see p. 627). A magnified view of one of the scales is figured *Lign.* 185, *fig.* 4, p. 567.

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THE

MEDALS OF CREATION.

CHAPTER XII.

FOSSIL CEPHALOPODA; COMPRISING THE BELEMNITIDÆ, NAUTILIDÆ, AND

AMMONITIDÆ.



LIGN. 140. FOSSIL SEPIA OR CUTTLE-FISH: $^1/_3$ *nat.*
Solenhofen.
(KELÆNO[398] SPECIOSA. *Count Münst*
The impression of the body, head, and arms, wit

[398] *Kelæno* (one of the Furies) = Acanthoteuthis (Wagner); probably identical with Belemnoteuthis, which also has ten sub-equal arms.—*Mr. Woodward.*

FOSSIL CEPHALOPODA

THE molluscous animals named *Cephalopoda*

(from their organs of prehension being arranged around the upper part of the body) are the most ancient, numerous, and interesting of this division of animated nature; and their fossil remains comprehend the most varied and striking forms of extinct beings that occur in the sedimentary strata, from the earliest Secondary to the latest Tertiary formations. The living species are but a feeble representation of the countless myriads which swarmed in the ancient seas; yet they afford important assistance in developing the characters of the numerous extinct genera, whose relics abound in the strata, and will continually be presented to the observation of the collector. It is therefore necessary to enter somewhat in detail on the structure of these beings, that the student may obtain a correct idea of the nature of the curious fossils to which the mineralized remains of the durable parts of these animals have given rise, and whose origin has but lately been correctly ascertained. The body of these mollusca is either enclosed in a shell, as in the *Nautilus*, or contains a calcareous or cartilaginous part, as in the *Sepia*, or cuttle-fish; they have a distinct head, and eyes as perfect as in the vertebrate animals; complicated organs of hearing; and a powerful manducatory apparatus, surrounded by arms serving for prehension. They have below the head a tube which acts as a locomotive instrument to propel the animal backwards, by the forcible ejection of the water that has served the purposes of respiration, and which can be thrown out with considerable force by the contraction of the body. The figures 1 and 6, *Lign.* 142, are views of a naked (that is, *shell-less*) cephalopod, showing the arms, eyes, and a pair of fins, for swimming. The Cephalopoda, thus endowed with powerful organs of

locomotion, traverse the seas unrestricted, and are seen in groups of myriads in the midst of the ocean, and only appear periodically near the shores. Their fossil remains consist of—

1st. The external shells; which are generally symmetrical, and either straight (as in *Orthoceras*, *Lign.* 155); arched or bent (as in *Crioceras*, *Lign.* 160); spiral (as in *Turrilites*, *Lign.* 163); or involute,[399] and simple (as in the *Argonaut*), or divided, by smooth or foliaceous partitions, into chambers or air-cells, connected by a hydraulic tube or siphuncle (as in *Nautilus*, *Lign.* 149 and 150, and *Ammonites*, *Lign.* 156 and 157).

[399] *Involute*, as applied to the shells of Cephalopoda, implies that the inner whorls are embraced by the outer turn or whorl; *convolute*, the inner turns apparent, or exposed; *evolute*, the whorls coiled in one plane, but not touching each other; *revolute*, the extremities bent inwards.

2dly. The internal horny or calcareous support, called *osselet*, and its appendages.[400] (*Lign.* 143.)

[400] The *bone* or *shell* of the Cuttle-fish, the friable part of which, reduced to powder, forms *pounce*, is the *osselet* of that cephalopod.

3dly. The ink-bladder, with its inspissated contents, termed *sepia*.

4thly. The mandibles of the mouth, or beaks, called *Rhyncholites*. (*Lign.* 150, *fig.* 1.)

5thly. The soft parts of the animal in the state of molluskite; impressions of the head and tentacula, and remains of the clasps or curved hooks of the arms of some species (see *Lign.* 140 and 145).

These several parts are generally found separate, but they sometimes occur in their proper relative position, and from such examples the nature of the original may be determined.

The Cephalopoda[401] are divided into two orders, according to the number of their organs of respiration, or gills; namely, the *Dibranchiata*, or those which have two gills, (called also *Acetabulifera*, from their arms being furnished with rows of little cups or suckers;) and the *Tetrabranchiata*, which have four gills, or branchiæ, and very numerous arms without suckers.

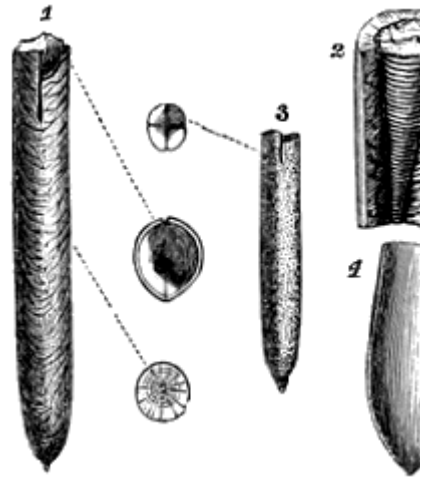
[401] The best systematic account of the Cephalopoda and Gasteropoda, both recent and fossil, yet published, is contained in the first part of the very valuable Manual of Mollusca, by Mr. S. P. Woodward, of the British Museum.

FOSSIL DIBRANCHIATE CEPHALOPODA.

The *Argonaut*, or Paper Nautilus, whose elegant fragile shell is too well known to require description, is the only living genus of this Order, in which the animal is protected by a hard calcareous external covering. This shell is symmetrical, and convoluted on a vertical plane, and consists of but one cavity or chamber. The other genera are naked, and possess an internal chambered shell (as in the recent *Spirula*), or some modification of such an apparatus. The last chamber or cell of these enclosed shells is too small to admit any part of the body of the animal; a character by which the fossil species of this Order may be distinguished from those of the other order. Others have a horny or calcareous osselet, as the bone of the Cuttle-fish, and pen of the Calamary or Sea-pen (see *Bd.* pl. 28); and in an appendage of this kind a conical chambered shell is contained in many of the fossil genera, hereafter to be noticed. These animals have eight arms, with the addition in some genera of two long tentacula, which are furnished with rows of suctorial disks or cups, called *acetabula* (see *Lign.* 142, *figs.* 1, 6).

These naked Cephalopoda, devoid of any external defence, possess a very extraordinary means of escape from their enemies. They are furnished with a bag or bladder, containing a dark fluid resembling

ink in appearance, which they have the power of ejecting into the surrounding water upon the approach of danger; and by the obscurity t us induced, they foil the pursuit of their adversaries: the Nautilus and other cephalopods, protected by a large external shell, are destitute of such an apparatus. The deep brown colour, *sepia*, was formerly prepared from the fluid of the ink-bags of different species of Cuttle-fish; a similar substance secreted by extinct naked Cephalopoda, as we shall presently demonstrate, is found in a fossil state. These preliminary remarks on the organization of the recent animals will prepare us for the investigation of the extinct species. We will first notice those remarkable fossils, called *Belemnites*, or thunder-stones.



LIGN. 141. BELEMNITES: $^1/_2$ *nat. Chalk an*

Fig. 1.— BELEMNITELLA MUCRONATA. *Chalk. Brighton.* On the right of and a transverse section.

2.— Portion of a Belemnite, containing the internal conical cham *Oolite.*

3.— BELEMNITELLA QUADRATA. Beauvais, France. The quadrangu
figure on the left. (*M. D'Orbigny.*)

4.— BELEMNITES DILATATUS. *Lower Greensand* (*Néocomien*). *Franc*

BELEMNITES

BELEMNITE (from a supposed resemblance to the head of a dart or javelin). *Lign.* 141 to 144. Among the innumerable relics of an earlier world, which swarm in the sedimentary deposits, there are perhaps no fossil bodies that have excited more curiosity, and given rise to so many fruitless conjectures as to their nature and origin, as the Belemnites.[402] These are long, cylindrical, or fusiform fossils, more or less pointed at one extremity, and having at the other and larger end a conical cavity, which is either occupied by a chambered shell, or filled up with the material in which the fossils are imbedded. Their substance is like fibrous calcareous spar, varying in colour from a dark brown to a light amber; many are transparent, others nearly opaque. When broken transversely they present a radiated structure (*Lign.* 141, *fig.* 1) and a minute central cavity, or axis, is seen to extend through the whole length of the solid portion of the stone (see *Lign.* 142, *fig.* 5.). A longitudinal section (*Lign.* 142, *figs.* 4 and 5) shows the conical cavity in the upper part, and that the shaft consists of a series of concentric layers. Such are the characters of these fossils in the examples of most frequent occurrence.

[402] See Park. Org. Rem. vol. iii. p. 122.

The Belemnites vary in size from the small, delicate, transparent species, *Lign.* 142, *figs.* 3 and 4, to massy opaque specimens, several inches in circumference, and from ten to twenty inches in length. They present also considerable variety of form; some are regularly cylindrical, as in *Lign.* 141

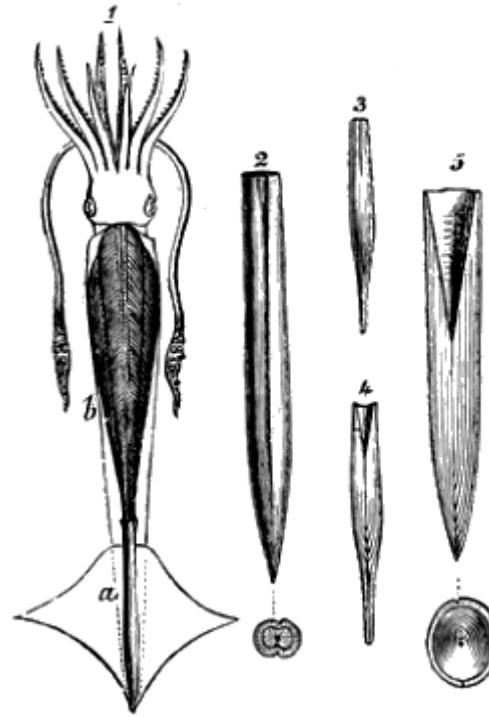
fig. 1; others broad and flattened, as in *fig.* 4; or subfusiform, as in *Lign.* 142, figs. 3 and 4. The small end is slender and pointed in some belemnites, and in others is obtuse, or rounded, with a projecting point. In many there is a longitudinal groove or furrow on the ventral aspect; and some species have a furrow on each side, as in that represented in *Lign.* 142, *fig.* 2.

But the fossils above described are only a part of the original structure of the Belemnite. When in a perfect state, the cavity seen in *Lign.* 142, *fig.* 5, is occupied by a chambered conical shell, called the *phragmocone*, composed of a series of shallow concave cells, of a nacreous or pearly substance, which are pierced by a siphuncle at the margin; see *Lign.* 141, *fig.* 2.

The parts of the BELEMNITE at present known consist of—

1st. The spathose osselet, or *guard*, having at the larger end a conical cavity, called the *alveolus*, as in *Lign.* 141, *fig.* 1, and *Lign.* 142, *fig.* 5.

2dly. A conical, chambered pearly shell, termed the *phragmocone*, which is situated in the *alveolus* (as in *Lign.* 141, *fig.* 2).



LIGN. 142. BELEMNITES: $^1/_2$ *nat.*

Fig. 1.— A front view of the supposed animal of the Belemnite, by *M.* the base of which the *Belemnite*, *a*, is attached.

2.— BELEMNITES BIPARTITUS; the figure below shows the form o *France.* (*M. D'Orbigny.*)

3.— BELEMNITES LISTERI (G. A. M.); *from the Galt. Ringmer.*

4.— A longitudinal section of B. LISTERI.

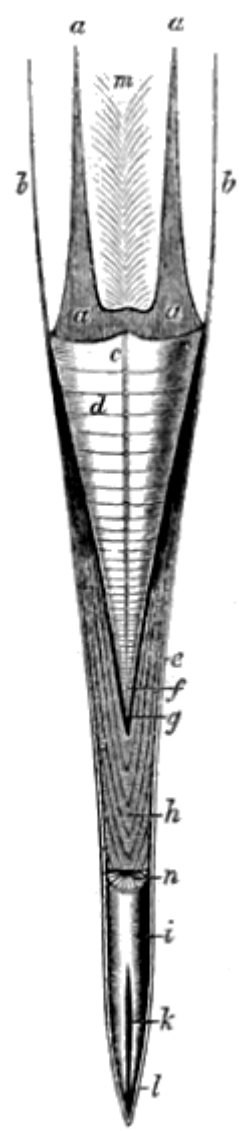
5.— BELEMNITES SEMICANILICULATUS: a longitudinal section; the *alveolus*. *From the Firestone (Craie tufeau) of France.*

6.— A side view of fig. 1.

3dly. The horny prolongation of the *capsule* (the outer investment of the *guard*), called the *receptacle*, as in *Lign.* 143.

4thly. The *ink-bag*, and its inspissated fluid, *sepia*;

(*Bd.* pl. 44′, figs. 7, 9.)



LIGN. 143. THE STRUCTURE OF THE SHERRY PARTS OF THE
Oxford Clay. Christian Malford. ($^1/_4$ *nat.*

a, a. The dorsal basilar processes of the phragmocone.
b, b. Upward extension of the attenuated osselet.
c. Siphunculus.
d. Phragmocone: the transverse lines indicate the septa.
e. The capsule or outer investment of the guard.
f. The distal part of the phragmocone.
g. The alveolus or cavity in the guard.
h. Vertical section of the guard.
i. The solid part of the rostrum or guard.
k. The sulcus or groove on the ventral aspect of the rostrum.
l. Shows the continuation of the capsule, in section, continued
m. Diverging parallel striæ observable between the dorsal pro
n. Transverse section of half the diameter of the radiated struc


a
a



LIGN. 144. VERY PERFECT SPECIMEN OF BELEMNIT
Oxford Clay. Christian Malford, Wilts. ($^1/_6$ n

a, a. Basal processes of the phragmocone.

b. The phragmocone.

c. The rostrum or guard of the osselet, containing the apex of

The invariably radiated crystalline structure of the Belemnite has evidently resulted from the peculiar organization of the original osselet, which is formed of thin concentric laminæ, of very minute prismatic trihedral fibres, arranged at right angles to the planes of the successive layers.[403]

[403] The Belemnitic shell presents the same arrangement of its constituent layers as the Pearl-mussel, Pinna, and other *Aviculidæ*, viz. the outer layer is prismatic-cellular, the inner nacreous: the first is formed by the free margin of the mantle, the second by the visceral ("peritoneal") part of the mantle.—*Mr. Woodward.*

From the obvious analogy of the structure above demonstrated with that of the recent dibranchiate Cephalopoda, several eminent naturalists inferred that the animal of the Belemnite was closely related to the existing types; and the late Mr. Miller, in a communication to the Geological Society of London, gave a restored figure of the original, which, as modified by M. D'Orbigny, is represented *Lign.* 142, *figs.* 1 and 6. The indefatigable and successful researches of the Rev. Dr. Buckland have confirmed the general correctness of this restoration. In the Lias of Dorsetshire two specimens of the Belemnite, with its chambered shell and horny or pearly receptacle, still retaining the ink-bag and its contents, have been discovered, and were figured in the Br. Treatise (*Bd.*

pl. 44′, 44″). A third specimen, showing the ink-bag, is in the British Museum.

The ink-bag of the Belemnite is very small, as might be expected, from the extent to which it is protected by a chambered shell. The mandibles or beaks of the Belemnite are supposed to have been horny, as in the other naked Cephalopoda; since no calcareous beaks have been found associated with their remains.

"The Belemnite having the advantage of its dense, but well-balanced internal shell, must have exercised the power of swimming backwards and forwards, which it possessed in common with the modern decapod (*ten-armed*) Dibranchiata, with great vigour and precision. Its position was probably more commonly vertical than in its recent congeners. It would rise swiftly and stealthily to infix its claws in the belly of a supernatant fish, and then perhaps as swiftly dart down, and drag its prey to the bottom and devour it. We cannot doubt at least but that, like the hooked Calamaries of the present seas, the ancient Belemnites were the most formidable and predacious of their class."—OWEN.

The Belemnites of the oolitic limestones frequently contain the phragmocone, either filled with calcareous spar, or with its cells empty. In the clays the horny sheath or receptacle is sometimes found pressed flat and extending above the alveolus of the osselet, and has often a thin coat of nacre of a pearly lustre, but it is more commonly detached.

The Belemnites abound in the Lias, Oolite, and Chalk, and have not been discovered in any other deposits; there are nearly thirty British species, some of which are restricted to the Chalk, and others to

the Oolite and Lias.

A few characteristic forms are represented, *Lign.* 141 and 142, in order to illustrate the three groups which, according to M. D'Orbigny, are peculiar to the grand divisions of the Cretaceous formation.

1. BELEMNITELLA MUCRONATA. *Lign.* 141, *fig.* 1. —The name *Belemnitella* is given to those Belemnites which have a slit, or crevice, on the anterior margin of the alveolus or cavity, and two lateral impressions. The surface is sometimes granulated, and often has vascular markings, produced by the investing integument of the living animal. The form of the aperture is shown in the middle dextral figure; and the radiated structure, as seen by a transverse section, in the sketch.

This species is abundant in the *White Chalk*, particularly in certain localities in Norfolk and Devonshire. It is more frequent in the chalk of Kent than in that of Sussex; and in the cretaceous strata around Brighton, than in those near Lewes. I have never been able to detect the least vestige of the phragmocone, or chambered shell, in the alveolus. This Belemnite is occasionally imbedded in flint nodules; and such examples possess the calcareous crystalline structure of the chalk and limestone specimens. In the chalk of Ireland, the Belemnites which have been corroded, or perforated by marine borers (*cliona*), are often injected with flint; and if the calcareous substance be removed by immersion in dilute hydrochloric acid, exquisite siliceous casts may be obtained (see also page 403). It is not unusual to find flints with a cavity, occasioned by the solution and removal of the calcareous guard, and having a siliceous conical cast of the alveolus,

occupying the upper part of the interspace. The reader will recollect that the pulley-stones of the Derbyshire Encrinites were produced by a similar process (see p. 285, vol. i.).

The American cretaceous sands abound in a species of Belemnitella, nearly related to *B. mucronata*.

2. BELEMNITES LISTERI. *Lign.* 142, *fig.* 3.—This small elegant Belemnite has two lateral grooves, and is generally as transparent as amber; it has frequently a nacreous or calcareous pellicle partially investing the guard. It seldom exceeds two inches in length. It is abundant in, and peculiar to, the GALT, or blue marl of the Chalk, and is constantly associated with the Inocerami, previously described as common at Folkstone, Bletchingley, Ringmer, and other localities of that deposit. The Red Chalk of Norfolk contains the same species (*Min. Conch.* tab. 589).

3. BELEMNITES DILATATUS. *Lign.* 141, *fig.* 4.—This species is distinguished by its flattened form, and by the longitudinal furrow being situated on the margin opposite to the siphuncle of the phragmocone, instead of being on the same side, as is most usual. It is supposed by M. D'Orbigny to be characteristic of the Neocomian beds, or lowermost division of the Shanklin Sand.

4. The Chalk-marl contains a Belemnite of a more elongated form than those above described, the apex gradually tapering to a point, with a slight double furrow on each side. It is named *B. lanceolatus* (*Sow. Min. Conch.* tab. 600, figs. 8, 9), and is very common in the marl-pits at Steyning, Clayton, and Hamsey, in Sussex.

At the base of Golden Cap Hill, near Charmouth, there are two strata of marl-stone observable on the shore, which are literally paved with Belemnites. Great numbers of these fossils have Serpulæ and other extraneous shells attached to them, a proof that the ink-bags and other soft parts of the mollusks had decomposed, and that the guards had lain uncovered at the bottom of the sea.

M. De Koninck has discovered in the Devonian limestone of Belgium, at Couvin and Visé, a small fossil body which closely resembles in form and structure the rostrum or guard of a belemnite; it is, however, too fragmentary to admit of positive detemination.[404]

[404] Bulletin del'Académie Roy ale de Bruxelles, tome x. No. 3. p. 207.

BELEMNOTEUTHIS

BELEMNOTEUTHIS[405] (J. C. Pearce). *Lign.* 145.—Within the last few years much additional knowledge has been obtained regarding the nature of the extinct Cephalopoda, by the discovery in the Oxford clay, at Christian Malford, not only of several examples with the receptacle and ink-bag in their natural relative positions, but also with the remains and impressions of the mantle, body, tentacula with their hooks, and the fins!

[405] For the history of this interesting Cephalopod consult Phil. Trans. 1848, and 1850; Ann. Nat. Hist. June 1850; Petrif. p. 459, &c.

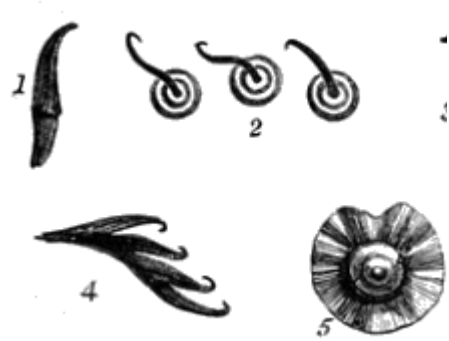


LIGN. 145. BELEMNOTEUTHIS ANTIQUUS.
Oxford Clay. Christian Malford. ($^1/_2$ *nat.*

a. The uncinated arms and tentacles.
b. Remains of the head and eyes.
c. The mantle, with indications of fins.
d. The pigmental sac or ink-bag.
e. The osselet: the transverse lines indicate the septa of the horny sheath or capsule.
f. The solid terminal apex of the osselet.

BELEMNOTEUTHIS ANTIQUUS

Certain argillaceous strata of the Oolite, as well as of the Lias, appear to have been peculiarly favourable for the preservation of the muscular tissue and integuments, and in many specimens of BELEMNOTEUTHIS, the arms, the large sessile eyes, the funnel, a great proportion of the muscular parts of the mantle, remains of the two lateral fins, the ink-bladder and duct, and the phragmocone, are well displayed, as in the beautiful example, *Lign.* 145, for the drawing of which I am indebted to S. P. Woodward, Esq., of the British Museum. (See also *Lond. Geol. Journ.* pl. xv. and xvi.)



LIGN. 146. HORNY RINGS AND HOOKS OF BELEMNOT

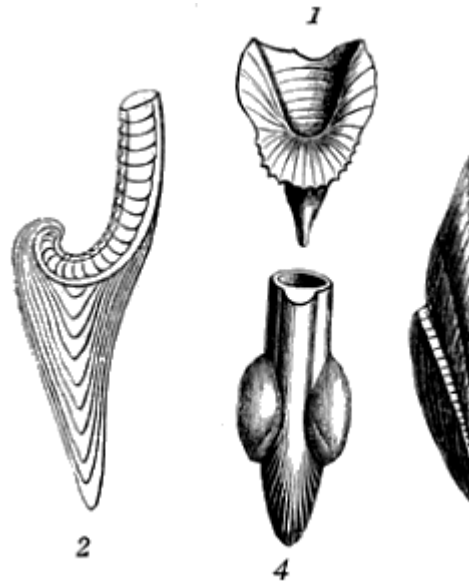
Fig. 1, 3. —Detached hooks (*natural size*).
2.— Three hooks with attached horny rings: from a specimen in th
4.— Part of one of the arms, showing four hooked spines.
5.— Transverse section of the distal part of the osselet of BELEMNC chambered shell in the centre, surrounded by the radiated oss

From the extraordinarily perfect condition of the Belemnoteuthis here figured, which of itself exemplifies the essential parts of its structure, a brief description will suffice. The body is of an elongated form, with a pair of lateral fins, two large sessile eyes, eight uncinated arms, and a pair of armed tentacles; each arm was furnished with from twenty to forty pairs of hooks, placed alternately. Like the Sepia it had a pigmental sac or ink-bag, which is generally found filled with the inspissated secretion. The inferior part of the body is of a conical form, and contains a brown horny osselet, with a siphunculated phragmocone, that terminates in a guard or rostrum of a fibrous structure.

[In the recent genus *Onychoteuthis*, the tentacles alone are armed with claws; *Enoploteuthis* has claws both on the arms and on the tentacles, but the latter are long and feeble, and the hooks are confined to their extremities. The extinct *Belemnoteuthis* (like the *Acanthoteuthis* of Solenhofen, *Lign.* 140) had eight nearly equal arms, the dorsal pair being rather smaller than the rest; each arm was furnished with twenty to forty pairs of hooks, forming a double, alternating row. The tentacles were not longer than the arms, and like them had a double series of hooks extending from their bases to the points. In all essential points of structure, the Belemnoteuthis is most nearly related to the Calamaries (*Teuthidæ*), but, in consequence of the prolongation of its pointed shell posteriorly, the fins become lateral (as

in *Sepiola* and *Sepia*), instead of terminal. Whilst the complicated (chambered) structure of its shell, and the peculiar character of the *tentacles*, show that it must be regarded as a type distinct from and equal in importance to the Calamaries. It cannot be doubted that the *Belemnite* and *Conoteuthis* present similar conditions of the soft parts; and the four genera will form the Family BELEMNITIDÆ. The normal position of these animals in the sea is horizontal, whilst that of the Nautiloid genera must have been vertical, with the head downwards.—*Mr. Woodward.*]

The fossils which have afforded this unexpected and highly interesting illustration of the nature of the extinct animals of this Order have been obtained by closely examining the shales in which they abound, and, before removing the solid osselet, carefully searching the surrounding stone for traces of the more perishable parts. The attention of the collector can scarcely be too often directed to the necessity of examining the surrounding matrix before extricating a fossil from its bed.



LIGN. 147. OSSELETS OF EXTINCT DIBRANCHIATE
(*Woodward, Manual*, p. 76, pl. 1 & 2

Fig. 1.— Belosepia sepioides; $^1/_2$ *nat. Eocene. Bracklesham.*
2.— Spirulirostra Bellardii; $^2/_3$ *nat. Miocene. Turin.*
3.— Beloteuthis subcostata; $^1/_4$ *nat. Lias. Wirtemberg.*
4.— Beloptera belemnitoides; $^2/_3$ *nat. Eocene. Bracklesham.*

BELOPTERA

BELOPTERA. (*Bd.* pl. xliv. *fig.* 15. *Min. Conch.* tab. 591.)—Under this name Mr. Sowerby figures and describes a very curious fossil, from the London Clay at Highgate, which seems to hold an intermediate place between the Cuttle-fish and the Spirulirostra. The guard, which is of an oblong form, with an obtuse apex, has the structure of the osselet of the Sepia, and contains in its upper part a phragmocone, the cells of which are very narrow. In strata of the same age, in France, three species have been discovered by M. Deshayes. I allude to these shells, that the attention of the collector may be directed to

the search after other examples in our tertiary deposits.

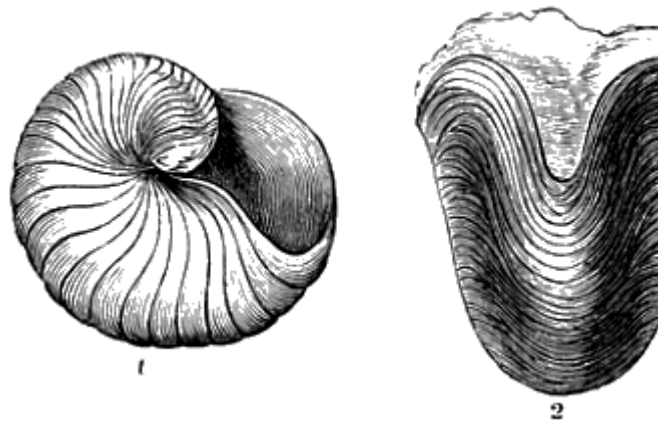
FOSSIL CALAMARY, OR SQUID. GEOTEUTHIS.[406] (*Bd.* pl. xxviii. xxix.)—The common Calamary (*Loligo vulgaris*) is so often seen on our shores, that its general aspect must be familiar to all who frequent the sea-side. In this animal, the osselet, or internal support, is a cartilaginous elongated body, which, from its form, is called Sea-pen (*Bd.* pl. xxviii.); and even this delicate structure is found in a fossil state. In the Lias of Lyme Regis, Miss Mary Aiming first discovered specimens of *Sea-pens* in juxtaposition with the ink-bag, as in the recent Calamary; and subsequently many similar examples have been found, both in England and on the Continent. Dr. Buckland has given some exquisite figures of these fossils; and his collection contains a matchless series of these most interesting organic remains. In some specimens the ink-bag and its tube or duct, but little compressed, are occasionally met with, having a brilliant nacreous pellicle, the remains of the sheath, attached to the surface. The ink-bag is sometimes of considerable magnitude; specimens have been found at Lyme Regis nearly a foot in length.[407] The circumstance of the ink-bags being generally full of sepia admits of the inference (as Dr. Buckland with his wonted acumen remarks), that these individuals died suddenly; for their living analogues reject the inky fluid upon the least approach of danger. The perfect condition of the bag proves also their instantaneous enclosure in the deposit, for the distended membrane would otherwise have burst from decomposition, and the contents would have escaped. The fossil marine reptiles, the Ichthyosauri, &c., with which these fossils are associated, present similar phenomena, as we shall hereafter have

occasion to remark, and strengthen the probability, that swarms of the inhabitants of the Liassic ocean were suddenly destroyed, and imbedded, on the area now occupied by their remains.

[406] Geoteuthis has hooks on its arms; hut, being a Calamary (*Teuthid*), it would probably have unequal arms.—*Mr. Woodward.*

[407] The large ink-bags figured by Dr. Buckland (Br. Tr. vol. i. pp. 372-379, pl. xliv′.) belonged to the great Geoteuthis Bollensis, of Schuble.—*Mr. Woodward.*

In the cream-coloured limestone, of Solenhofen, so rich in organic remains of the highest interest (*Wond.* p. 578), the soft parts of naked Cephalopoda have also been discovered. I have figured, *Lign.* 140, a beautiful specimen obtained by the late Count Münster, which exhibits an imprint of the body, the arms and tentacles being represented by ten double rows of horny hooks, which precisely resemble those of Belemnoteuthis. M. D'Orbigny supposes that the original animal closely resembled a recent decapod called *Enoploteuthis leptura*.



LIGN. 148. FOSSIL SHELLS RELATED TO THE ARGONAUT.[4]

Fig. 1.— BELLEROPHON COSTATUS. *Mt. Limestone. Yorkshire.*
2.— BELLEROPHON BILOBATUS. *Sil. Syst.*

[408] Some naturalists consider the Bellerophon to be allied to the Carinaria (*Heteropod*).

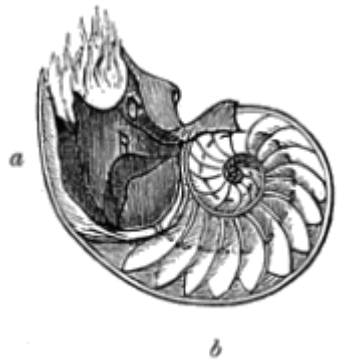
BELLEROPHON.—It has been already stated, that the animals of one genus of the existing dibranchiate Cephalopoda are protected by a thin, flexible, symmetrical, keeled shell, convoluted on a vertical plane, and having but one chamber—this is the *Argonaut*, or *Paper Nautilus*, an inhabitant of the Mediterranean. This animal belongs to the Octopoda, or those which have eight arms; and in one pair of these processes the extremities expand into broad and thin membranes, by which the delicate, elastic, calcareous envelopement, or shell, is secreted. There membranes usually encompass the shell, and meet and overlap each other along its keel; and by them chiefly the shell is retained in its position. When these membranes are withdrawn, or the animal dies, the shell, having no muscular connexion with the

soft parts, readily separates from the body. Hence the doubts so long entertained as to the relation between the animal of the Argonaut and its shell, but which are now set at rest; the observations on the living animal by Madame Tower, and the anatomical demonstrations by M. Sander Rang, having removed the obscurity in which the subject was formerly involved.

In the Silurian, Devonian, and Carboniferous deposits there are several species of a genus of shells, the animals of which are by some considered to have been analogous to the recent Argonaut. It is named Bellerophon. I have figured two species; one from the Mountain Limestone, *Lign.* 148, *fig.* 1; the other from the Silurian System. There are about thirty British species, most of which are of small size; some of them are keeled, others have a slight dorsal depression, as in *fig.* 1. and many have the back rounded, and the sides lobed, as in *Lign.* 148, *fig.* 2.

FOSSIL TETRABRANCHIATE CEPHALOPODA.

I am not aware of the existence of any British fossils analogous to Spirula (*dibranchiate*); for the minute fossil polythalamia, formerly referred to this class, are now known to have belonged to animals possessing an organization altogether different, as we have already explained (see p. 369). I therefore proceed to notice the fossil remains of those *Cephalopoda* which were furnished with an external shell having its cavity divided by cells, which are perforated by a hydraulic tube or siphuncle; and of which group the recent NAUTILUS is the type.



LIGN. 149.

NAUTILUS POMPILIUS IN ITS SHELL.

a. The animal, occupying the last or body chamber of the shell.

b. The shell cut vertically through the middle, and showing the air-chambers and the siphuncle.

The appearance and structure of the recent shell are familiar to every one; a correct knowledge of the nature of the original animal has, however, been obtained but very recently. In its general characters the animal of the Nautilus, which is an inhabitant of the seas of hot climates, resembles the naked Cephalopoda; it possesses four *branchiæ*, or gills, and numerous hollow arms and retractile tentacula. Its head is furnished with a muscular flattened disk, which serves as an operculum to the shell when the animal is retracted. The beaks are horny, and coated at their tips by calcareous matter. It has no ink-bag, and is destitute of fins or other organs for swimming. The body occupies the ample outer cell of the shell, to which it is firmly attached by two lateral muscles; and it has a siphuncle, that passes from the posterior part of the animal through the shelly tube, and by

which communication is maintained with the entire series of cells or chambers. The siphuncle is provided with a small artery and vein, and traverses the entire series of chambers, thus maintaining the vitality of the shell. Mr. Edwards considers that "it may be looked upon as an elongated cæcum, and that it is not under any circumstances used by the animal as a hydrostatic balance."[409]

[409] The reader interested in this subject should consult the *Memoirs* by M. Valenciennes, Mem. de l'Inst.; M. Vander Hoven, in the Proceedings of the Zoological Society; Prof. Owen's *Memoir on the Pearly Nautilus*, Mr. Gray's paper in the An. Nat. Hist., Mr. Edward's Monograph in the Palæont. Soc., and Mr. Woodward's *Manual*.

Upon making a vertical section of the shell, the inner volutions are exposed, and the cavity is seen divided at regular intervals into cells, by smooth, concave, nacreous septa; these vary in number according to the age of the individual; there are about thirty-five in an adult specimen. The partitions are pierced in the *centre* by a shelly tube, which traverses each cell to within a short distance of the next partition; and this tube is rendered a continuous channel in the living animal, by the membranous siphuncle. This series of air-chambers constitutes an apparatus which renders the Nautilus nearly of the same specific gravity as the surrounding water, and enables it to rise to the surface of the sea, or sink to the bottom, by a very small amount of muscular exertion. The Nautilus swims, like the Cuttle-fish, by expelling the water from its respiratory chamber; the walls of which are very thick and powerful muscles.

From this very general description of the only

living representative of the numerous genera of tetrabranchiate Cephalopoda, which swarmed in such prodigious numbers in the ancient seas, we may pass to the consideration of the fossil Nautili, and their related congeners. Our remarks must be limited to the genera that will serve to demonstrate the most important modifications of structure, and explain the nature of the fossil remains of this extensive class of extinct beings.

The genera into which these shells are distributed are founded upon the mode in which the shell is coiled, its form, the character of the partitions or septa, and the situation of the siphuncle. A little reflection will enable the student to understand the principles of this classification. The essential character of all the shells of this class, is to have an external chamber larger than the inner chambers, and which contains the body of the animal; to be divided internally into different compartments, by partitions (concavo-convex, with the concavity outwards); and to have a pipe or tube extending from the outer open chamber to the innermost cell. They are divided into three groups or families.

1. THE NAUTILIDÆ (*Bd.* pl. xxxi.): in these the septa are smooth, or but slightly undulated, and the siphuncle either traverses the centre of the cell-partitions, or is situated towards the inner margin or turn of the spire.

2. THE ORTHOCERATIDÆ (*Lign.* 155): in these the siphuncle is complicated in its structure; it is central or lateral; the septa are smooth. (*Woodward's Man. Moll.* p. 87.)

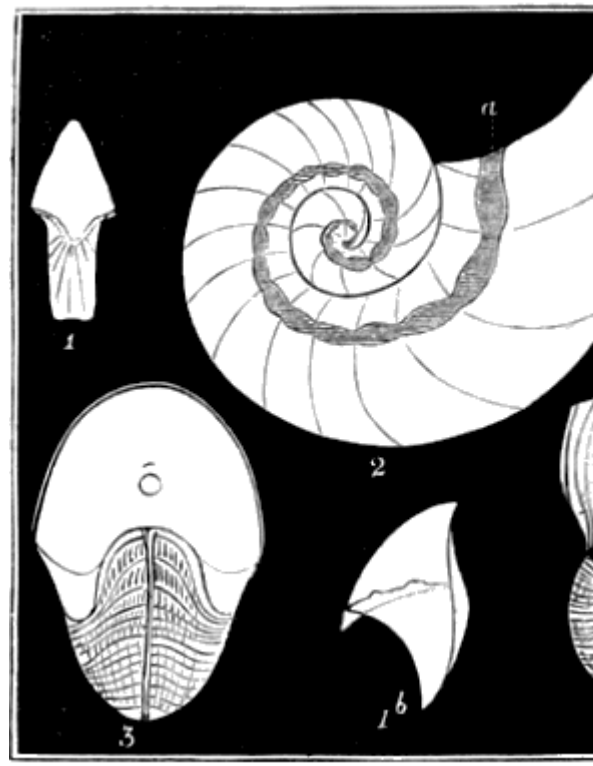
3. THE AMMONITIDÆ (*Bd.* pl. xxxv-xlii.): in these the septa are more or less waved, and their margins

foliated or crenated, that is, indented; and the siphuncle is situated at or near the outer margin.

In the Nautilus, the shell is convoluted on the same plane, in spiral whorls, all of which are contiguous, and the siphuncle is central.

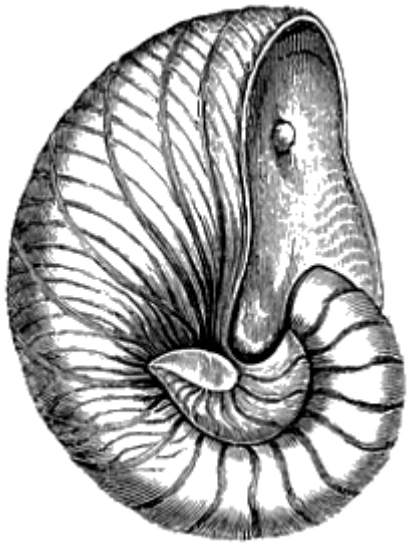
The British strata contain about sixty species of Nautili. The Tertiary formations have yielded five or six; the Cretaceous a like number; the Lias and Oolite ten or eleven; the Carboniferous about thirty species; and the Devonian two species. In the London Clay a large and beautiful species is abundant (*Nautilus imperialis. Min. Conch.* tab. i.), having the shell very commonly entire; but the outer opaque coat frequently flakes off, and exposes the pearly or nacreous internal layer. The septa generally retain their original nacreous structure, and the cells are either occupied by clay or marl, or are partially filled or lined with calcareous spar, brilliant pyrites, or other mineral matter. These Nautili are often found constituting the nuclei of the *septaria*, or clay nodules, with which this deposit abounds.[410] The small species, *N. centralis* (*Ly. fig.* 179), and *Nautilus* (*Aturia*) *ziczac* (*Wond.* p. 247), occur in the same strata. The London Clay of the Isle of Sheppey and of the coasts of Hants and Sussex is productive of these fossils.

[410] Three other well-marked species are figured and described by Mr. Edwards (Monog. Pal. Soc.) from the English eocene strata: viz. *N. Sowerbyi*, *N. urbanus*, and *N. regalis*.



LIGN. 150. FOSSIL NAUTILI. *Chalk ma*

Fig. 1.— BEAK OF A NAUTILUS, (*Rhyncolite.*) Back view.
1*a*.— Anterior view of the same.
1*b*.— Profile of the same.
2.— Vertical section of NAUTILUS PSEUDO-ELEGANS. *Hamsey.*
a. The siphuncle.
3.— Front view of N. DESLONGCHAMPSII. (*M. D'Orbigny.*) *Hamsey.*
3*a*.— Lateral view of the same.

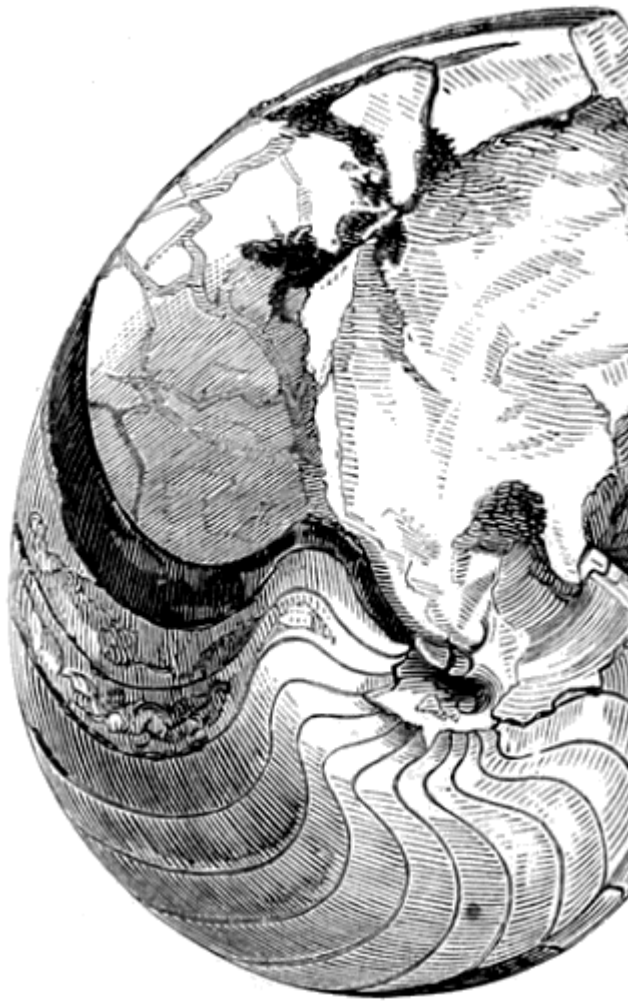


LIGN. 151. NAUTILUS ELEGANS.
Lower Chalk. Lewes. ($^1/_6$ *nat. size*.)

In the White Chalk near Lewes, casts of several very large Nautili have been found; but shells of this genus are more abundant in the lower division, the *Chalk-marl*. A large and beautiful species, *Nautilus elegans* (*Min. Conch.* tab. 116), is not unusual in the marl-pits near Lewes, Clayton, Steyning, &c. and may be considered as characteristic of that portion of the Cretaceous deposits. The first specimen discovered (*Foss. South D.* tab. xx) was from the marl-bank immediately at the foot of the mound on which stands the church of HAMSEY, a little hamlet on the north of Lewes; a spot from which I obtained numerous other cephalopodous shells, at that time unknown as British species. The collocation of fossils at Hamsey is similar to that observable in the quarries at St. Catherine's Mount, near Rouen. These remains only occur as casts, no vestige of the shell remaining; but sections will sometimes show the

situation of the siphon, its tube being filled with a different material from that which occupies the cells. This is exemplified in the section of a smaller species (*N. pseudo-elegans*, *Lign.* 150, *fig.* 2), in which the channel of the siphon is filled with a dark-coloured marl, *a*; the lines formed by the section of the smooth septa are also shown. In the same lignograph, *fig.* 3, a front view and profile of another chalk-marl Nautilite are figured.[411]

[411] The student will find a section of the shell of the recent Nautilus a very instructive object of comparison, in the investigation of the fossils of this family.



LIGN. 152. NAUTILUS SAXBYI. *Lower Greensand.*

In the Chalk, as well as in many other calcareous deposits, the shells of the Nautili, Ammonites, &c. are very rarely preserved; even the internal septa are often dissolved, and the stony casts, moulded in the cells, remain distinct, and readily separate (*Lign.*

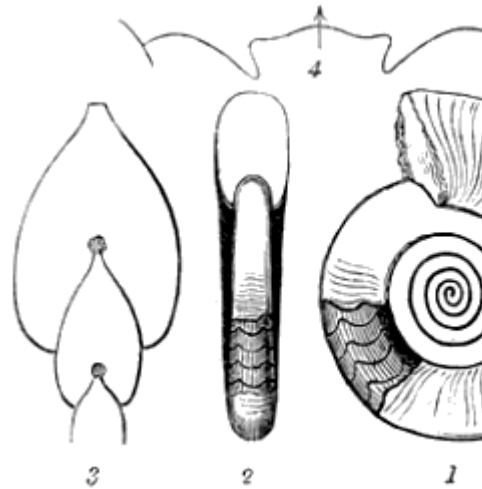
153). An entire series, from the innermost cell to the outer chamber, may sometimes be obtained (in the Coralline Oolite); forming, as it were, a dissected model of the internal structure.[412] The beaks or mandibles are occasionally found fossil (*Lign.* 150, *fig.* 1).

[412] *Bd.* pl. xlii. *fig.* 1: see also plates xxxi. to xliii., for illustrations of Nautilites.



LIGN. 153. CASTS OF CHAMBERS OF NAUTILUS AND A

Fig. 1.— Cast in calcareous spar of a chamber of NAUTILUS. *From the London Clay.*
2.— Cast of a chamber of AMMONITES EXCAVATUS. *From the Coral Rag.*



LIGN. 154. CLYMENIA: $^1/_2$ *nat. Devoni*

Fig. 1.— CLYMENIA SEDGWICKII.
2.— Front view of the same.
3.— Vertical section of C. STRIATA, showing the siphunculus on the inner edg
4.— Suture of C. STRIATA.

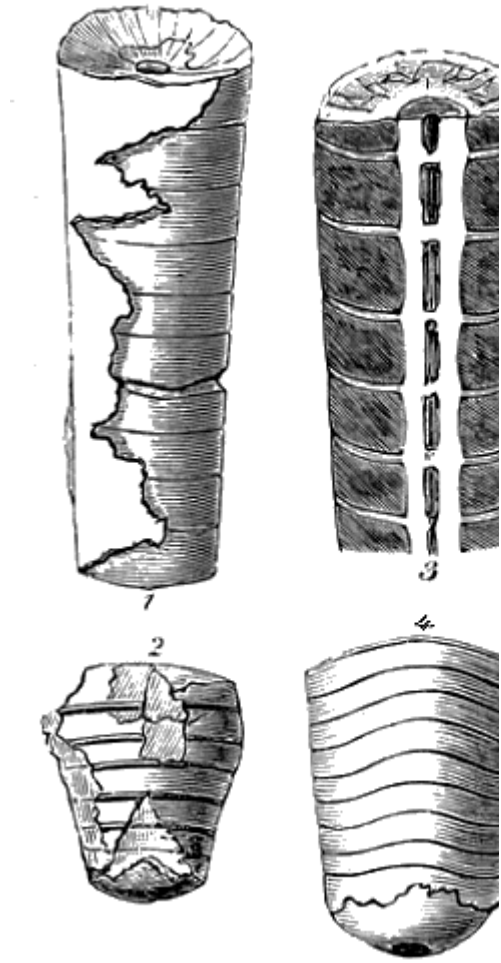
CLYMENIA (*Lign.* 154, *Ly. fig.* 406).—This genus belongs to the Nautilidæ, and is peculiar to the Devonian deposits. It differs from the allied genera in the siphuncle being situated on the inner margin of the septa. The shell is discoidal, and the septa are very slightly lobed. At Elbersreuth, near Bareuth, in the N. E. of Bavaria, the Devonian strata abound in these shells; thirty-five species have been found, the greater number being peculiar to that locality.

In England they are chiefly found at South Petherwin, Cornwall, and in the Devonshire marbles. (*See Phillip's Pal. Foss. Devonshire.*)

ORTHOCERAS.

ORTHOCERAS (straight shell), *Lign.* 155.—The shells of this genus may be described as Nautili uncoiled and extended in a straight line. They are straight, elongated, chambered shells, with smooth and gently undulated septa, which are concave towards the opening or upper part, and have the siphuncle either central, or not far removed from the centre. The *Orthoceratites* more especially belong to the ancient Secondary strata. They first appear in the Silurian, and abound in the Devonian and Carboniferous. They vary in size from a few inches to several feet in length, and eight or nine inches in diameter; and in form, from a slender elongated cone, to a short, massy, almost spherical figure, with a contracted orifice. Some examples have been noticed with upwards of sixty cells. Mr. Sowerby figures and describes *O. giganteum* (*Min. Conch.* tab.

246), from Scotland, as exceeding seven or eight feet in length; and I discovered on the beach at Brighton, where it had probably been brought by some vessel, among ballast, a fine fragment of the same species, indicating as great a magnitude. Several species are figured, *Lign.* 155, to show the structure and appearance of these fossils. The casts of the separate cells are often found. The section, *fig.* 3, from the red marble of Devonshire, beautifully displays the situation of the siphuncle, and the lines of the septa. The shelly siphuncle, which is moniliform (*bead-like*), or dilated at each chamber, is replaced by white spar; and the membranous internal tube is filled with a dark substance, probably molluskite.



LIGN. 155. ORTHOCERATI

Fig. 1.— ORTHOCERAS STRIATUM. (*Min. Conch.*) *Devonian.*

2.— ORTHOCERAS CONICUM. *Whitby. Carboniferous.*

3.— Vertical section of an *Orthoceras*, showing the central siphon *Devonshire.*

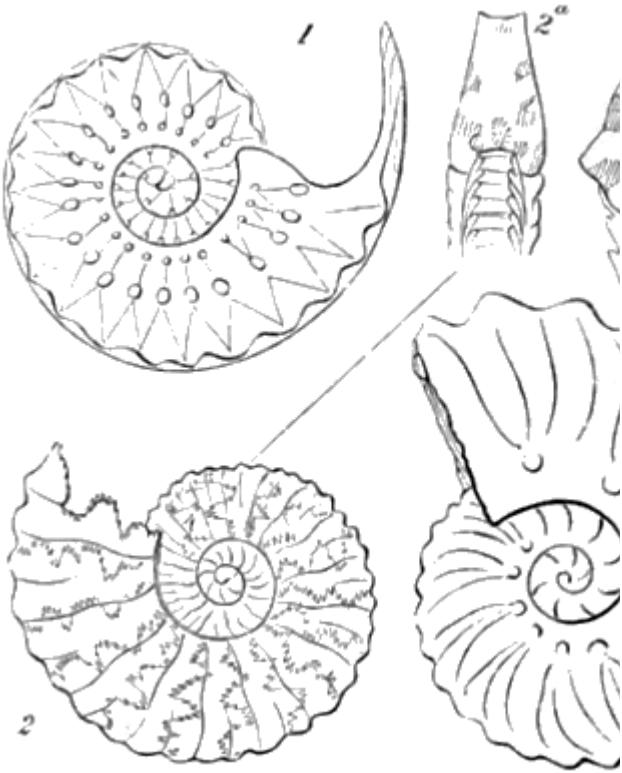
4.— ORTHOCERAS LATERALE. *Carb.* (*Min. Conch.*)

5.— ORTHOCERAS GREGARIUM. (*Munch. Sil. Syst.*)
a. One of the septa.
b. A portion covered at the upper part by the shell.
c. The lower part of the same specimen, displaying the septa

There are some species in which the internal tube, as well as the external, is calcareous, and the two are connected at regular intervals, by radiating, hollow processes. These Orthoceratites have been principally obtained from the Silurian limestones, at Lake Huron; they also occur in Ireland. Mr. Stokes, who first investigated their structure, has arranged them in a distinct genus, with the name of *Actinoceras* (*radiated-horn*).[413]

[413] See Geol. Trans, second series, vol. v. p. 708.

Slabs of reddish Devonian limestone, containing Orthoceratites, may be seen in some of the pavements at Hampton Court, and in Chelsea College, which when wet present excellent sections of the enclosed shells.



LIGN. 156. AMMONITES FROM THE CRETACEOUS FO

Fig. 1.— AMMONITES VARIANS. *Chalk-marl. Hamsey*.
2.— AMMONITES DUFRENOYI.
2*a*.— Shows the keel and septum of the same.
3.— AMMONITES LAUTUS. *Galt. Folkstone.*
3*a*.— Keel and septum of the same.

AMMONITIDÆ.—The AMMONITES, or *Cornua Ammonis* (so called from a supposed resemblance to the horns engraven on the heads of Jupiter Ammon), are among the most common and well-known fossils of the British secondary strata. In some districts, as in Yorkshire and Somersetshire, where the

Ammonites abundantly prevail, they were noticed in very remote times. Local legends, ascribing their origin to swarms of snakes turned into stone by the prayers of some patron saint, are still extant, and are perpetuated by the name of snake-stones, by which these fossils are provincially known. The Lias, near Whitby, in Yorkshire, contains immense numbers of two or three species, one of which (*Am. bifrons*) is figured in *Lign.* 127, *fig.* 7, and another in *Lign.* 157.



LIGN. 157. AMMONITES COMMUNIS.
Lias. Whitby.

The shells comprehended in this family are either spiral, involute, arched, or straight; their septa are deeply lobed, and have the margins foliated. The siphuncle is dorsal, as shown by the notch in the cast, *Lign.* 156, *fig.* 3*a*. Several hundred species have been described; they are divided into genera which are characterized by essential modifications in the direction of the spire, and the inflections of the septa. Thus, in the *Ammonites*, *Lign.* 156, the spire is involute, and all the turns contiguous; in *Crioceras* (*curved-horn*), *Lign.* 160, *fig.* 2, evolute; in *Scaphites*, incurved at both extremities, *Lign.* 162; *Hamites*, bent

like a siphon, or hook, *Lign.* 161, *fig.* 1; *Turrilites*, spiral, round a vertical axis, *Lign.* 163; and in *Baculites*, straight, *Lign.* 161, *fig.* 2. New genera are continually being added, to embrace modifications of structure which appear to be too important for specific distinctions. I will endeavour to render this arrangement more clear to the student by the following definitions.

A straight tube, or horn, of an elongated conical figure, tapering to a point, and having its cavity divided by transverse partitions, which septa are not straight, but undulated, and their edges, which fit into the walls of the tube, deeply wrinkled, and the whole series pierced by a pipe running along near the outer margin, would be the model of the shell termed *Baculites*, *Lign.* 161, *fig.* 2, (*Bd.* pl. xliv. *fig.* 5;) which may be regarded as a straight Ammonite. A similar shell, gently arched or curved, would be a *Toxoceras*, *Lign.* 160, *fig.* 1; the same tube, bent upon itself, like a siphon, into unequal limbs, not contiguous, a *Hamites*, *Lign.* 161 (*Bd.* pl. xliv. *fig.* 10); bent and approximate, or anchylosed in a straight line, *Ptychoceras*, *Lign.* 161, *fig.* 4; partially convoluted, the whorls contiguous, and the free end recurved, *Scaphites*, *Lign.* 162; the same form, but the spire not contiguous, *Ancyloceras*, *Lign.* 160, *fig.* 3; spirally twisted around an axis, *Turrilites*, *Lign.* 163 (*Bd.* pl. xliv. *fig.* 14); coiled, but the turns not touching each other, *Crioceras*, *Lign.* 160, *fig.* 2; lastly, coiled up in the form of a disk, all the turns being contiguous, *Ammonites*.

AMMONITE.

AMMONITES. *Lign.* 156, 157, 158.—Shell discoidal, more or less compressed, whorls of the

spire contiguous, and often visible; septa lobed, their margins deeply sinuated; aperture symmetrical, border or lip thickened, often notched and auriculated. Siphuncle dorsal.

The student will be able readily to distinguish Ammonites from Nautili by attention to the above definition. The situation of the siphuncle, the foliated or wrinkled edges of the septa, as shown in the cast, *Lign.* 156, *fig.* 2; and when these characters are wanting, the arched ribs and elevations, as in *figs.* 1 and 3, will serve as discriminating features. Like the fossil Nautili, the Ammonites most commonly occur as casts, the shell having been dissolved. Sometimes these consist of semi-transparent calcareous spar, the cast of each cell being distinct, but held together by the interlocking of the foliations of the septa; such examples are of great beauty and interest (see *Bd.* pl. xlii. figs. 2, 3); they most frequently occur in the limestones of the Oolite. The siphuncle is often preserved, even in the chalk specimens, in which all traces of the shell are lost. In a large Ammonite from, near Lewes, not only the shelly siphuncle remains, but even the internal membranous tube, converted into dark molluskite. Separate portions of similar siphuncles occur in the chalk, and have been mistaken for tubular shells.



LIGN. 158. AMMONITES JASON.
$^1/_2$ *nat. Oxford Clay, Trowbridge, Wilts.*
a.—Lateral processes of the margins of the aperture

The outer lip, or margin of the aperture, is occasionally found entire. In some species there is a dorsal process, as in a very common Chalk Ammonite (*A. varians*, *Lign.* 156, *fig.* 1), which extends far beyond the margin; in other species, from the Oxford Clay, there are long, narrow, lateral appendages, (*Lign.* 158). In the collection of S. P. Pratt, Esq., there is a small Ammonite, from the Inferior Oolite of Normandy, in which these processes meet over the aperture, leaving only a circular aperture towards the back of the shell (where the siphuncle of the animal would be situated) and a narrow fissure on the side next the involute spire. The specimen is unique, and can scarcely be regarded as a normal form.[414] (Mr. Woodward.)

[414] M. Steenstrup has described a species of *Purpura*, which at the close of its life shuts up the aperture of its shell, with the exception of the respiratory siphon.—*Mr. Woodward.*

From the small size of the cells of the Ammonites, particularly in those species which are of a depressed

or flattened form, it was long doubted whether the outer chamber could have been sufficiently capacious to contain the body of the animal; and it was supposed that these shells were internal, like the recent *Spirula*, or *Crosier*. But Dr. Buckland has clearly demonstrated, that the outer cell of the Ammonite, if restricted in breadth, is sufficiently ample in length to have contained the soft parts of a Cephalopod, equal in magnitude to the largest known specimens, its proportion to the chambered part being as considerable as in the Nautilus. The outer chamber often occupies more than half, and in some instances the entire circumference of the outer whorl (see *Bd.* pl. xxxvi.).

In certain argillaceous deposits, as the Galt, and the clays of the Lias, Ammonites with the shell preserved are abundant; generally the outer opaque layer is wanting, or adheres to the matrix when a specimen is removed, leaving only the internal nacreous, or pearly coat. Folkstone, on the coast of Kent, is celebrated for examples of this kind, which may easily be collected from the Galt, which forms the base of the cliffs, at Eastware Bay. Watchett, in Somersetshire, is equally rich in the pearly Ammonites of the Lias; entire layers of these beautiful organic remains occur in the limestones and in the shale exposed at low water.[415]

[415] A splendid group of these Ammonites may be seen in the Gallery of Fossils at the British Museum.

The shell of the Ammonite is generally thinner and more delicate than that of the Nautilus. However thin these shells may be, they are possessed of great strength of structure. Not only is the shell one continuous *arch*, but it is moreover provided with

transverse arches or corrugated *ribs*, which, like the flutings on metal pencil-cases, and *corrugated sheet-iron*, greatly strengthen the thin material. These ribs are further subdivided, so as to multiply supports as the convexity of the shell enlarges, in a manner somewhat similar to the *groin-work* of vaulted roofs. The spines, tubercles, and bosses, which often arise from the ribs, are so many additions to the strength of the latter. The sides of the shell are also supported by the transverse plates forming the *septa*, or divisions of the chambers, and, as these plates are very sinuous where they meet the sides of the shell, they distribute their support over a considerable portion of the surface.[416] These complicated edges of the *septa* form the delicate and intricate lines of foliation (*sutures*) seen on the casts of Ammonites (*Lign.* 156, *fig.* 2), Baculites (*Lign.* 161, *fig.* 3), Hamites, &c. In some species the shell is thick and dense, as in the Ammonites of the Kimmeridge Clay near Aylesbury, in which one species (*Ammonites biplex*, *Min. Conch.* pl. ccxciii.) in particular abounds, and is very generally invested with the shell, as perfect as if recent. The same Ammonite occurs in the Portland limestone above, in the state of casts, without any vestige of the shell. In some strata the shell is replaced by calcareous spar; in others by silex or flint.[417] In the pyritous clays and shales of the Lias, the shell and all its delicate internal mechanism are coated with or replaced by brilliant sulphuret of iron, forming the most exquisite natural electrotype imaginable. Polished vertical sections of these fossils often exhibit the inner cells filled with transparent white calcareous spar; sometimes with groups of crystals of sulphate of lime. The Ammonites of the Galt, and of the Kimmeridge Clay, are also frequently imbued with the same mineral.

[416] See Bd. i. p. 339, &c.

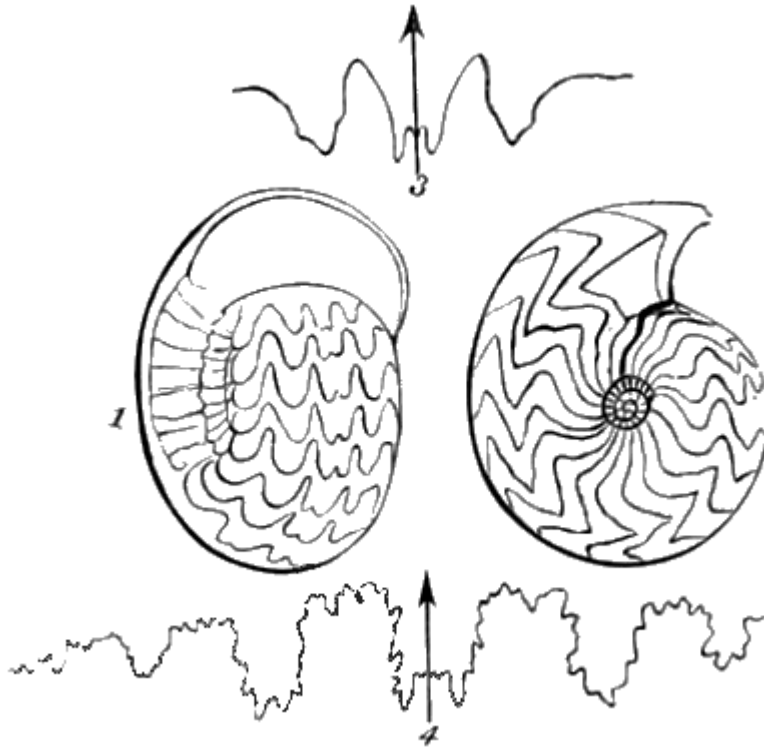
[417] See an admirable figure of a chalcedonic specimen, exhibiting the foliated septa of an Ammonite, *Bd.* pl. xli.

There are about two hundred identified species of Ammonite in the British strata, ranging through all the secondary formations; they have not been found in the Tertiary deposits. They vary in size from half an inch to four feet in diameter.[418]

[418] I have seen imprints of the large Chalk Ammonite, *A. peramplus* (Min. Conch. pl. ccclvii.), on the shore off Rottingdean, and Beachy Head, which indicated even larger proportions.

Certain species are restricted to particular formations, and are therefore oftentimes of essential aid in determining the relations of a deposit; for example, the *Galt* contains several species not found in the upper division of the Chalk; and in the Chalk-maid are species that have not been discovered in other strata. Certain Ammonites of the Lias are peculiar to that formation (as *A. Walcottii*, *Lign.* 127, *fig.* 7, p. 397; and *A. communis*, *Lign.* 157). Ammonites of species allied to those of our Middle and Lower Oolites have been discovered in strata in the Himalaya mountains, several thousand feet above the level of the sea.





nat.
Carb. Syst.

Fig. 1.— GONIATITES LISTERI.
2.— GONIATITES STRIATUS.
3.— Outline of a suture of *Goniatite*.
4.— Outline of a suture of *Ammonites venustus*.
The *Arrows* in figs. 3 and 4 denote the direction of the dorsal line.

GONIATITES. CERATITES. CRIOCERAS.

GONIATITES, *Lign.* 159.—From the numerous family of Ammonites, a separation has been made of a large division, in which the margins of the septa are not deeply notched or foliated, and are destitute of lateral crenatures or denticulations, so that their

outline always presents a continued uninterrupted line. The siphuncle is relatively small. The last or outer cell of the shell extends beyond one turn of the chambered part. The back is occasionally keeled, but in most species is round. In illustration of this genus, which is named *Goniatites*, I have selected two common species (*Lign.* 159) from the Carboniferous limestone, and annexed outlines of a suture (the edge of the septum) of a Goniatite, and of an Ammonite, for comparison. The importance of the separation of this type of Ammonites into a distinct genus, relates to the Goniatites being restricted to some of the older sedimentary strata; for although there are sixty British species, none of them have been observed above the Carboniferous system.[419]

[419] *G. Henslowi*, *G. striatus*, and *G. sphæricus*, are figured in *Bd.* pl. xl.

In CERATITES the sutures are more simple than in the Ammonite, being lobed rather than foliated; and the alternate lobes have their edge crenulated or finely toothed. (*C. nodosus*, *Bd.* pl. xl.) This genus is found in the Muschelkalk and the Keuper formations of Europe and Asia.

Our limits will not permit us to extend this notice of the very numerous family of Ammonitidæ,[420] except to offer a few illustrations of some of the modifications in form to which we have already alluded, and which will assist the student in discriminating these fossil remains.

[420] For further information, Dr. Buckland's Treatise, and the respective articles in the Penny Cyclopædia, may be referred to. Mr. Woodward's Manual should be consulted for the classification of the family, and M. D'Orbigny's Paléontologie Française for the

illustration of species.

CRIOCERAS (*coiled-horn*), *Lign.* 160, *fig.* 2.—This shell differs from the Ammonites in the turns of the spire being distant from each other. The siphuncle is continuous, and the septa are regularly divided into six lobes. I have found specimens of this genus in the Chalk-marl at Hamsey, and in the White Chalk, near Lewes (*Foss. South D.* tab. xxiii. *fig.* 9).



LIGN. 160. SHELLS OF THE FAMILY AMMON
Chalk and Greensand.

Fig. 1.— TOXOCERAS EMERICIANUM, and its septum. *Hamsey.*

2.— CRIOCERAS PUZOSIANUM. (*M. D'Orbigny.*) *Lewes.*
3.— ANCYLOCERAS FURCATUM, and its septum. *France.*

In the genus ANCYLOCERAS (*incurved horn*), *Lign.* 160, *fig.* 3, the whorls are separate, and, at first, spiral (like *Crioceras*); but afterwards the shell is prolonged, and then inflected at the large extremity, like a Scaphite, but the whorls are not contiguous.

A very large species of *Ancyloceras* occurs in the Kentish Rag, near Maidstone, some specimens of which are eighteen inches in length. It is figured and described, by the name of *Scaphites Hillsii*, in the admirable Memoir of Dr. Fitton on the Strata below the Chalk (*Geol. Trans.* vol. iv. pl. xv.); the present genus was not then established. The Shanklin Sand in the Isle of Wight also contains a gigantic species, which is figured and described by Mr. J. D. Sowerby, in the *Geol. Trans.*, as *Scaphites gigas*. *Ancyloceras* occurs also in the Oolite.

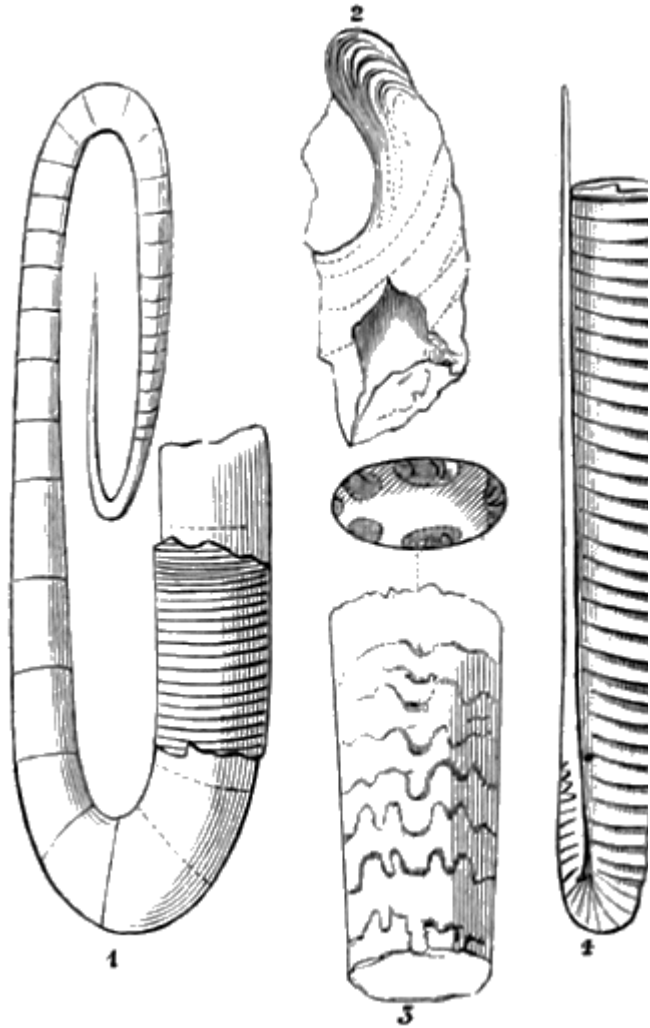
TOXOCERAS. HAMITES.

In TOXOCERAS (*bow-horn*), *Lign.* 160, *fig.* 1, the shell is slightly curved, like a horn. Two or three species of *Toxoceras* are found at Hamsey. The tubercles, in the casts, are the bases of spines, with which the back of the shell was armed, as I have ascertained by examples examined in the rock (see *Foss. South D.* tab. xxiii. *fig.* 1). The specimens figured of the above two genera occur in the *Neocomian* strata of France.

HAMITES (*hook-shaped*). *Lign.* 161, *fig.* 1.—Shell involute, spiral, the turns not contiguous; spire irregular, elliptical; the large end reflected towards the spire. The term *Hamite*, proposed by the late Mr. Parkinson, was formerly given to all the fragments of

sub-cylindrical chambered shells, that were bent, or slightly hooked; and the genera *Ancyloceras*, *Toxoceras*, &c., have been separated from them, by M. D'Orbigny. But from fossils recently obtained from Cretaceous strata in Pondicherry, and other parts of India, it seems probable that these genera will be found to merge into each other; at present it is convenient to keep up the distinction. The Hamites are distinguished from Ancyloceras, which they most resemble, by their elliptical, irregular spire.

PTYCHOCERAS (*folded horn*). *Lign.* 161, *fig.* 4.—This is another genus formed from the Hamites. The shell is bent double in the shape of a siphon, and the limbs are united together. The specimen figured is from the *Neocomian* strata of the Lower Alps.



LIGN. 161. HAMITES, ETC. FROM THE CHALK-MARL.

Fig. 1.— HAMITES CYLINDRACEUS, with part of the shell. (*M. D'Orbigny.*)

3.— BACULITES BACULOIDES, with the mouth entire. *Hamsey.*

3.— Part of the stem of the same species, showing the sinuous septa. A detached septum is figured above.

4.— PTYCHOCERAS EMERICIANUM. (*M. D'Orbigny.*)

BACULITES.

BACULITES (*staff-like*). *Lign.* 161, *figs.* 2 and 3.—This, as the name implies, is a straight, elongated, conical, chambered shell; the upper part is destitute of septa, and probably contained the body of the animal.

In my early researches in the Chalk-marl of Hamsey, I discovered numerous solid, oval, and cylindrical pipes of marl, with scarcely any vestige of organic structure, whose origin it was impossible to determine. At length I found the specimen, *Lign.* 161, *fig.* 2, which showed the perfect aperture of a chambered shell; and afterwards I found portions which displayed the foliated septa. (*Foss. South D.* tab. xxiii. *figs.* 5, 6, 7.) The Baculite, when perfect, is elongated to a point; the septa are very numerous and foliated; the siphuncle is situated on the margin. I have a splendid specimen from the Chalk of France, (collected by *M. Alex. Brongniart*,) which is composed of distinct casts of the cells, held together by the deep inflections of their margins, in the same manner as are the sparry casts of Ammonites, previously described.[421]

[421] See *Bd.* pl. xliv, *fig.* 5.

The Galt, near Folkstone, abounds in fossils of the above genera, principally of *Hamites*; and the nacreous substance of the shells is very often preserved. From the Chalk-marl near Dover, Southbourn, Ringmer, and Southerham, near Lewes, and from Clayton, near Hurstpierpoint, in Sussex, I have obtained examples of several species.

SCAPHITES.

SCAPHITES (*boat-like*). *Lign.* 162.—This name was given by Mr. Parkinson (*Org. Rem.* vol. iii. pl. x. See

Pict. Atlas) to some small chambered shells from the Chalk and Shanklin Sand, of a boat-like form, with the inner whorls coiled up in a spire, and half hidden by the outer chamber, which becomes contracted and recurved on itself, is destitute of septa, and terminates in an oval or transverse mouth. The siphuncle is dorsal. An *Ancyloceras* closely coiled would be a Scaphite. Hamsey marl-pit yielded to my early researches the first Scaphites discovered in the British strata, together with Turrilites, and other cephalopodous shells, previously unknown in England.[422] The Scaphite is of an elliptical form, the spire and the mouth approaching close to each other; the spire occupies about one-half of the shell. Except the thick outer lip or margin of the aperture, which is almost constantly found changed into pyrites, it is rarely that any vestige of the shell remains. The same mineral constitutes casts of the spiral part; and these, when separated from the other portion, might be taken for Ammonites; see *fig.* 2. There are two varieties at Hamsey; one, with the surface covered by fine transverse striæ, which arise singly from the inner margins, and bifurcate on the dorsal part; *fig.* 1. The other is also striated, but has a row of prominent ribs on the inner half of the broad central portion of the shell; *fig.* 4. Scaphites occur in the Upper Green Sand of Dorsetshire, and in the Chalk-marl in several places in England; and at Rouen, in France; and a large species, *S. Cuvieri*, has been found in New Jersey.

[422] Sow. Min. Conch, vol, i. p. 53.





LIGN. 162.

SCAPHITES. *Chalk-marl. Hamsey.*

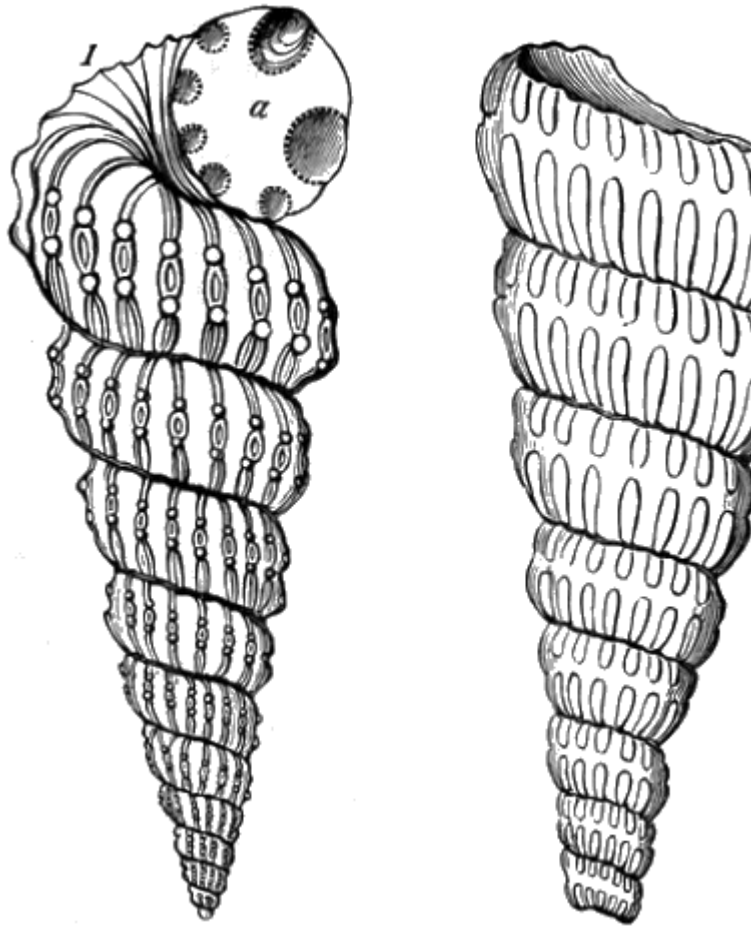
Fig. 1 and 4.—SCAPHITES ÆQUALIS. (*Parkinson.*)

2. —Cast in pyrites of the spiral part of a SCAPHITE.

2*a*.—Front view of the same specimen.

3. —Front view of SCAPHITES ÆQUALIS.





Chalk-marl.

Fig. 1.— TURRILITES CATENATUS. (*M. D'Orbigny.*) *France.*
a.—One of the septa.
2.— TURRILITES COSTATUS. *Hamsey.*

TURRILITES.

TURRILITES. *Lign.* 163.—Shell spiral, more or less conical, coiled obliquely round an axis, and turriculated. Spire sinistral, whorls contiguous, apparent, with a perforated umbilicus. Edges of septa

very sinuous. Siphuncle continuous, situated either on the external convexity, or near the suture at the base of the wreath.

The discovery of three species of these elegant shells rewarded my researches in the little marl-pit at Hamsey, already noticed, and were the first examples of the genus found in England.[423] Like the Ammonites, Scaphites, Hamites, &c. with which they are associated, the TURRILITES of our Chalk-marl seldom possess any traces of their shells. The specimens are solid and tolerably sharp casts, with occasional indications of the septa, and more rarely of the siphunculus. They vary in size from two or three inches to two feet in length; and are frequently more or less elliptical, from compression. The three species which generally occur in the Sussex and Kentish chalk, are *T. costatus*, *Lign.* 163, *fig.* 2; *T. tuberculatus* (*Foss. South D.* pl. xxiv. *fig.* 7), characterised by its four rows of tubercles; and *T. undulatus* (*Foss. South D.* pl. xxiv. *fig.* 8), the wreaths of which are ornamented with plain, slightly undulated, transverse ribs. These are all reversed, or *sinistral* shells; that is, the spire is twisted to the left, the aperture being on the right hand of the observer when the shell is placed on its apex, as in *fig.* 1. Several other species of Turrilites occur in the Chalk of France,[424] one of which, *T. catenatus*, is represented *Lign.* 163, *fig.* 1.

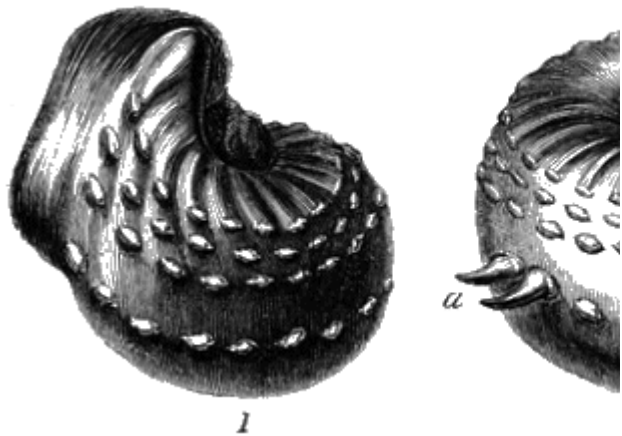
[423] Sow. Min. Conch, tab. xxxvi.

[424] See M. D'Orbigny's Paléontologie Française.

Some of the Turrilites attain a considerable magnitude. The largest found in England is a specimen of *T. tuberculatus* (*Min. Conch.* tab. lxxiv.),

from Middleham, in the parish of Ringmer, near Lewes; when perfect, it must have been full two feet in length: it consists of six wreaths, the siphuncle, in the state of pyrites, appearing in three or four; portions of the nacreous internal layer of the shell remain.[425] In some specimens in my possession, the form of the aperture, and the termination of the columella, are distinctly shown; as in the fine example the last whorl of which is represented in *Lign.* 164.

[425] This specimen is now in the British Museum.



LIGN. 164. TURRILITES TUBERCULATUS, (*Bosc.*) *nat.*

Chalk-marl, Lewes.

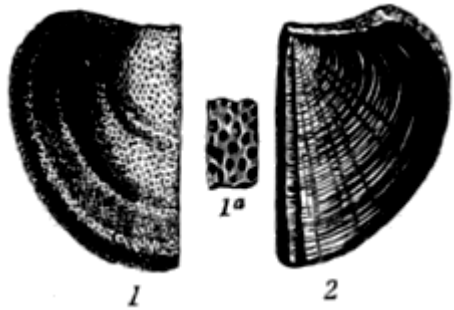
Showing the form of the aperture, and the spinous tube indurated chalk-marl; the last wreath only is figured.

Fig. 1.— Posterior view, exhibiting the expanded outer lip, and the obt
2.— Front view, showing the form of the aperture.
a.—Two tubercles, bearing spines.

The Chalk-marl of Lewes, of the Sussex coast, and of the cliffs near Dover, and the Upper Green Sand of Dorsetshire, have yielded the principal British specimens of this genus. Several species occur in the lower cretaceous strata, at St. Catherine's Mount, near Rouen, associated, as in England, with Scaphites, Hamites, and other allied genera.[426]

[426] See Fossils of the South. Downs for figures of many species of the Cephalopoda of the Sussex Chalk.

APTYCHUS.



LIGN. 165. APTYCHUS SUBLÆVIS. $^1/_2$ *nat.*
Kimmeridge Clay, Hartwell, Bucks.

Fig. 1.— The convex surface.
1*a*.— Magnified section of portion.
2.— The concave side.

APTYCHUS, Meyer. (Trigonellites, *Parkinson*.) *Lign.* 165.—Associated with the remains of Ammonites in several localities, are found flattened triangular bodies, from less than an inch to an inch and a half in diameter, the nature of which is still somewhat problematical. A good figure is given by Mr. Parkinson of one species (*Org. Rem.* vol. iii. pl. xiii. figs. 9, 10, 12. See *Pict. Atlas*), with the name

Trigonellites latus. These bodies frequently occur in pairs and in apposition, as in the specimen figured in *Lign.* 165. Their structure is cellular; one surface is slightly concave and striated, and the other covered with minute circular pores. Altogether their appearance is that of bodies enclosed in vascular integuments. It is supposed that they are the opercula of Ammonites. These fossils are commonly found in the last or body chamber of Ammonites, in the Oxford Clay, near Chippenham, the Coral Oolite of Malton, the Lias of Lyme Regis, and the lithographic limestone of Solenhofen. M. Ewald states that they may be found in the Chalk *Scaphites* by making a longitudinal section of the body chamber: but I have not succeeded in detecting them in the examples from the chalk-marl which I have broken up for that purpose. As these bodies (alluded to by authors as *Trigonellites*, *Aptychus*, *Munsteria*, &c.) will probably come under the observation of the collector, especially among the fossils of the Kimmeridge Clay, these remarks are introduced to suggest diligent research, in the hope that the origin of these fossils may at length be discovered.

DISTRIBUTION OF FOSSIL CEPHALOPODA.

GEOLOGICAL DISTRIBUTION OF FOSSIL CEPHALOPODA.—Even from this short review of the principal types of the fossil Cephalopoda, the great interest which attaches to the study of this class of organic remains is strikingly demonstrated. Their geological distribution is alike replete with phenomena of an important character. In the Lower Palæozoic (Lower and Upper Silurian) strata, the chambered mollusks belong (with a very few doubtful exceptions) to the Nautilidæ, namely,

Nautilus, Lituites, Cyrtoceras, Orthoceras, &c. The Devonian and Carboniferous systems contain Nautilus, Clymenia, Gyroceras, Cyrtoceras, and Orthoceras, together with a peculiar group of Ammonitidæ, the *Goniatites*. The Trias in general is extremely poor in Cephalopoda; the Permian group affording but two species of Nautilus, and the Muschelkalk two other species: but, in addition to these, the Muschelkalk contains Ceratites, which is a genus peculiar to the Triassic group, and chiefly abounds in the St. Cassian beds (in the Austrian Alps), where it is accompanied by Nautilus, Orthoceras, Ammonites, and Goniatites. In the Lias and Oolite Nautili abound, and we meet for the first time with Belemnites. The same families, viz. Nautilidæ, Ammonitidæ, and Belemnitidæ, prevail throughout the Cretaceous strata. The Tertiary formations contain a few Nautilidæ only; no vestiges of the Ammonitidæ and true Belemnitidæ, which, as we have seen, swarmed in the ancient seas, are perceptible, while in the existing oceans, the *Nautilus* and *Spirula* are the sole representatives of the numerous shell-bearing cephalopoda of the ancient geological eras. Thus, the Nautilidæ extend from the oldest to the newest fossiliferous strata, the genus being still in existence: the Ammonitidæ, on the other hand, though less ancient in origin, do not pass beyond the limits of the cretaceous epoch.

In the following tabular arrangement these facts are placed in a more distinct point of view:—

Tabular View of the Distribution of Cephalopoda through the Geological Epochs.

Existing Genera	Argonauta. Octopus, &c.	Octopoda.	Dı

	Loligo, Cranchia. Sepiola, Onychoteuthis, &c.	(*Teuthidæ*	Decapoda.
	Sepia (*Sepiadæ*).		
	Spirula.		
	Nautilus (*Nautilidæ*).	TETRABRANCHIATA.	
General fossil in the Tertiary Formations	SEPIADÆ	Sepia, Spirulirostra, Belopt Belemnosis.	
	NAUTILIDÆ	Nautilus and Aturia	
Cretaceous Deposits	BELEMNITIDÆ	Belemnites, Belemnitella, a Conoteuthis.	
	NAUTILIDÆ	Nautilus.	
	AMMONITIDÆ	Ammonites, Crioceras, Scaj Ancyloceras, Toxoceras, Ha Ptychoceras, Helicoceras, T Baculites.	
Oolite and Lias	SEPIADÆ	Sepia.	
	TEUTHIDÆ	Teudopsis, Beloteuthis, Ged Leptoteuthis, Ommastrephe	
	BELEMNITIDÆ	Belemnites. Acanthoteuthis Belemnoteuthis.	
	NAUTILIDÆ	Nautilus.	
	AMMONITIDÆ	Ammonites, Ancyloceras.	
Trias	NAUTILIDÆ	Nautilus.	

	AMMONITIDÆ[427]	Ammonites, Goniatites, and
Carboniferous System	NAUTILIDÆ	Nautilus, Gyroceras, Cyrtoc Gomphoceras, and Orthoce Actinoceras, &c.
	AMMONITIDÆ	Goniatites.
Devonian System	NAUTILIDÆ	Nautilus, Clymenia, Cyrtoc Phragmoceras, Gomphocer Orthoceras, Actinoceras, &
	AMMONITIDÆ	Goniatites.
Upper and Lower Silurian Systems	NAUTILIDÆ	Nautilus, Lituites, Gyrocera Cyrtoceras, Phragmoceras, Gomphoceras, Oncoceras, Orthoceras, Actinoceras, &

[427] The Ammonitidæ are from the St. Cassian beds only.

With regard to the zoological affinities between the living and extinct species of testaceous Cephalopoda, Dr. Buckland remarks, "that they are all connected by one plan of organization; each forming a link in the common chain which unites the existing species with those that prevailed among the earliest conditions of life upon our globe; and all attesting the identity of the design that has effected so many similar ends, through such a variety of instruments, the principle of whose construction is, in every species, fundamentally the same.

"Throughout the various living and extinct genera of these beings, the use of the air-chambers and siphuncle of their shells, to adjust the specific gravity of the animals in rising and sinking, appears to have

been identical. The addition of a new transverse plate within the coiled shell added a new air-chamber, larger than the preceding one, to counterbalance the increase of weight that attended the growth of the shell and body of these animals." (*Bd.* p. 380.)

The occurrence of the Nautilus, and its congeners, among the earliest traces of the animal kingdom, and their continuance throughout the immense periods during which the family of Ammonitidæ was created, flourished, and became extinct, and the existence of species of the same genus at the present time, are facts too remarkable to have escaped the notice even of those who are not professed cultivators of geological science; and I am induced to quote the following beautiful lines, by Mrs. Howitt, to impress this interesting phenomenon more strongly on the mind of the youthful reader.[428]

[428] The poetess has, however, not been literally accurate regarding the Nautilus and its habits, nor as to the formation of stratified rocks, but has given a romantic rather than a scientifically correct view of this interesting Cephalopod, and of the disappearance of its congener. The young reader must, therefore, remember that the Nautilus sometimes *floats*, but *never sails*; and that the whole race of Ammonites *died out* in course of time, and were not annihilated by convulsive movements of earth and sea.

"TO THE NAUTILUS.

"Thou didst laugh at sun and
breeze,
In the new created seas;

Thou wast with the reptile
broods
In the old sea solitudes,
Sailing in the new-made
light,
With the curl'd-up
Ammonite.
Thou surviv'dst the awful
shock,
Which turn'd the ocean bed
to rock,
And changed its myriad
living swarms,
To the marble's veined forms.

"Thou wast there, thy little
boat,
Airy voyager! kept afloat,
O'er the waters wild and
dismal,
O'er the yawning gulfs
abysmal;
Amid wreck and overturning,
Rock-imbedding, heaving,
burning,
Mid the tumult and the stir;
Thou, most ancient mariner,
In that pearly boat of thine,
Sail'dst upon the troubled
brine."

ON COLLECTING FOSSIL CEPHALOPODA.

ON THE COLLECTION OF BRITISH FOSSIL CEPHALOPODA.—In the Tertiary formations of England, the remains of but seven species of Nautilus

(comprising Aturia) have been noticed; the large species (*N. imperialis*) is the most common. These are generally in a good state of preservation, and only require the careful removal of the surrounding clay or marl. When pyrites largely enters into the composition of the specimens, the investing matrix can seldom be effectually cleared off: if the outer surface, and general form, be not well displayed, breaking the specimen will often expose the inner cells, with the siphunculus, in a beautiful state. The *Nautilus imperialis* is occasionally imbedded in the septaria of the Isle of Sheppey, and of Bognor and Bracklesham, on the Sussex coast. Sections of such examples, in the vertical direction of the enclosed shell, afford, when polished, very brilliant and interesting fossils; the septa and the shelly tube of the siphunculus are often preserved.

The Cephalopods of the Cretaceous formation, with the exception of those in the argillaceous strata of the Galt, are generally destitute of their shells, and only occur in the state of casts; and the Chalk Nautili are liable to separate at the divisions of the septa, and an entire series of the casts of the chambers may sometimes be obtained, so as to display the entire form of the original shell. The Ammonites of the White Chalk, although mere casts, yet retain their configuration, the foliated margins of the septa dove-tailing them together. I have already mentioned that search should be made along the back of these specimens for the siphuncle, the shelly tube of which is sometimes well defined. In the Chalk-marl the casts are sharper than in the White Chalk, and generally of a deep ochreous colour, with the lines of the sinuous septa clearly defined. The siphuncle is occasionally preserved in pyrites, in the Ammonites, Nautili, Turrilites, and Scaphites; and the outer lip or

margin of the mouth, or aperture, of the latter, and of the Ammonites, is frequently replaced by the same mineral.

The Ammonites, Hamites, &c. of the Galt have their pearly coat remaining, but this investment is extremely delicate; and although when first removed from the marl it is beautifully iridescent, the vivid hues are very evanescent, and the shell becomes opaque and of a light fawn colour. Very commonly the shell flakes off, wholly or in part, leaving a cast of indurated pyritous marl. I have preserved specimens with the shell many years, by applying a thin coat of mastic varnish with a soft camel-hair pencil, before the marl had become dry, and while the shells were entire. The Galt Ammonites, like the Nautili of the London Clay, are often invested with pyrites, and have the inner cells and siphuncle well preserved.

The argillaceous strata of the Oolite and Lias contain Ammonites, &c. in much the same state of mineralization as those of the Galt. The Kimmeridge Clay, in some localities, particularly around Aylesbury (and especially at Hartwell Park, the seat of Dr. Lee), abounds in Ammonites with the shell as perfect and beautiful as if just dredged up from the sea. But, like the fossils of the Galt, few of the specimens are durable; although in many examples the shell may be preserved by the application of mastic varnish. The most common Ammonite at Hartwell is *A. biplex* (*Sow. Min. Conch.*), which varies from three inches to one foot in diameter; the surface is covered by very strong ribs that encircle the whorls. The shell is thick, and composed of several laminæ.[429]

> [429] According to the observations of my son, the outer layers, when highly magnified, present an appearance of opaque areolæ, with irregular radiating fibres; the inner laminæ are covered with minute pores, apparently the orifices of tubuli, some of which are arranged singly in crescents, and others are confluent, like short strands of beads. I mention the fact to direct attention to the microscopic examination of the structure of these splendid fossils.

The sparry casts of the separate cells of Ammonites which occur in some of the calcareous beds of the Oolite, will not fail to be observed by the collector. It is convenient to preserve such specimens either on a tray or board, in which a groove is made for their reception, or in a mould of gutta percha.

In collecting *Belemnitidæ*, the caution already given, of examining the surrounding clay or marl, must not be disregarded; the student should remember, that traces of the soft parts of the animals, even of mere impressions of the body and head, with the tentacula and their acetabula, or little horny rings and hooks, are more important than the most splendid examples of the spathose durable osselet. The guards should be selected with especial reference to their containing the phragmocone (see *Lign.* 141, *fig.* 2), or chambered conical shell, in the alveolus or cavity of the upper and larger end. An apparently worthless fragment of a Belemnite will often be found to possess this part of the structure, as in the example figured, which, until fractured longitudinally, had been thrown by among useless duplicates. The search for the remains of the fossil naked Cephalopoda, as the Teuthidæ and Sepiadæ, and their ink-bags, must be made in a like cautious

manner. In the Lias marls, the ink-bag and its duct is often found partially covered by a pellicle of nacre, without any trace of the other parts of the animal. A reference to Dr. Buckland's plates (*Bd.* pl. xxviii. xxix) will familiarize the student with the appearance of these fossil remains.

A FEW BRITISH LOCALITIES OF FOSSIL CEPHALOPODA.

Abingdon, Berks. Ammonites, fine casts in spar and limestone; Middle Oolite.

Aylesbury, Bucks. Ammonites, several species; splendid examples of *A. biplex*, with the shell remaining, in the Kimmeridge Clay.

Aymestry. Upper Silurian; Gomphoceras, Orthoceras, &c.

Bath. Fine Ammonites in the Oolite.

Beachy Head. Along the shore, gigantic Ammonites in the Chalk, at low-water.

Benson, Oxfordshire. Fine Hamites, in Chalk-marl.

Blackdown, Devonshire. Beautiful siliceous casts of Ammonites; Green Sand.

Bognor, Sussex. Nautili, in the Tertiary Clays and sandy Limestones; also, along the neighbouring coast, in Septaria.

Bolland, Yorkshire. Mountain Limestone; Goniatites.

Boreham, near Warminster, Wilts. Nautili and

Ammonites in Green Sand.

Bracklesham Bay, Sussex. Nautili in Tertiary Clay.

Bridport, Dorset. Ammonites; Inferior Oolite.

Brighton. In the Chalk, Ammonites, Belemnitellæ, &c.

Brill, Lucks. Ammonites, as at Aylesbury.

Buxton, Derbyshire. Goniatites; Mountain Limestone.

Charmouth, Dorsetshire. Ammonites, Belemnites, &c.; Lias.

Cheltenham. Ammonites, Belemnites, Nautili, &c. in abundance; Inferior Oolite and Lias.

Chicksgrove, Tisbury, Wilts. Ammonites, several species; some chalcedonic; Upper Oolite.

Christian Malford, near Chippenham. In Oxford Clay, Belemnites, Belemnoteuthis, and Geoteuthis; *very fine*.

Clayton, near Hurstpierpoint, Sussex. In Chalk-marl, Ammonites, Nautili, and Turrilites; very fine specimens.

Closeburn, Dumfriesshire. Orthocerata, large species; Silurian.

Comb Down, near Bath. Ammonites and Nautili; Oolite.

Connaught, Ireland. Goniatites; Mountain Limestone.

Cork. Orthocerata; Mountain Limestone.

Crockerton, near Warminster. Ammonites, in Galt.

Dover. In the cliffs, and along the shore, in Chalk and

Chalk-marl, Turrilites, Ammonites, Nautili, &c.

Dowlands, near Lyme. Fine Ammonites, &c. in the Lias.

Dundry, near Bristol. Ammonites, &c. Inferior Oolite.

Earlstoke, Wilts. Hamites, Ammonites, &c. in Green Sand.

Faringdon, Berks. In the gravel-pits, Nautili, Ammonites, &c. In the Coral Rag, beautiful casts in limestone and spar of Ammonites, Belemnites, &c.

Folkstone, Kent. In the Galt, at Eastware Bay, in the cliff, and along the shore at low-water, Belemnites, Hamites, Ammonites, &c. in profusion.

Hamsey, near Lewes, Sussex. Chalk-marl; Turrilites, Scaphites, Hamites, Baculites, Crioceratites, Ammonites, Nautili; Belemnites, very rare.

Hartwell, Bucks, seat of Dr. Lee. Splendid Ammonites, with their shells, in Kimmeridge Clay.

Heytesbury, Wilts. Nautilus elegans, and other Chalk-marl Cephalopoda.

Horncastle. Very fine Ammonites.

Hythe, Kent. In Green Sand, large Ancyloceratites, Ammonites, &c.

Ilminster, Somerset. Upper Lias, Ammonites; Marlstone, Belemnites and Ammonites.

Kelloway. Many beautiful Ammonites, &c.; Middle Oolite.

Keynsham, near Bristol. Splendid Nautili and Ammonites; the large *A. giganteus*, two or three feet in diameter; and specimens with the chamber filled with spar, of surpassing beauty; Lias.

Lewes, Sussex. Nautili, Ammonites, &c. in the Chalk and Marl quarries of the vicinity.

London. Tertiary strata in the vicinity. Highgate Hill, fine Nautili, and Aturia ziczac, Beloptera, &c.

Ludlow. Upper Silurian; Lituites, Orthoceras, Phragmoceras, &c.

Lyme Regis, Dorsetshire. Ammonites, Nautili, Belemnites, Sepiæ, &c. in profusion in the Lias; and Scaphites and Turrilites in the Chalk.

Lympne, Kent. Ammonites, Ancyloceratites, &c. in Green Sand.

Maidstone, Kent. Ammonites, of large size, in Shanklin Sand.

Malton. Ammonites, several large species. Lower Oolite.

Marsham, near Abingdon. Ammonites; Oolite.

Marston Magna, near Ilchester. *Ammonite-marble*; Lias.

Newton Bushel, Devonshire. Nautilus, Orthoceras, Cyrtoceras, Goniatites, &c. in the Devonian rocks.

Norwich. In Chalk, Belemnites in profusion; Ammonites, &c.

Nutfield, Surrey. Fuller's-earth pits: beautiful Nautili

(*N. undulatus*, and *A. Nutfieldiensis*), and Ammonites.

Offham, near Lewes. In the Chalk-pits, large Ammonites; Chalk-marl in a pit, on the right-hand side of the road, a quarter of a mile north of the village, Hamites, Turrilites, Scaphites, Nautili, rare species of Ammonites, &c.

Oxford. Quarries in the vicinity, Ammonites, Belemnites, &c.

Petherwin, Cornwall. Clymenia, Goniatites, Orthoceras, &c. in the Upper Devonian rocks.

Portland. Upper Oolite; gigantic Ammonites.

Roak, near Benson, Oxfordshire. In Chalk-marl, Hamites, Ammonites, &c.

Scarborough. Kelloway Rock; Ammonites, &c.

Scarlet, Isle of Man. Nautili, &c.; Mountain Limestone.

Settle, Yorkshire. Goniatites; Mountain Limestone.

Sherbourn, Somersetshire. *Ammonite-marble*; Lias.

Southerham, near Lewes. In the Chalk-pits, large Ammonites; in the Marl, Nautili, Ammonites, Turrilites, &c.

South Petherton, Somerset. Marlstone; Belemnites and Ammonites in profusion.

Speeton, Yorkshire. Galt; Crioceras, Ancyloceras, &c.

Steyning, Sussex. In Chalk-marl near the town, Belemnites (*B. lanceolatus*), Nautili, Ammonites, &c.

Swindon, Wilts. In the Portland-stone quarries, Ammonites, in abundance; principally casts of *A. biplex*, and *A. triplicate*. In the Kimmeridge Clay in the vicinity, Ammonites with the shell preserved.

Tisbury, Wilts. In Portland-stone, fine Ammonites, often chalcedonic (see *Bd.* pl. xli.).

Trowbridge, Wilts. In Oxford Clay, Ammonites, Belemnites, &c. were obtained in great numbers during the railway cuttings.

Watchett, Somersetshire. Ink-bags of Sepiadæ, &c.; splendid Ammonites; Lias.

Whitby, Yorkshire. Ammonites, Belemnites, &c. in abundance; Nautili, &c.; Lias.

Yeovil, Somersetshire. Nautili and Ammonites; Inferior Oolite.

CHAPTER XIII.

FOSSIL ARTICULATA; COMPRISING THE ANNELIDES, CIRRIPEDES, CRUSTACEANS, AND INSECTS.

THE division of the Animal Kingdom termed *Articulata*, embraces, as the name implies, those animals which have a *jointed* body, generally possessing an external-jointed skeleton, composed of

segments more or less annular and distinct. It comprehends six classes; namely—

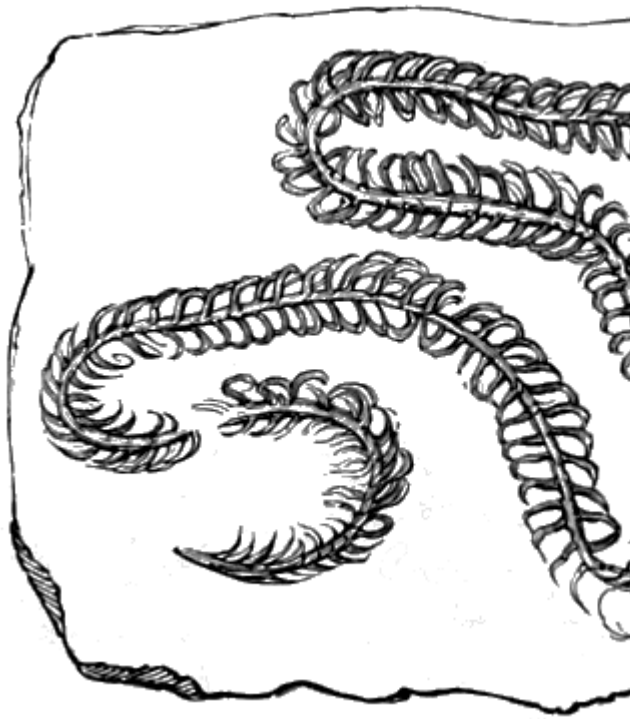
1. ANNELATA, or ANNELIDA; *i. e.* formed of rings; comprising the Red-blooded Worms.
2. MYRIAPODA; as the Centipede.
3. CIRRIPEDIA; *i. e.* having curled-feet; as the *Balanus* and *Lepas* (Barnacle).
4. CRUSTACEA; as the Crab, Lobster, and Water Flea.
5. ARACHNIDA; Mites, Scorpions, and Spiders.
6. INSECTA, or Insects.

Of the first, third, fourth, and sixth of these classes, remains occur in the British strata, some being referable to existing, but the greater part to extinct species and genera. I propose to describe a few illustrative examples of the fossils belonging to each Class.

ANNELIDA.—This name is given to a class of *Articulata*, consisting of worms, whose bodies are formed of little rings, or annular segments, and which have red blood; as the Leech, Earth-worm, &c. Some are naked (the *Dorsibranchiata* and *Abranchiata*), and move with great celerity; as the *Gordius*, or Hair-worm, and the *Nereis*, so frequent on the sands of the sea-shore. Others have shelly coverings (the *Tubicolæ*), as the *Serpula*, and are sedentary, or fixed to other bodies. The soft bodies of certain species are protected by a coat, or tube, formed by the agglutination of sand, or other foreign substances, as in the *Sabella* (*Lign.* 123, *fig.* 6, p. 385).

The fossil remains of the testaceous Annelides are very abundant in some deposits; and even the naked, flexible, soft-bodied forms have left proofs of their

existence in some of the most ancient sedimentary rocks. Traces of nine species, belonging to five genera of these soft, naked Annelides, have been observed in the Silurian strata of Britain.



LIGN. 166. FOSSIL IMPRESSION OF NEREIS. *Siluri*
(*Drawn by Miss Murray.*)
NEREITES CAMBRENSIS. (*Murch. Sil. Syst.*) *Lla*

FOSSIL NEREIS. SERPULA. CIRRIPEDIA.

The first notice of these remarkable remains appeared in the invaluable work of Sir R. I. Murchison on the Silurian System.[430] The living species of NEREIS (*Dorsibranchiate*) are free, agile animals, having a distinct head, provided with either eyes or antennæ, or both; they are the most perfect in structure of all the Annelides. The fossil represented in *Lign.* 166 indicates that the body of the original was composed of about one hundred and twenty segments; the feet were half the length of a

segment of the body; and the *cirri* of the feet were longer than such segment. A more slender species, (*Nereites Sedgwickii*,) the body consisting of a greater number of segments, is also figured and described by Sir It. I. Murchison. Other impressions in the same stone resemble those that would be produced by smooth Annelides (*Abranchiate*) related to the *Gordius*, or Hair-worm.[431]

[430] Murch. Sil. Syst. p. 699.

[431] Murch. Sil. Syst. p. 701, pl. xxvii.; and M'Coy, Cambridge Pal. Foss. p. 128, pl. 1. D.

SERPULA.—The animals of this genus are sedentary or fixed, having calcareous tubes or shells, but to which they have no muscular attachment. They have plumose or arborescent gills affixed to the anterior part of the body. The shelly tubes of the *Serpulæ* are constantly seen on our coasts, encrusting stones, rocks, shells, sea-weeds, &c., and may be known by their contorted or twisted forms. There are a hundred and fifty British fossil Tubicolæ. A large species has been discovered in the Silurian rocks (*Murch. Sil. Syst.* pl. v. *fig.* 1); several occur in the Carboniferous, Oolitic, and Cretaceous, and many in the Tertiary strata. In the Upper Chalk, a smooth tortuous *Serpula* is not uncommon (*S. plexus*, *Min. Conch*, tab. 598); it occurs in masses several inches long. But I have not observed either in the Chalk, or in any other deposit, indications of banks of *Serpulidæ*, like those now in progress off the Bermudas, and which resemble coral-reefs in their solidity and extent.

CIRRIPEDIA.—These animals have a soft body, enveloped in a membrane, which in some genera is

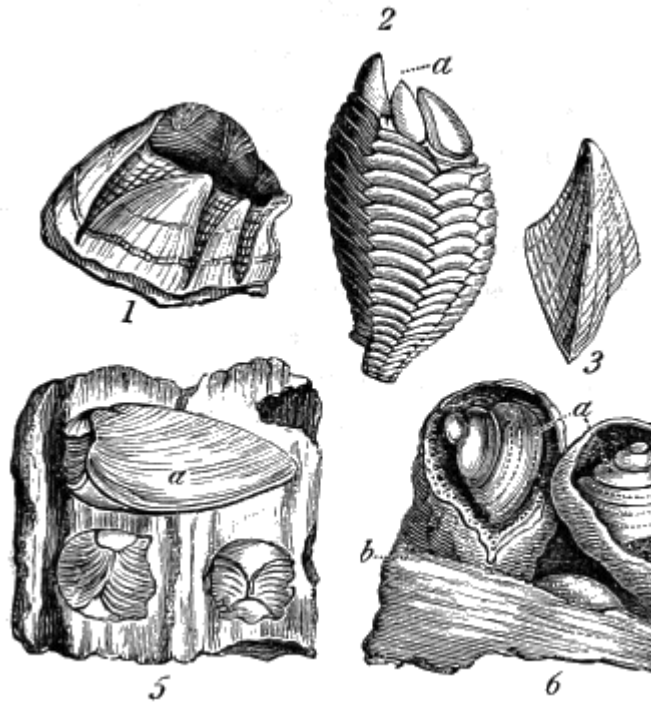
protected only by a horny sheath, but in general is enclosed in a shell composed of various calcareous plates.[432] They have six pairs of feet, terminating in long, slender, articulated tentacula, furnished with cilia, and coiled up like tendrils at the extremities near the mouth. The name of the class (*curled-feet*) has originated from the appearance presented by the curled tentacula when projecting from the oval aperture of the shell. The testaceous Cirripedes or *Barnacles* are divided into two groups; namely, the *sessile*, or those which in their adult state are fixed by the base to other bodies, (BALANIDÆ,) as the Acorn-shell, or *Balanus*; and the *pedunculated*, which have a process of attachment, peduncle or stem, (LEPADIDÆ,) as the Duck-barnacle, or *Lepas*. But the young animals of these genera have powerful locomotive organs, and are capable of swimming, by sudden jerks, like some of the crustaceans, to which class, especially in this stage of their existence, they closely approach. But after a short period of freedom, the young Cirripede fixes itself in some locality suitable to its economy, and rapidly undergoes the transformation which results in the sessile adult Barnacle or Lepas.[433]

[432] Until within the last few years the valves of the *Cirripedes* have been generally figured and described in works on Conchology as being allied to the *Mollusca*.

[433] See Mr. C. Darwin's admirable Monograph on the Cirripedia, published by the Ray Society, 1851.

BALANUS. *Lign. 167, fig. 1.*—The shell of this sessile Cirripede is of a conical shape and cellular structure. It consists of a thick plate at the base, or place of attachment; of a series of plates, united by

sutures, arranged around the body of the animal, and called *parietal* valves; and of pieces termed *opercular* valves, by which the aperture is closed. The shell of the *Balanus*, so common on the rocks of our shores, and on every pile and pier within reach of the tide, is composed of six parietal, and four opercular valves. The fossil *Balanus*, *Lign.* 167. *fig.* 1, is from the CRAG, a formation containing many shells of this genus: in this example, the six parietal plates of the conical shell only remain, but in some specimens the opercular valves are also preserved. There are about twelve species of Balanus in the Crag; but none have been found either in the older Tertiary, or in the secondary rocks of England. In the newer *Pliocene* deposits of the Sub-Apennines, and of North America, several species are common.



LIGN. 167. FOSSIL BARNACLES AND PHOLADES.

Fig. 1.— BALANUS TESSELATUS. (*Sow. Min. Conch.*) *Crag. Suffolk.*

2.— LORICULA PULCHELLA. (*Mr. G. B. Sowerby, jun.*) *Chalk. Kent.*
a. The situation of the aperture of the shell.

3.— A valve (*Tergum*) of SCALPELLUM MAXIMUM. *Chalk. Lewes.*

4.— Another valve (*Carina*) of the same species.

5.— PHOLAS PRISCUS[434]; in wood. *Lower Green Sand. Sandgate.*
a. One of the shells seen in profile.

6.— Univalve Shells (*Neritæ*) in hollows formed by *Pholades*. (*Mr. Bensted.*) *Lower Green Sand. Maidstone.*
a. The *Nerites* lodged in the cavities.
b. Fragment of wood remaining attached.

[434] Figs. 5 and 6 are referred to and described at pages 409 and 410, vol. i.

LEPADIDÆ.—The pedunculated Cirripedes, of which the common *Duck-barnacle* is a well-known example, have a strong, muscular, hollow stalk, or peduncle, which supports a multivalve shell, containing the body of the animal. In *Pollicipes* and *Scalpellum* there are small calcareous plates covering the junction of the body with the peduncle. Detached valves of several species of these two genera are met with in the Chalk, Galt, and Shanklin Sand, of Kent and Sussex; and three species have been found in the English Tertiary beds.[435] The valves of these fossil Cirripedes are most usually found in a disconnected state (*Lign.* 167, *figs.* 3 and 4); but the Tertiary *Scalpellum quadratum* is sometimes better preserved; and Mr. Morris has described a most beautiful group of *Pollicipes* (*P. concinnus*), attached to an Ammonite, from the Oxford Clay. Mr Wetherell, of Highgate, has also discovered, in the Upper Chalk, near Rochester, an almost perfect Cirripede, named by Mr. G. B. Sowerby, jun., *Loricula pulchella* (*Lign.* 167, *fig.* 2), and lately more fully described in detail by Mr. Darwin.[436]

[435] See Mr. Darwin's Monograph of the Fossil *Lepadidæ*, Palæontographical Society, 1851.

[436] Monograph of the Fossil Lepadidæ, p. 81, pl. v.

CRUSTACEA.—The animals whose fossil remains we have now to consider, are characterised by their crustaceous external integument or shell, which is disposed in segments, more or less distinct, the annular portions supporting articulated limbs or appendages. They are aquatic, free, locomotive beings, and possess distinct *branchiæ*, or organs fitted for aquatic respiration. The Crab and Lobster are

examples of those tribes in which the external crust is calcareous, and "coloured by a pigmental substance, diffused more or less irregularly through it; and is formed upon and by a vascular organized integument, or corium, which is lined by the smooth serous membrane of the visceral cavities." (*Owen.*) The subdivisions of this class have relation to the forms, combinations, and proportions of the primary rings or segments of the external crust or integument, but it will not be requisite for our present purpose to enter upon this department of the subject. It may, however, be necessary to mention, that in the normal type of Crustaceans, the integument consists of twenty-one rings or segments, which form the three regions into which the body is divided; namely, the head or *cephalic*, the *thoracic*, and the *abdominal*; each of which is assumed to consist of seven rings, although some of these are generally anchylosed, and form but one segment; and even the three regions are occasionally more or less blended together. The cephalic portion of the crust contains the principal organs of sense, and the commencement of the digestive apparatus, and includes the masticatory appendages. The *thoracic* portion is formed of the rings to which the extremities serving for locomotion are attached: and, together with the cephalic, contains almost all the viscera. The consolidation of the rings or segments takes place most generally in the cephalic, and next in frequency in the thoracic; and but rarely occurs in the abdominal region. These animals possess organs of sight variously modified, and in some species highly complicated; some have smooth or simple eyes (*stemmata*), and others compound eyes, like those of insects, with distinct facets. In one grand division (called *Edriopthalmia*), the eyes are sessile

and immovable; in the other (*Podopthalmia*), they are supported upon moveable stems or peduncles. These few remarks on the organization of the recent crustaceans are required, to make our description of the fossil remains intelligible to the general reader. As the shell, or calcareous integument, even in those species in which it is very dense and thick, is moulded upon the soft parts it envelopes, the experienced naturalist is able, from its configuration alone, to obtain certain conclusions as to the form, size, and position of the contained viscera; and, as these animals annually shed their solid case and acquire a new one, which is moulded on the soft parts, the form and relative situation of the internal organs must necessarily be faithfully represented by the external integument, even when it has acquired its greatest degree of consolidation; thus the regions of the stomach, heart, branchiæ or respiratory organs, &c. may be distinctly traced on the external shell. Hence the fossil carapaces may afford important data regarding the structure and economy of the extinct species. M. Desmarest[437] was the first naturalist who successfully applied this *phrenological method* to the investigation of the fossil crustaceans.

[437] Histoire Naturelle des Crustacés Fossiles; par MM. Alex. Brongniart et Desmarest. 1 tom. 4to. Paris, 1822.

The fossil remains of Crustaceans consist of the calcareous covering or carapace, with the articulated extremities, and, rarely, the jaws and antennæ. For the most part, the specimens are mutilated, and present only portions of the carapace, abdominal segments, and detached claws; but in strata composed of very fine detritus, such as the cream-coloured limestones of Solenhofen and Pappenheim,

examples often occur in the most beautiful state of preservation, appearing as if the animals had been carefully embalmed in a soft paste, that had quickly consolidated around them, and preserved them without mutilation or blemish. In some examples, even the colour of the original remains. The specimens found in hard limestones and coarse conglomerates are generally mutilated, and, as the under surface of the carapace, and the sternal plates to which the legs are attached, present more irregularity than the dorsal portion of the shell, they are firmly impacted in the stone, so as to render the development of some of the most important characters difficult, if not impossible. The antennæ and claws are often separated, or altogether wanting; the most common relics being the pincers and the carapace, or united cephalo-thoracic segments. The substance of the shell, which in the recent state consists of phosphate and carbonate of lime, with gelatine or cartilage, is commonly a friable carbonate of lime, tinged with oxide of iron. These remarks apply more particularly to the crabs, lobsters, shrimps, prawns, &c. Numerous species of the smaller crustaceans, as the *Cypris*, and the extinct family of *Trilobites*, occur in myriads, and, in some formations, are the principal constituent of deposits of great thickness and extent.

The remains of this class have been found throughout the vast series of the fossiliferous strata. Extinct forms appear in prodigious numbers in the most ancient formations, and are succeeded by genera which approach more nearly to the more highly organized crustaceans. The Crab and Lobster tribes are represented by certain species in the Lias, Oolite, and Chalk; while in many of the Tertiary strata the existing types prevail.

The London Clay, in the Isle of Sheppey, yields many beautiful examples of the higher order of crustaceans, as the Crab, Lobster, &c. In the Chalk these remains are more rare, but a few fine specimens have been obtained. On the Continent, certain localities are extremely rich in these remains. Upwards of sixty species were discovered by Count Münster in the Jura limestone, at Solenhofen; and the Muschelkalk of Germany has yielded several extinct genera. The beautiful state in which these fossils occur, is exemplified in the specimen from Solenhofen, figured in the frontispiece of this work; *Pl. I. fig. 2*.

FOSSIL CRABS.—Of the *brachyurous*, or short-tailed, crustaceans, of which the common Crab is an example, and of the *Anomura* (abnormal-tailed), there are remains of several genera in the Tertiary deposits. The Isle of Sheppey is the most productive locality in England. The carapaces of several kinds occur in the septaria and nodules of indurated clay; the chelate hand-claws (*pincer-claws*) are often found detached, and sometimes in connexion with the shield. The most numerous specimens are referable to two species. One of them (*Cancer Leachii*) is from two to three inches wide, and has a convex shell, the surface of which is covered by minute punctations, with three tubercles on each anterior lateral margin. [438] The carapace of the other species is more distinctly lobed, and studded with aculeated or spiny tubercles; it is named *C. tuberculatus*.[439]

[438] Hist. Nat. Crust. Foss. pl. viii. figs. 5 and 6.

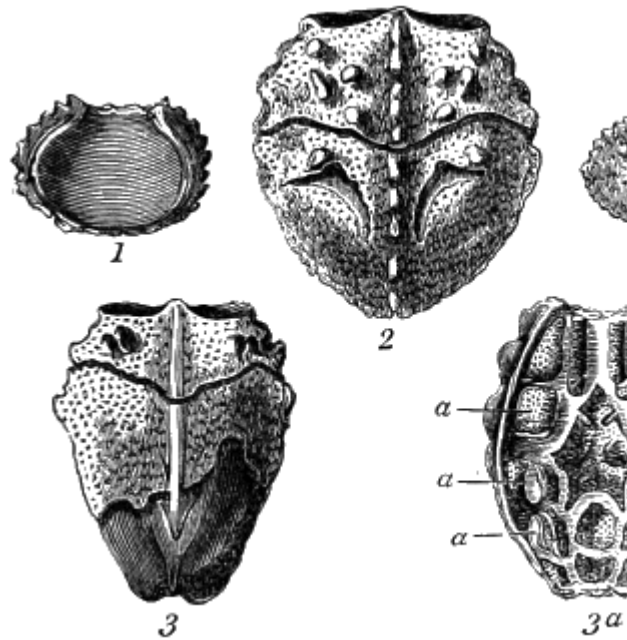
[439] König, Icones Foss. Sect. *fig.* 54. These two species are now referred to the genus *Zanthopsis*.

A species of Crab, characterised by its relatively large claws, is common in the soft Tertiary limestone of Malta; and examples, in a fine state of preservation, are often seen in cabinets; see *Wond.* p. 251.

I am not aware that vestiges of more than one genus of brachyurous crustaceans have been observed in the British Secondary formations; namely, the *Podopilumnus Fittoni* (M'Coy), from the Greensand of Lyme Regis: but several small species belonging to the anomurous group have been found in the Galt.

In the *Galt* at Ringmer, a village near Lewes, I discovered, many years since, four or five species of small crustaceans, which are figured and described, *Foss. South D.* pl. xxiv.; their natural relations were pointed out to me by the late eminent naturalist, Dr. Leach. Specimens of two of the species have since been collected at Folkstone, but as these are only the carapaces, no additional light has been thrown upon the structure of the originals.

The smallest species consists of the carapace or cephalo-thoracic segments, united into a transversely obovate, obscurely trilobate shell, the surface of which is covered with minute irregular papillæ; with four tubercles on each lateral portion, and an irregularly tuberculated dorsal ridge (see *Lign.* 168, fig. 1, 1*a*.); it probably belongs to the genus ETYUS; and I have named it *Etyus Martini*, in honour of my friend, P. J. MARTIN, Esq., author of several excellent Memoirs on the Geology of Western Sussex.



LIGN. 168. FOSSIL CRUSTACEANS: *nat. Galt. Near Lewes.*]

Fig. 1. ETYUS MARTINI (G. A. M.): showing the
— empty carapace or shell. *Ringmer.*

1*a*. The dorsal surface of the same.
—

2. CORYSTES[440] STOKESII (G. A. M.). *Ringmer.*
—

3. CORYSTES[440] BRODERIPII (G. A. M.).
— *Ringmer.*

3*a*. The under surface of the same species,
— displaying the sternal plates and the bases of the claws, three of which are marked *a, a, a.*

[440] These two crustaceans are included in the fossil genus NOTOPOCORYSTES,

established by Professor M'Coy, 1849.

There are two species that appear to have some relations with *Corystes*, a genus which includes several recent crustaceans that inhabit our shores, and are characterised by their elongated oval shell and four antennæ, the external pair being long, setaceous, and furnished with two rows of cilia. The tail is folded under the body when the animal is in repose. They have ten legs, the anterior pair *chelate* (*with pincers*), the others terminating in an acute elongated nail or claw. The fossils consist of the carapace, and one example possesses the inferior or thoracic plates and the remains of the bases of some of the legs (see *Lign.* 168, fig. 3*a*).

NOTOPOCORYSTES STOKESII. *Lign. 168, fig. 2.*—The carapace is relatively wider than in most species of this genus; is has a strong dorsal ridge of irregular oblong tubercles; the union of the cephalic and thoracic segments is marked by a transverse undulated groove; there are three or four tubercles on the surface of each lateral portion of the former, and one on each of the latter. The whole surface is finely granulated. The openings left by the attachment of the peduncles of the eye remain.

NOTOPOCORYSTES BRODERIPII. *Lign. 168, fig. 3.*—This species, like the former, has a transverse undulated furrow, indicating the union of the cephalic with the thoracic segments; the dorsal ridge is smooth, and there are two tubercles on each lateral cephalic portion of the shield. The carapace is longitudinally ovate, much depressed, with three sharp points directed forwards on each margin of the anterior part: the whole surface is finely granulated. In the specimen *fig.* 3*a* the sternal plates, with

portions of the first joints of the claws, remain; one example (figured *Geol. S. E.* p. 169) possessed six or seven arcuate abdominal segments, which were turned under the body.[441]

> [441] I have described these small crustaceans somewhat minutely, and have given them specific names, in the hope of directing the attention of collectors to these highly interesting relics, and leading to the discovery of more illustrative examples. See Foss. South D. pp. 96, 97.

The carapace or shell of the other crustacean observed in the Sussex Galt (*Notopocorystes Bechei*) is of an orbicular inflated form (see *Geol. S. E.* p. 169, *fig.* 3), and ornamented with twelve or thirteen aculeated tubercles; its margin is dentated.

In the friable arenaceous limestone of the Cretaceous formation at St. Peter's Mountain, near Maestricht, the cheliferous claws of a small kind of crustacean (*Mesostylus Faujasii*, *Wond.* p. 338), are frequently discovered (and occasionally in the Chalk of Kent and Sussex), but with no vestige of the carapace or shell. This curious fact is explained by the analogy existing between the fossil claws and those of the *Pagurus*, or Hermit-crab, whose body is only covered by a delicate membrane, the claws alone having a calcareous covering; hence the latter might be preserved in a fossil state, while no traces of the soft parts remained. In the fossil, as in the recent claws, the right arm is the strongest. There is no doubt that the crustaceans to which the fossil claws belonged possessed the same modification of structure as the recent (anomurous) Hermit-crab, and must have sought shelter in the shells of the mollusks with which their durable remains are associated.

FOSSIL LOBSTERS.

FOSSIL LOBSTERS.—The *macrurous*, or long-tailed, crustaceans, as the *Lobster*, are distinguished from those of the former divisions by the prolonged abdomen (or tail, as it is commonly termed), which forms a powerful instrument of locomotion, and enables the animal to dart backwards through the water with great rapidity; and this is furnished with an appendage or tail, which none of the ambulatory crustaceans possess.

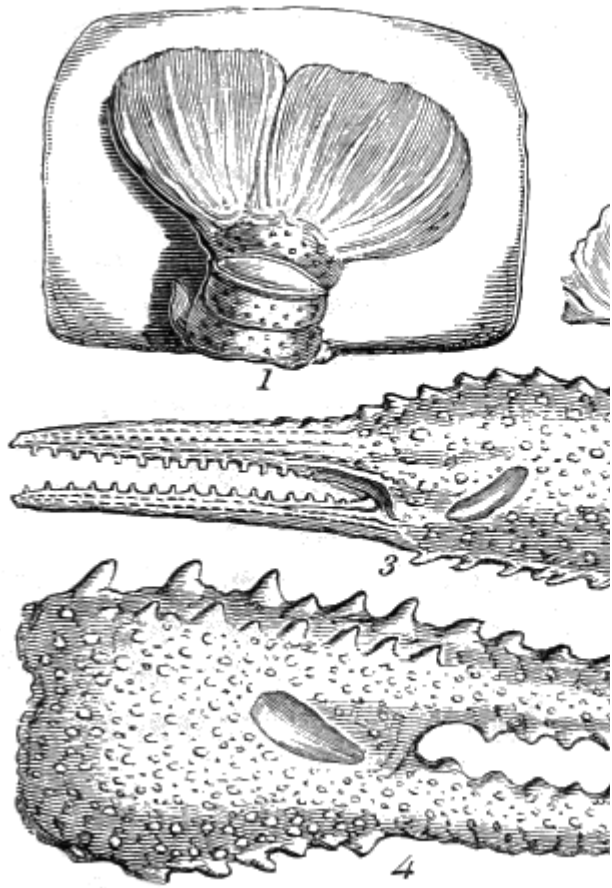
Of the fresh-water species, the Cray-fish (*Astacus fluviatilis*), and of the marine, the Lobster (*Astacus marinus*), are illustrative examples. The remains of three macrurous species occur in the London Clay of the Isle of Sheppey, associated with congenerous crustaceans; and the segments of the tails (*post-abdomen*) are often well preserved.

The Chalk contains a few species of the *Macrura*, which were first discovered in the quarries near Lewes, and are figured in *Foss. South D.* tab. xxx. xxxi.; they are among the most rare and delicate of the fossils of the Cretaceous strata. These remains consist of the carapace and claws, and rarely of the tail and antennæ, and are composed of a friable earthy crust, which, when first discovered, is of a dark chocolate colour, but quickly changes to a pale fawn, or reddish brown, by exposure to the air. In the specimens obtained by breaking the stone, the crustaceous covering remains attached by its rough external surface to one portion of chalk, and on the corresponding piece are sharp casts of the carapace and claws, having a glossy surface covered with minute papillæ formed by the bases of tubercles or spines. Four species have been observed.

ENOPLOCLYTIA LEACHII. *Lign.* 169, *figs.* 1, 2, 3.—This is a long delicate crustacean, having a pair of equal, slender, anterior chelate claws, the fingers of which are long, attenuated, and armed with a row of obtuse cylindrical spines. The surface of the hand-claws is muricated, or covered with short erect aculeated tubercles. The pincers in the specimen figured *Lign.* 169, *fig.* 3, are shorter than in most examples. The carapace is elongated and sub-cylindrical, with a dorsal ridge and two lateral furrows, indicating the normal division of the cephalic and thoracic segments of the shield; the antennæ are long, filiform, and setaceous (*bristly*), and are placed on squamous peduncles (see *Lign.* 169, *fig.* 2).

There appear to have been five legs on each side; the anterior or chelate pair are the most usual relics of this animal; of the other claws and the branchiæ, but obscure indications have been obtained. The abdominal segments are arcuate, and six or seven in number; their surface is granulated; the appendage, or tail, is foliaceous and marginate, with a few longitudinal ridges (see *Lign.* 169, *fig.* 1).[442] The claws of these crustaceans may be easily recognised by their general aspect, and the length and straightness of the fingers or pincers. In most examples traces remain of the tendinous expansion of the muscles of the moveable claw (see *Lign.* 169, *fig.* 3).

[442] See Foss. South D. p. 221, *et seq.* for further details.



LIGN. 169. FOSSIL CRUSTACEANS: *nat. Chali*

Fig. 1. Abdominal appendage, or tail, of
— ASTACUS[443] LEACHII (G. A. M.), with three abdominal segments.
2. Part of the head of *Astacus Leachii*, with
— remains of the squamous peduncles of the antennæ,
and of the long setaceous antennæ.
3. Chelate claw, with part of the carpus, or
— wrist, of *Astacus Leachii*.

4. Chelate claw of ASTACUS[443] SUSSEXIENSIS — (G. A. M.).

[443] These fossil Lobsters are now to be referred to Prof. M'Coy's genus ENOPLOCLYTIA.

ENOPLOCLYTIA SUSSEXIENSIS. *Lign.* 169, *fig.* 4.— The claws of this species are readily distinguished from the former by their broader and stronger proportions, and spinous character; the pincers are strong and tuberculated, and the moveable finger is more curved and shorter than its opponent. The entire crust of this lobster is muricated, or beset with spines and sharp tubercles.[444]

[444] Foss. South D. tab. xxx. *fig.* 3. In the beautiful work of the late Mr. Dixon, on the Fossils of Sussex, there are figures of very fine specimens of these two species of Enoploclytia (plate xxxviii*.) with detailed descriptions by Prof. Bell (p. 344); but unfortunately, from inadvertence, no reference is made to my former drawings and descriptions of these fossil Lobsters of the Chalk, and new names are given by the Professor; *E. Leachii* appearing as "Palæastacus macrodactylus," and *E. Sussexiensis* as "P. Dixoni." I need scarcely remind my readers that according to the established rules of Nomenclature the *earlier specific names* must be preserved; and that, Prof. M'Coy having already indicated the distinction of these fossils from the recent *Astacus* by providing an appropriate generic appellation, these new names are altogether inadmissible.

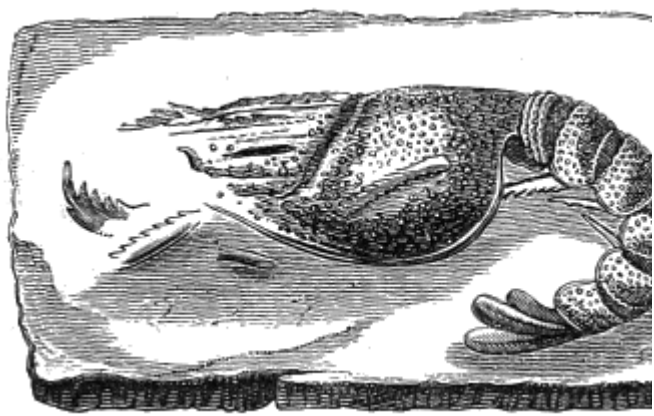
Claws of other *Astacidæ* have been found in the Chalk of Sussex and Kent; one species in particular is distinguished from those previously described by its

short curved pincers, and granulated surface;[445] and remains of other species of *Enoploclytia*, from near Cambridge and Maidstone, are described by Prof. M'Coy.

[445] This species may be named *Astacus cretosus*, to indicate its geological habitat.

The "Lobster-clays" in the Lower Greensand, or Neocomian, beds at Atherfield afford numerous fine specimens of a small long-clawed crustacean, allied to *Astacus*; a fine specimen is figured in the *Geology of the Isle of Wight*, title-page vignette, and see page 232. One or more species, apparently distinct from those of Atherfield, have been discovered by Mr. Beckles in beds of clay that appear to occupy the line of junction between the Wealden and Greensand, on the Sussex coast, between Pevensey and Bexhill.

Imperfect claws of *Astacidæ* have also been found at other places in the Shanklin Sand; and I have collected from the Galt at Ringmer, the abdominal segments of a small species, resembling *Meyeria ornata*, *Lign.* 170.



LIGN. 170. FOSSIL CRUSTACEAN. *Speeton Clay. Yorksl*

MEYERIA ORNATA: *nat.* (*Phillips and M'Coy.*)

The carapaces of two or three small *Astacidæ*, sometimes with the abdominal segments attached, as in the beautiful fossil figured in *Lign.* 170, are found in the Speeton Clay, near Scarborough. In this example the post-abdomen and its appendages are entire, and traces remain of the antennæ and some of the feet. These specimens are commonly imbedded in masses of indurated clay, as the fern-leaves in the Carboniferous ironstone, and are discovered by splitting the nodules through their longest diameter. The carapace of another small species (*Glyphea rostrata*)[446] occurs in the Oolite of Scarborough. My friend, the Rev. J. B. Reade, has also discovered an example of this species in that rich repository of organic remains, the Kimmeridge Clay, at Hartwell, Bucks.

[446] This is the *Astacus rostratus* of Prof. Phillips's Geol. York. vol. i. tab. 4, *fig.* 20.

A remarkable macrurous crustacean (*Eryon Cuvieri*) is found in the Jurassic limestone of Solenhofen. Perfect specimens of this species are occasionally seen in collections; it is distinguished by its very large, flat, oval shell, with the front lateral margins strongly dentated, and by its short setaceous antennæ; the front claws are as long as the body, and armed with pincers; the post-abdomen consists of six segments, terminating in a caudal appendage or tail.

In the United States several fossil crustaceans have been noticed in the Cretaceous strata of New Jersey; some of which are said to be related to *Pagurus*, and others to *Astacus*.

Fossil Prawns and Shrimps, of exquisite beauty,

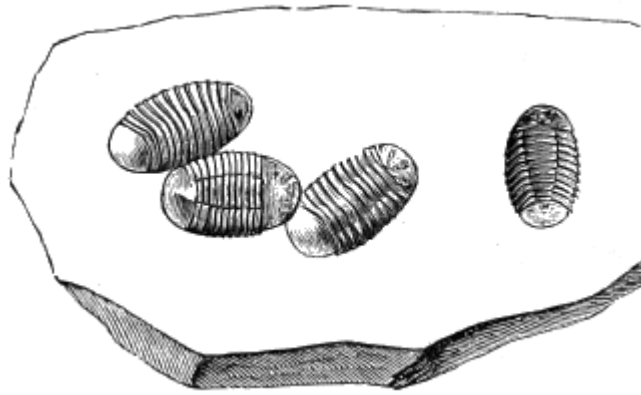
are found in the lithographic limestone of Pappenheim: a specimen from that locality (*Palæmon spinipes*) is figured *Wond.* p. 513: see also Frontispiece of this work.

A large crustacean of the Shrimp family has been discovered by the Earl of Enniskillen in the Lias of Lyme Regis.[447] Other specimens also of Macrura, more or less perfect, have been obtained from the same rich mine of organic remains: especially some in which the *branchiæ*, or respiratory organs, remain; and a portion of the post-abdomen, or tail, of a Cray-fish, as large as the common species.

[447] This beautiful fossil is figured and described by Mr. Broderip, Geol. Trans, second series, vol. v. pl. xii. under the name of *Coleia antiqua*.

FOSSIL ISOPODOUS CRUSTACEANS.

ISOPODOUS CRUSTACEANS. *Lign.* 171.—ISOPODA (*equal-feet*) is the term applied to an order of crustaceans in which the body is composed of a distinct head, and seven rings, each having a pair of equal feet; the common *Oniscus*, or wood-louse, is a familiar example of a terrestrial *Isopod*. This order includes many genera and species, some of which nearly approach the extinct family of crustaceans (Trilobites) whose remains abound in the palæozoic strata; and the parasitical Isopod, *Bopyrus*, that infests the common Prawn, is closely related to certain genera of Trilobites, hereafter described.



Lign. 171. ARCHÆONISCUS BRODIEI. *Purbeck limestone. Vale of Wardou*
Woodward, Esq.)
Impressions of the upper and under surfaces.

One species of fossil *Isopod* has been found in green fissile marl, at Montmartre; and another in fine-grained limestone, probably, from Pappenheim. [448] No fossil remains of this order had been noticed in the British strata, until the discovery of the *Archæoniscus* in the Purbeck strata by the Rev. P. B. Brodie. The quarry in which these relics were found is situated at Dallards, near the village of Dinton, about twelve miles west of Salisbury. They are principally distributed in a bed of light-brown and grey limestone, in the lower part of which are numerous fresh-water bivalves (*cyclades*), and a few small oysters. These Isopods often occur in clusters (see *Lign.* 171); the lenses of the compound eyes are sometimes detectable in the limestone, and, rarely, attached to the head; traces of legs have been observed, but no antennæ. In the same stratum the *elytron* (sheath, or wing-case) of a coleopterous insect was discovered. Mr. Brodie has obtained specimens an inch and a half in length, and an inch broad. These fossils appear to have been deposited

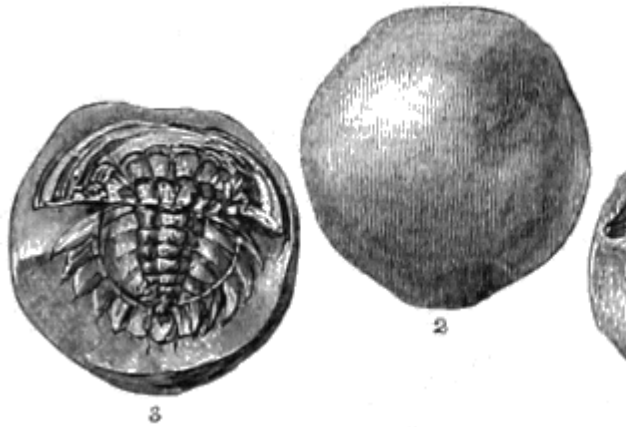
tranquilly at the bottom of the water which they inhabited, since they are usually found imbedded with their legs downwards, and generally well preserved.[449]

[448] Nat. Hist. Crust. Foss. p. 138.

[449] See Brodie's Fossil Insects, pp. 3 and 10.

The *Archæonisci* also occur in the Purbeck insectiferous limestone of Durlstone Bay, near Swanage, and have been discovered in strata of a similar character at the Ridgway railway-cutting between Dorchester and Weymouth, by the Rev. Osmond Fisher, of Dorchester.

ENTOMOSTRACA.—The Crustaceans that we have above noticed belong to the Sub-class MALACOSTRACA; and we have now to describe some fossil genera belonging to various divisions of the Entomostracous Crustaceans.



LIGN. 172. FOSSIL. LIMULUS, IN A NODULE OF IRON
Carb. Coalbrook Dale.

Fig. 1. LIMULUS ROTUNDATUS, the imprint of *fig.* 3.

2. The nodule before it was broken.

3. LIMULUS ROTUNDATUS, (the corresponding portion of the nod
— of the carapace.

FOSSIL LIMULUS.

The LIMULUS (MOLLUCCA or KING CRAB) is a genus belonging to that Division of the Entomostraca termed Pœcilopoda and is abundant in the seas of India and America. The carapace is crustaceous and of a semilunar form, the head and thorax are blended together, and the superior abdominal shield, which is composed of confluent segments, appears like one piece, and has an indistinct trilobed character; the last segment is prolonged into a three-edged, sharp, styliform weapon. The Limulus has two reniform, compound eyes, composed of facets of a peculiar form. The gills are disposed on lamelliform processes. It is distinguished from all other crustaceans by the mastication of its food being performed by the first joint of the thoracic legs which surround the mouth, instead of by jaws.



LIGN. 173. LIMULUS TRILOBITOIDES.
Coal Measures. Coalbrook Dale.

Very fine examples of a fossil species of this remarkable genus are occasionally obtained from the lithographic stone of Solenhofen.[450] In England three small species have been discovered in nodules of ironstone and indurated clay, in the Carboniferous strata of Coalbrook Dale, by Mr. Prestwich.[451] In one example (*L. Anthrax*[452]) two of the legs are seen extending from under the body; in another species the sharp, pointed process of the tail is well developed (*Buckl.* p. 396, and tab. xlvi″.; see also *Lign.* 173). The specimen figured *Lign.* 172 is one of several examples which I obtained by breaking up nodules from that celebrated locality. *Fig.* 2 represents the nodule unbroken, and without any indication of its contents; by a well-directed blow it was separated into two equal portions, *figs.* 1 and 3, in which the carapace of the crustacean, and its marginal appendages, are well displayed. The rounded form of the carapace, and the membrane which appears to connect the spines, separate this

species from all others.

[450] Hist. Crust. Foss. pl. xi. *fig.* 6.

[451] See Mr. Prestwich's Memoir on the Geology of Coalbrook Dale, Trans. Geol. Soc. second series, vol. v. part 3.

[452] Trans. Geol. Soc. second series, vol. v. pl. xli. figs. 1-4.

The EURYPTERUS and Pterygotus are palæozoic crustaceans, of large size. They are regarded by Prof. M'Coy and Mr. Salter as belonging to the Pœcilopoda, and as differing from the Limulus chiefly in having the segments of the abdomen freely articulating with each other.[453] The *Eurypterus* was first described by Mr. Dekay, in the United States, probably from the Carboniferous system. The head is round, the thoracic and cephalic portions of the carapace being blended together, and the abdominal region is formed of eleven segments, with a caudal appendage. It has two depressed, lunated eyes, remote from each other, and eight feet, the anterior pairs furnished with *branchiæ*, and the hindmost pair relatively larger than in any other crustacean. Two American species are described; the one is five, and the other about four inches long.[454] In the Carboniferous strata at Burdie-house, near Edinburgh, and of Kirton, near Glasgow, a large species of this curious genius has been found by Dr. Hibbert and Dr. Scouler; the length of some specimens being estimated at from twelve to eighteen inches.[455]

[453] See Salter on Pterygotus, Quart. Journ. Geol. Soc. vol viii p. 387.

[454] Dr. Harlan, in Trans. Geol. Soc. Pennsylvania, vol. i. p. 96.

[455] See the elegant Memoir on the Fresh-water Limestone of Burdie-house, near Edinburgh, by Samuel Hibbert, M.D. F.E.S.E.

Other species of *Eurypterus* have been noticed in the Upper Silurian rocks of Kendal, Westmoreland, [456] and of Kington, Radnorshire; and in the Devonian of Russia.

[456] Pal. Foss. Cambridge, Appendix.

PTERYGOTUS.—In the Old Red sandstone of Forfarshire, and other parts of Scotland, the remains of this remarkable crustacean have been long known to the quarry-men by the name of "*petrified Seraphims*;" from an imaginary resemblance of the expanded post-abdomen to the usual representations of those ideal beings! This genus is characterised by the angular carapace, which forms a lozenge-shaped shield; and the appendage of the post-abdomen, which, instead of being divided into segments, as in most animals of this class, is a continuous flap. The eye-pits on the carapace are like those of Eurypterus, but are very large. The claws resemble those of the common lobster. The external crustaceous covering is ornamented with circular and elliptical markings, producing an imbricated or scaly appearance, the imprints of which gave rise to the enigmatical "Seraphims" of the Forfarshire sandstone. Some specimens indicate a total length of four feet![457]

[457] The Old Red Sandstone, or New Walks in an Old Field, by Hugh Miller, p. 147. There are specimens in the British Museum from the quarries of Carmylie.

Besides this Devonian species (*P. anglicus*), there is also a Silurian species (*P. problematicus*), from

Herefordshire.[458]

[458] See Quart. Journ. Geol. Soc. vol. viii. p. 386.

Several fossil genera of the Entomostracous Crustaceans belong to the *Phyllopoda* (*leaf-feet*), which constitute a subdivision of the BRANCHIOPODA (*gill-feet*). Of these perhaps the most remarkable is the Dithyrocaris, first discovered by Dr. Scouler in the Carboniferous shale near Paisley. This genus is allied to the recent *Apus*, and, like it, has a broad, flat, thin carapace, easily divisible down the middle of the back, and a lengthened tail or post-abdomen, with a trifid termination. Six species have been found in the Carboniferous deposits of the British Isles.

Ceratiocaris and Hymenocaris, which are related to the recent *Nebalia*, are also of the Phyllopod group, and maybe said to resemble a shrimp-like animal partly enclosed in a bivalve carapace, while its tail is exposed, and either protruded, or turned beneath the body. Of the first-mentioned genus there are three Upper Silurian species; and of *Hymenocaris* Mr. Salter has described a single species (*H. vermicanda*) from the Lower Silurian (Cambrian) of North Wales.

The *Limnadiadæ*,—another Phyllopodous family, of which the recent *Limnadia* is the type,—are well represented in the older rocks. These Crustaceans are also bivalved, but the body is wholly enclosed. They are of small size. ESTHERIA, a genus closely related to Limnadia, occurs plentifully in the Wealden of Sussex and Germany, and in the Lias of Westbury. Mr. Bean also has noticed a species (*E. concentrica*) in

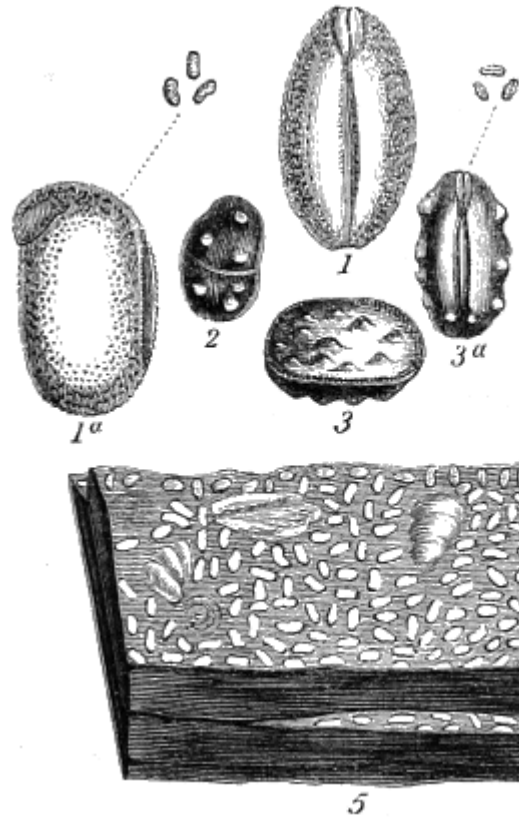
the Oolite shell of Gristhorpe Bay; and the *E. minuta*[459] is characteristic of the Keuper division of the Trias in England and Europe.

[459] This was formerly described as a *Posidonomya*.

LEPERDITIA and BEYRICHIA are other fossil genera belonging to the *Limnadiadæ*. These little crustaceans were gregarious in their habit, and, like Estheria, occur locally in great profusion. They are characteristic of the Silurian deposits; the former being an abundant Upper Silurian fossil in Europe and North America, and the latter,—a very minute form,—both in the Upper and Lower Silurian.

The next group of Entomostraca that we have to notice belongs to the LOPHYROPODA (*feet crested with bristles*), namely, the OSTRACODA (*shelled*). The recent genera, *Cypris*, *Cythere*, and *Cypridina*,[460] are types of the three families of this group, and are the existing representatives of numerous closely related forms that occur in a fossil state.

[460] The student should consult Dr. Baird's elegant and elaborate work on the Natural History of the British Entomostraca (published by the Ray Society), for information on the characters and habits of these interesting little crustaceans and their numerous allies



LIGN. 174. FOSSIL CYPRIDES. *Wealden. Sussex an*

Fig. 1.— CYPRIS VALDENSIS: *magn.*; showing the ventral aspect of the
1*a*.— Side view of the same, *magn.* The three small figures are of th
2.— CYPRIS FITTONI, *magn. Langton Green.*
3.— CYPRIS TUBERCULATA, *magn. Langton Green.*
3*a*.— View of the same, showing the lower edges of the valves unit
4.— CYPRIS GRANULOSA, *magn.*; view showing the hinge-line.
5.— A piece of WEALD CLAY, with Cyprides and Shells; *nat.*

CYPRIS. *Lign.* 174.—The animals of this genus belong to those Crustaceans in which the covering of the body is not divided into transverse segments, but consists of a large dorsal shield, having the form of a

bivalve shell. They are often very minute, and numerous kinds swarm in our lakes and pools. The species of an allied genus, named *Cythere*, the shells of which cannot always with certainty be distinguished in a fossil state from those of *Cypris*, inhabit salt or brackish waters. As the living *Cyprides* are interesting objects for microscopic examination, they are commonly shown in the exhibitions of the hydro-oxygen microscope, and their appearance is therefore well known. Two recent species are figured in *Ly.* p. 183. These animals have the body enclosed in a bivalve, horny case, the two pieces being united by a hinge-line. They have four feet, and two pairs of antennæ, with a pencil of cilia at the extremities; and one compound eye. They swim with rapidity, by means of their ciliated antennæ, and crawl about actively on the water-weeds and other subaqueous surfaces. Like the other crustaceans, they frequently moult or cast their cases, and the surface of the mud spread over the bottoms of still lakes is often covered with their exuviæ. The largest living Cypris (*C. clavata*) does not exceed one-eighth of an inch in length. The fossil cases or shells of Cyprides are found in considerable variety and in prodigious numbers in certain Tertiary and Secondary strata, which appear to have been deposited by fresh-water; as, for example, in the lacustrine marls of Auvergne (*Ly.* p. 183), and the fluviatile clays and limestones of the south-east of England. They have not been observed in any decidedly marine beds; but Mr. Lonsdale discovered in the Chalk, by means of the microscope, cases of crustaceans, that belong to the genus *Cythere* (*Ly.* p. 26, figs. 21-24), the recent species of which inhabit the sea. One or more species of Cypris have been observed in the older British Tertiaries,—by Sir C. Lyell, in Hordwell Cliff (*Geol.*

Trans. 2d ser. vol. iii. p. 288), and by Mr. Prestwich at Hempstead Cliff (*Brit. Assoc.* 1846); but in the Pleistocene deposits the Cypris and its congeners abound, and of these Mr. R. Jones has enumerated nine species (*Annals Nat. Hist.* 2d ser. vol. iii.). In many districts on the Continent, the Eocene marls and clays abound in these remains. Some of the fresh-water Tertiary strata of France contain myriads of a Cypris (named *C. faba*, from its bean-like form) which was formerly supposed, but erroneously, to be identical with a species found in the Wealden. The laminated marls of Auvergne contain, between every layer, countless myriads of the shells of Cyprides, through a depth of several hundred feet; although each lamina of marl scarcely exceeds the thickness of paper. Near Clermont, the green *cypridiferous* marls approach to within a few yards of the granite which forms the borders of that ancient basin (*Ly.* p. 184). In the eastern portion of the basaltic districts of India, Mr. Malcolmson has discovered two species of Cypris, associated with fresh-water univalves and bivalves.[461] In England the principal deposits of the Cyprides, are the clays and limestones of the Wealden and the Isle of Purbeck,[462] to the composition of which the relics of these minute beings have largely contributed. Entire layers of their cases are found in the laminated clays and marls on the southern shores of the Isle of Wight, at Atherfield and Sandown Bay, where some of the Wealden beds emerge from beneath the lower division of the Shanklin sand. Upon splitting the clay in the direction of the laminæ, the exposed surfaces are found to be covered with these minute bodies; as in the specimen, *Lign.* 174, fig. 5.

[461] Geol. Trans. 2d ser. vol. v. pl. xlvii.

[462] On account of the distinctive characters of their carapace-valves, M. Bosquet has suggested the appellation *Cypridea* as a generic name for the Cyprididæ of the Wealden and Purbeck beds.

The appearance of four characteristic Wealden Cyprides, of their natural size and magnified, is shown in *Lign.* 174. The one named *C. Valdensis*, or Wealden Cypris, by Dr. Fitton and Mr. Sowerby (fig. 1), is the most frequent, and occurs in numerous localities in Kent and Sussex. A Cypris having the case studded with relatively large tubercles (fig. 3), is found in many of the finer sandstones of Tilgate forest; another, with the shell tuberculated, but divided by a transverse ridge (fig. 2), indicating a rudimentary condition of the segments which characterise the class, is certainly distinct from the former, and can have no name more appropriate than that of *C. Fittoni*. The other beautiful species (*C. granulosa*, fig. 4) has the surface of the case covered with granules. One more species has been observed in the Weald clay, at Sandown Bay and Atherfield (by Mr. Lonsdale); it is distinguished by a short conical spine on each valve, and is therefore named *C. spinigera*. In the Weald clay at Resting-oak-hill, near Cooksbridge (*Geol. S. E.* p. 187), *C. Valdensis* is so abundant, that every thin flake is covered with its white calcareous shells; and upon breaking the nodules and septaria of reddish-brown ironstone which occur in that locality, myriads of beautiful sharp casts of the cases are observable in almost every fragment. They are associated with fresh-water bivalves and univalves (*Cyclas* and *Paludina*), and minute scales of fishes. The sandstone at Langton Green, near Tunbridge Wells, which contains casts and impressions of several species of fresh-water

shells, abounds in *Cyprides*; and the layers of argillaceous ironstone, interstratified with the sandstone in one of the quarries, are particularly rich in these remains. The surface of a recently broken slab is often covered by minute, polished, oblong, convex bodies, which are the casts of cypridean carapaces.

The Sussex marble is largely composed of the remains of these minute crustaceans. Upon examining thin polished slices of this limestone under the microscope, the cavities and interstices of the shells are found to be filled with the shields of Cyprides, entire or in fragments; and some specimens of the Purbeck marble equally abound in these remains. The Purbeck marls, as well as the limestones, often abound with Cyprides. According to Prof. E. Forbes, these belong to several species, all more or less distinct from those of the Wealden (*Brit. Association*, 1850). The Cyprides of the Wealden of Germany have been figured and described by Dr. Dunker; and several of the British forms are found there.

As the recent species inhabit still lakes, or gently running streams, and not the turbulent waters of estuaries, we cannot doubt that the strata in which these animals so largely predominate were deposited in lakes or bays, communicating with the river which transported to their present situation the bones and other remains of the colossal reptiles of the Wealden. And the beds of fresh-water snails, with scarcely any intermixture of other organic remains but the Cyprides, which are spread over extensive areas in the Wealden and Purbeck districts, appear to afford corroborative proof of this inference.

Four species of minute bivalved Entomostraca from the Carboniferous deposits have been referred to *Cypris*: viz. *C. arcuata*, Bean, from the Coal-shale at Newcastle; *C. inflata*, Murchison, Coal-measures, near Shrewsbury; *C. Scoto-Burdigalensis*, Hibbert, Coal-measures at Burdie-house, and Coal-shale at Derry; and *C. subrecta*, Portlock, also from Derry, Tyrone.

CYTHERE.[463]—This animal differs but little from Cypris except in having an additional pair of feet. In the Subgenus CYTHEREIS the valves are thick, oblong, and strongly hinged; thus differing from the thin and more or less oval valves of the true Cythere and of Cypris. Several species of *Cythere* and its sub-genera occur in the Tertiary, Cretaceous, Oolitic, Liassic, Permian, and Carboniferous deposits.[464]

[463] For description and illustration of this genus, see Baird's British Entomostraca, p. 163, &c.

[464] Consult M. Bosquet's Memoir on the Tertiary Entomostraca of Belgium and France; Mr. T. R. Jones's Monograph of the Cretaceous Entomostraca (Palæontographical Society), and of the Permian Entomostraca, in Prof. King's Monograph of the Permian Fossils (Palæont. Soc.); and Prof. M'Coy's Synopsis of the Characters of the Mountain Limestone Fossils of Ireland.

Three species of Entomostraca, very closely related to CYPRIDINA,[465] from the Carboniferous rocks of Belgium, hare been figured and described by M. De Koninck; one species from the Carboniferous rocks of Ireland, by Prof. M'Coy;[466] and two species from the Cretaceous limestone of Maestricht,[467] by M. Bosquet. The genera *Cyprella* and *Cypridella* have

been established by M. De Koninck for the reception of some allied forms found in the Carboniferous strata of Belgium; and Entomoconchus (M'Coy) and *Daphnoidia* (Hibbert) are allied British Carboniferous forms.

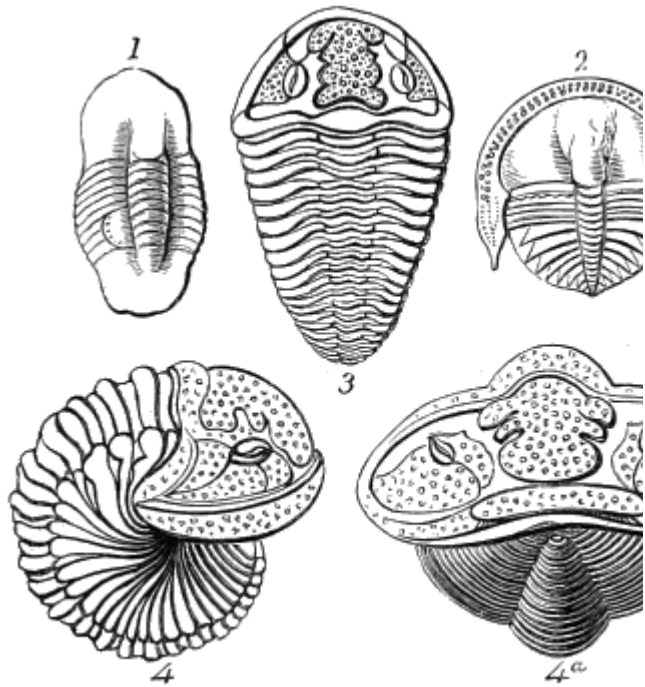
[465] See Baird's British Entomostraca, p. 176, &c.

[466] Under the name of *Daphnia primæva*.

[467] Under the generic appellation of *Cyprella*.

TRILOBITES.—Among the numerous petrifactions which are found in the limestones in the neighbourhood of Dudley, in Staffordshire, there are certain fossil bodies which, from their extraordinary form and appearance, have for more than a hundred and fifty years been objects of great interest to the naturalist, and of wonder to the general observer, and have long been provincially termed *Dudley insects*, or *locusts*.[468] By the earlier naturalists these fossils were referred to fishes, to molluscs, and to insects, before their real character was discovered. The most common type consists of a convex, oblong body, divided transversely into three principal parts, and longitudinally into three lobes, by two deep, parallel furrows; this last character suggested the name *Trilobita*, or *Trilobites*, by which the family is now distinguished by naturalists.

[468] LHYWD. Philos. Trans. for the year 1698.



LIGN. 175. TRILOBITES. *Silurian Limestones.*

Fig. 1.— ILLÆNUS PEROVALIS. (*Murch. Sil. Syst.*)

2.— TRINUCLEUS LLOYDII. (*Murch. Sil. Syst.*)

3.— CALYMENE BLUMENBACHII: the upper surface of the carapace above. DUDLEY.

4.— The same, coiled up, and seen in profile.

4*a*. The same, seen in front.

—

These fossils are the carapaces, or shells, of crustaceans, belonging to an extinct family,[469] which comprises many genera, and numerous species. Mortimer, Da Costa, Guettard, and Linnæus recognised the crustacean character of this interesting, but obscure class of organic remains: their true affinities, however, were first scientifically determined by Alex. Brongniart.[470] Many memoirs

on the *Trilobites* have since been published by eminent Continental and American writers;[471] and much light has been thrown on the subject by the labours of Martin,[472] Parkinson, [473] Stokes, Phillips,[474] König,[475] Dr. Buckland,[476] Sir E. I. Murchison,[477] and others. The beautiful illustrations and interesting description of the Trilobites in Dr. Buckland's Bridgewater Treatise (*Bd.* p. 389, and pl. xlv. xlvi.) must have rendered the reader familiar with the most important facts relating to these extinct beings; but subsequent discoveries have thrown additional light on their structure and natural affinities. The works of M. Burmeister,[478] Mr. Salter,[479] Prof M'Coy[480] and especially of M. Barrande,[481] should be carefully referred to by the student in this branch of Palæontology.

[469] The Trilobites appear to have been related more nearly to the Phyllopoda than to any other division of the Crustacea.

[470] Hist. Nat. Crust. Foss. Burmeister on Trilobites; Introduction.

[471] A Monograph on the Trilobites of North America, by Jacob Green, M.D. Philadelphia, 1832.

[472] Petrificata Derbiensia.

[473] Organic Remains of a Former World, vol. iii. See Pictorial Atlas.

[474] Geology of Yorkshire; and Palæozoic Fossils of Devon.

[475] Icones Fossilium Sectiles.

[476] Bridgewater Treatise.

[477] Silurian System, chap, xlvii.

[478] Die Organisation der Trilobiten. 1843. Translation: Ray Society.

[479] In the Quarterly Journal of the Geological Society, and in the Memoirs and Decades of the Geological Survey of Great Britain.

[480] Palæozoic Fossils in the Cambridge Museum.

[481] The Silurian System of Bohemia: the Trilobites.

In the Trilobites the head is distinct, and without antennæ, and the feet are supposed to have been rudimentary, soft, and membranaceous: the essential characters which separate them from all other crustaceans, except *Bopyrus* (a parasite on the branchiæ of the common prawn), are, according to Mr. Macleay, the deficiency of antennæ, and of lateral posterior abdominal appendages, and the presence of evanescent feet. Like other crustaceans, the Trilobites were subject to the process of metamorphosis during their early stages of life; and M. Barrande has ascertained that one species, the *Saö hirsuta*, appeal's in no less than twenty different stages of development. In its earliest, embryonic condition, it is a simple disk, and it passes through various stages until it becomes a perfect adult trilobite, having seventeen free thoracic segments and two caudal joints. No less than ten genera and eighteen species were instituted by palæontologists on *some* of the forms only which this one species presents in its different stages of metamorphosis, before M. Barrande's laborious and long-continued investigations gave him an insight into the true relations of these various conditions of the same animal to one another. This talented and

indefatigable palæontologist has arrived at like results with other Trilobites, and has been enabled to add greatly to our knowledge of the natural history and geological distribution of this interesting group of crustaceans. See Transact, of the Sections, Brit. Assoc. 1849 and 1850; and *Trilob. Bohême*, pl. vii.

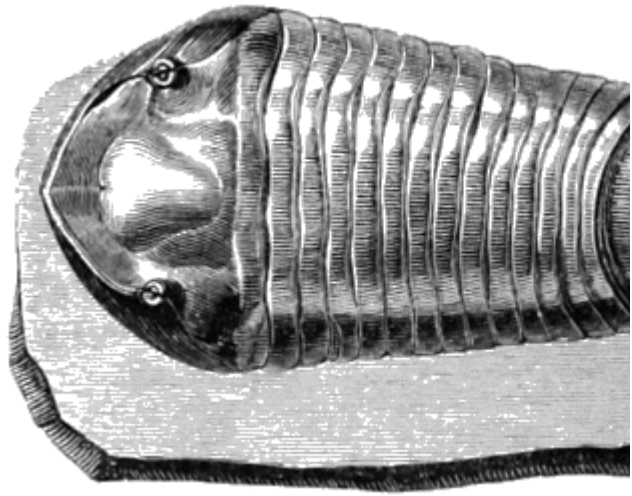
The *Trilobites* have been arranged in numerous genera, the names of which in a few cases are expressive of natural characters, but in others have reference to the obscurity that still invests some parts of the organization of these animals.[482]

[482] As, for example, Asaphus, *obscure*; Calymene, *concealed*; Agnostus, *unknown*.

CALYMENE BLUMENBACHII. *Lign.* 175, *figs.* 3, 4.—This is the Trilobite so well known as the Dudley locust, or insect. It consists of an ovate, convex, trilobed crustaceous shell, or case, and is found either expanded, as in *Lign.* 175, *fig.* 3, with its under surface attached to, and blended with, the limestone (*Wond.* p. 789); or coiled up like an Oniscus, or wood-louse, as in *figs.* 4 and 4*a*. The head is large, convex, rounded in front, with a broad border, and divided into three lobes by two longitudinal depressions. The eyes are two in number, compound, and have numerous facets; they are situated on the sides of the head, remote from each other. The carapace is deeply trilobed by two longitudinal furrows; the thoracic portion is composed of thirteen segments; the caudal shield is small and nearly semicircular. This species is from one to four inches in length. It occurs from the Lower Llandeilo rocks up to the Upper Ludlow inclusive.

The structure here described may be regarded as

the normal type, but numerous and important modifications prevail in the different genera.



LIGN. 176 HOMALONOTUS DEPHINOCEPH
(*Reduced from* pl. vii. *Sil. Syst.*) *Upper Silurian*

In the genus HOMALONOTUS, *Lign.* 176, the thoracic portion of the carapace is but obscurely lobed, and consists of thirteen segments; the abdominal is distinct from the thoracic, and formed of nine rings; it terminates in a prolonged point. The *H. Herschelii* is a large Trilobite, very plentiful in the Upper Silurian schists of the Cape of Good Hope.

In another genus, ASAPHUS (*Geol. Surv. Decade 2*), the carapace is wide and much depressed; the middle lobe distinct, the cephalic portion rounded in front, and terminating posteriorly in a sharp process on each side. The eyes are compound, and each contains upward of six thousand lenses, many of which remain in some examples.[483] Some American species belonging to this group are of a gigantic size, as, for example, the *Isotelus gigas* (of Mr. Dekay),

which is eighteen inches long. In the ISOTELUS[484] the body is of an oval shape, and the posterior angles of the head are rounded; the thorax is composed of eight segments.

[483] Mem. Geol. Surv. Decade 2, pl. v. p. 2, note.

[484] *Isotelus*, i. e. equal extremities.

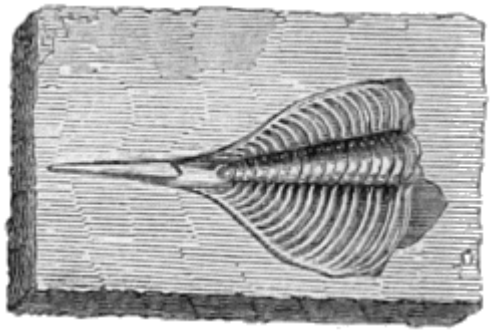
Another division of the Trilobites has the body contracted, and very thick, and the abdomen large and scutiform, without any segmentary divisions; the small crustacean (*Illænus perovalis*, *Murch.*) *Lign.* 175, *fig.* 1, will serve to illustrate these characters.

The Trilobite called BUMASTUS by Sir R. Murchison (from its grape-like form) presents a very curious modification of the normal type. Both the head and caudal extremity are rounded, with no distinct longitudinal furrows; and the whole surface of the carapace is covered by extremely thin, apparently imbricated, lamellæ, the edges of which are undulated, and the intermediate spaces studded with minute dots. The eyes are smooth, and not granulose, as in Calymene. This genus is known in England by the name of the BARR TRILOBITE, from its occurrence in the limestone near Barr, in Staffordshire; it is sometimes five inches long, and three and a half wide (*Geol. Surv. Decade 2*, pl. iii. and iv.).

The genus OGYGIA (*Bd.* pl. xlvi. fig. 9) is characterised by the elliptical and depressed form of the carapace, its nearly balanced extremities, and the prolongation of the buckler, or cephalic portion, on each side, into slender spikes, distinct from the body; the thoracic and abdominal regions are divided by

two deep, longitudinal furrows, into three lobes; there is also a straight, longitudinal groove, in the front of the buckler (see figures and descriptions of *O. Buchii*, *Geol. Surv. Decade 2*). The Trilobites of this genus are found in the Lower Silurian rocks of North Wales and Ireland; they occur also in great abundance in the slate rocks of Angers, and some species are more than a foot in length.

Some species of the genus PHACOPS have long, pointed caudal appendages, as the *P.* (formerly *Asaphus*) *caudatus* (*Lign.* 177; *Bd.* pl. xlv. figs. 10, 10′; and *Geol. Surv. Decade 2*, pl. i.). The eyes are often well preserved, and each contains about 240 spherical lenses.



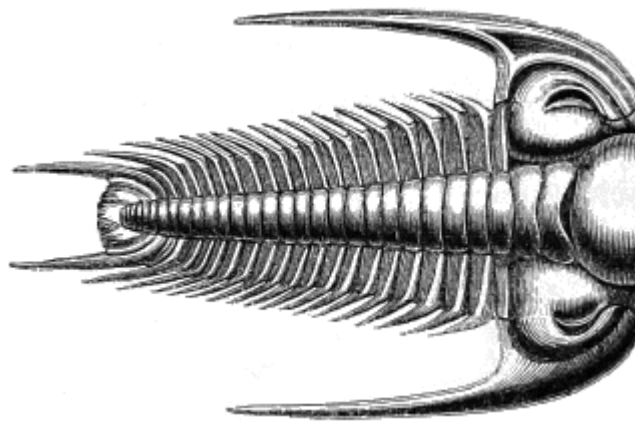
LIGN. 177. PHACOPS CAUDATUS. *Upper Silurian. Dudley.* The caudal extremity.

TRINUCLEUS. *Lign.* 175, *fig.* 2; *Ly.* fig. 432.—This genus comprises several small forms which are found in the Lower Silurian rocks of England, and occur in the equivalent deposits of Sweden, Norway, and Russia.[485] In the *Trinucleus*, the cephalic shield is obtuse, trilobed, rounded, and terminating in lateral spikes; and its margin is marked by numerous pit-like depressions. There are six body-rings or thoracic segments. The caudal shield is large and somewhat

triangular. There are no distinct eyes.

[485] Murch. Sil. Syst. p. 217.

PARADOXIDES. *Lign.* 178.—The Trilobites of this genus are easily recognised by the ends of the lateral segments of the thorax and abdomen terminating in deflected points, which extend in spikes beyond the membrane they supported, and particularly those near the tail, which are much elongated; whereas in the other genera the lateral points of the segments are united by a membrane, which often forms a border beyond them. The cephalic buckler is semicircular, and its lateral angles are lengthened out behind into two strong spines; it is divided on the median line into four protuberances, by transverse grooves. The thorax consists of from sixteen to twenty segments; the abdominal buckler is generally very small and rounded. The animals of this genus have the body much depressed, and the lateral lobes wider than the middle lobe: some species are of considerable size, attaining several inches in length.



LIGN. 178. PARADOXIDES BOHEMICUS: *nat. Silurian. Bohemia.*

A very peculiar form of Trilobite (*Brontes flabellifer*, *Ly*. p. 348) is found in the Devonian strata of the Eifel and South Devonshire; the head, or cephalic region, is narrow, and has two lunated eyes; the thoracic region is trilobed and short, and composed of about ten small articulations; the abdominal very small, and bordered by segments, which radiate and form a wide, fan-shaped expansion. Other species of this genus occur in the Silurian rocks.

With regard to the under surface of the Trilobites much remains to be known. No decided indications either of antennæ or extremities have been discovered. In an American specimen, Mr. Stokes detected a plate,[486] which appears to be a *labrum*, or upper mandible or lip, resembling that of *Apus cancriformis*. This animal has a similar labrum, "and lateral influted terminations of the shelly segments of the body, with a distinctly trilobed *pygidium* (tail or caudal portion), and a prolonged tail: the feet being foliaceous, and the abdomen merely covered by a membrane."[487] In the upper or dorsal surface of the carapace the Trilobites approach certain *Isopoda*, particularly in the characters of the buckler and eyes. Mr. Macleay states that among the existing crustaceans there are certain genera which individually possess some one or more of the characters, which have been thought peculiar to the extinct Trilobites. Thus the *Serolis* (*Bd.* pl. xlv. fig. 6), and the *Bopyrus*, have a trilobed form; the female *Cymothoæ* have the coriaceous margin of the body, and in some species are without eyes as are many of the Trilobites; while the eyes of the males of some *Cymothoæ* are composed of large facets, and are situated on the back of the head, wide apart, as in the *Calymene*; rudimentary feet, and the absence of

antennæ occur in *Bopyrus*; and lastly, the *Sphæroma* has an onisciform body, and the power of rolling itself up into a ball, like the Calymene (*Lign.* 175, *fig.* 4). The analogy between the Bopyrus and the Barr Trilobite is so close, that if the latter had a body with thirteen equal segments, and short crustaceous feet, it would be in every essential particular a male *Bopyrus*.[488] Burmeister regards the Trilobites as being related to the *Branchipus*. From the absence of eyes in the female, and their presence in the male of certain recent genera of crustaceans, it is not improbable that a similar character may have prevailed in the Trilobites, and that certain fossils referred to different genera, from the presence or absence of eyes, may have been the males and females of the same species.

[486] Geol. Trans, vol. ii. p. 208. See also *Bd.* pl. xlv, *fig.* 12; and Burmeister, pl. vi.

[487] Murch. Sil. Syst. p. 665.

[488] Ibid. p. 667.

The habits of the Trilobites, as deducible from Mr. Macleay's exposition of their structure and affinities, must have resembled those of the *Cymothoadæ*, some of which, like the Calymenes, coil themselves up, and are not parasitical; while their close affinity to Bopyrus, and the apparent absence of distinct crustaceous feet, imply that they were to a certain degree sedentary. The flat under surface of their bodies, and the lateral coriaceous margin of several species, which is so analogous to that of the multivalve shell *Chiton*, render it probable that they adhered by a soft, articulated, under surface, to the rocks or sea-weeds. Their instruments of progression are unknown; whether they moved by means of

membranaceous feet, or by the undulations of setigerous segments, like the earth-worm, or by wrinkling the under surface of the abdomen, like the Chiton, are questions yet to be determined. It is evident, from their longitudinally trilobed form, and lateral coriaceous margin, that they had the power of firmly adhering to flat surfaces; and while thus sedentary the thin but hard dorsal crustaceous shell would protect them from the attacks of their enemies. "The Trilobites, probably, like the Chitones, adhered in masses one upon another, and thus formed those conglomerations of individuals which are so remarkable in certain rocks; but it is not likely that they were parasitical, since almost all the existing parasites that adhere to other animals, have strong feet, armed at their extremities with hooks for that purpose."[489] From the form of the *labrum* of the mouth (*Barrande*, pl. i. and ii A) it is inferred that they were carnivorous, preying on naked mollusks, or on the annelides, with which their remains are associated.

[489] Murch. Sil. Syst. p. 669.

As the compound eyes of the *Trilobites*[490] are similar to those of existing crustaceans and insects (see *Wond.* p. 792), the highly interesting and important fact is established, that the mutual relations of light to the eye, and of the eye to light, were the same in the remote epoch when the Trilobites flourished, as at the present time; and that the condition of the waters of the sea, and the atmosphere, and the relation of both these media to light, have undergone no change through the countless ages that have elapsed since the deposition of the Silurian strata.[491]

[490] The compound eyes in many

specimens remain in a high state of preservation. M. Barrande in the eye of a *Brontes palifer* counted 30,000 lenses. See also Barrande, pl. iii.

[491] See Dr. Buckland's eloquent and instructive commentary on this subject, *Bd.* pp. 401-404.

GEOLOGICAL DISTRIBUTION OF FOSSIL CRUSTACEANS. We have seen that the Tertiary strata contain the remains of many of the highest organized crustaceans; a few brachyurous, macrurous, and entomostracous genera appear in the Cretaceous, Oolitic, and Liassic formations; whilst the Isopodous *Archæoniscus* and several species of Cypris occur in the Wealden and Purbeck deposits. Some few Entomostraca have been enumerated from the Trias and Permian.

One species of macrurous decapod has been found in the Muschelkalk of Germany; and Mr. Prestwich's "Apus dubius" (*Geol. Trans.* 2d ser. vol. v. pl. xli. *fig.* 9), and Dr. Ick's crustacean, noticed in *Journ. Geol. Soc.* vol. i. p. 199, both from the Coal Measures of England, are probably true Decapodous Crustaceans. With these exceptions not a species of the numerous tribes of Crabs, Lobsters, &c. has been observed in the older formations, though composed of such enormous thicknesses of marine detritus, and containing countless myriads of the relics of the inhabitants of the ocean.

A few species of *Limulus*, several *Cytheres* and allied genera, and a few Trilobites (*Phillipsia* and *Griffithides*) belong to the strata of the Carboniferous System. In the Devonian System we find some

minute entomostracans, the gigantic *Pterygotus*, and various Trilobites (*Brontes*, *Cheirurus*, *Homalonotus*, *Phacops*, &c.); but it is the Silurian rocks that constitute the grand mausoleum of those ancient beings, the Trilobites.

There are about thirty genera of Trilobites found in the Silurian rocks of Great Britain and Ireland. Many of these are common to the Upper and Lower Divisions of that system; and some of them are met with both in the Silurian and in the Devonian rocks, as *Phacops*, *Brontes*, *Cheirurus*, *Harpes*, and *Homalonotus*. The *Calymene Blumenbachii* (*Lign.* 175, *figs.* 3 and 4) ranges through the Ludlow and Wenlock, to the Bala and Llandeilo formations. The *Phacops caudatus* also (*Lign.* 177), the *Cheirurus bimucronatus*,[492] and the *Encrinurus punctatus*[493] extend from the Ludlow, to the Llandeilo formation. The Upper Silurian rocks exclusively contain some peculiar forms, as *Encrinurus variolaris*, *Bumastus Barriensis*, and several species of *Acidaspis*. And the Lower Silurian has several distinct genera, namely, the *Trinucleus* (*Lign.* 175, *fig.* 2), *Ogygia*, *Agnostus*, *Asaphus*, *Olenus*, *Remopleurides*, &c. One species of *Pterygotus*, and one of *Eurypterus*, the *Ceratiocaris* and *Hymenocaris*, and several species of the minute bivalved Entomostraca (*Leperditia* and *Beyrichia*) are all that remain to be enumerated as constituting, in company with the *Trilobites*, the Crustacean fauna of the ancient Cambrian and Silurian seas.[494]

[492] In Murchison's Silurian System this form is figured (pl. xiv. figs. 8 and 9) and described as Paradoxides bimucronatus.

[493] This is described and figured as Asaphus tuberculatus in Buckland's Bridgewater Treatise, pl. xlvi. *fig.* 6.

[494] We have also to refer to the indications of the existence of other large Silurian Entomostraca afforded by the magnificent series of fossil foot-tracks lately brought to England by W. E. Logan, Esq., and obtained by that gentleman from the Potsdam Sandstone (Lower Silurian) of Eastern Canada. These foot-marks and trails have been determined by Prof. Owen as being most probably referable to some large Crustaceans of the *Limulus* Group, and are named by him *Protichnites*. (See drawings and descriptions in the Quarterly Journal of the Geological Society, vol. viii.)

ON COLLECTING FOSSIL CRUSTACEANS.—The Crabs and Lobsters of the argillaceous tertiary strata are generally imbedded in nodules of indurated clay and septaria. On the shore beneath the cliffs on the north of the Isle of Sheppey, and near Southend, specimens may be observed in the nodules that have been exposed to the action of the waves, the attrition to which they have been subjected having partially worn away the surrounding stone, and displayed the enclosed fossils. In these examples the carapace is occasionally seen on one side, and the pair of pincer-claws on the other face of the boulder; the other feet and the plates of the thorax may sometimes be developed in such examples by chiselling away the enveloping mass. In the laminated marls of the tertiary and other deposits, in which the minute crustaceans, as the *Cyprides* abound, thin slabs covered with these relics may be easily extracted; and many of the tertiary clays and sands yield *Cytheres*, together with *Foraminifera* and other minute fossils, on careful washing and examination with a lens.

The Chalk crustaceans, particularly those which are muricated, or beset with spines and tubercles, as the *Enoploclytia Sussexiensis* and *E. Leachii* (*Lign.* 169), require considerable patience and dexterity to develope successfully. The crustaceous covering of the carapace and claws adheres firmly to the chalk by the rough external coat, while the inner, smooth, glossy surface as readily separates. Hence, upon breaking a block of chalk containing portions of these crustaceans, we find one piece exhibiting a chalk cast of the claw or carapace, covered with tubercles or papillæ, that have been moulded in the bases of the spines of the crust; and on the other portion the crustaceous shell imbedded by its outer surface, and presenting the internal glossy lining, beset with circular depressions, which are the bases of the spines. This crust is exceedingly friable, and will flake off by a very slight touch. To obtain specimens with the external characters, it is necessary to proceed with great caution; and when indications of a crustacean are observed in a block, the chalk should be chiselled or sawn off to within half an inch of the surface of the fossil, and the remainder of the stone be cleared away, piece by piece, by means of a penknife or graver. By this process the fossils figured *Foss. South D.* pl. xxix. xxx. xxxi. were developed. When a fine specimen has been broken, and the shell is attached to one piece of the stone and the cast to the other, it is possible to obtain an illustrative example of the external surface, by cementing the pieces accurately together with very thin hot glue; and, when firmly consolidated, the chalk may be removed, and the spines, tubercles, and papillæ of the crustaceous covering be developed by the method previously described. A thin coating of mastic varnish will give durability to the crust,

and improve its appearance; but the rich brown colour it possesses when first exposed soon disappears. The Crustaceans of the Galt are often found amongst the argillaceous and pyritous nodules flung aside in heaps where the Galt is used for brick-making.

The *Cytheridæ* of the Chalk, Galt, Oolite, &c. are to be obtained by disintegrating the matrix in water, and examining the debris, after sifting, under a lens.

The Limuli of the Coal-measures often form the nuclei of clay nodules, as in the example figured *Lign.* 172, in which *fig.* 2 represents the nodule without any external indication of its contents, and *figs.* 1, and 3, the same broken, and displaying the crustacean. Traces of the legs, branchiæ, and other appendages, should be diligently sought for in fossils of this kind, for they are more likely to be detected in such specimens than in those found in limestone. It is possible that polished sections of the coiled up examples of Trilobites (*Lign.* 175, *fig.* 4) would throw some light upon the nature of the hitherto undiscovered organs of locomotion and respiration of this extinct order of Crustaceans.

A FEW BRITISH LOCALITIES OF FOSSIL CRUSTACEANS.

Abberley. Silurian: *Trilobites* and *Beyrichia*.

Aberystwith, neighbourhood of. Silurian: *Trilobites*.

Arundel, Sussex. Chalk-pits in the vicinity. Astacidæ and Cytheridæ.

Atherfield, Isle of Wight. Wealden: *Cyprides* in clay (*Lign.* 174).

Barr, Staffordshire; limeworks at Hay Head. Silurian: *Trilobites*, particularly of the genus *Bumastus*.

Bewdley, Shropshire. Silurian: *Trilobites*.

Bolland, Yorkshire. Carboniferous Limestone: *Trilobites* (*Cyclus*, *Phillipsia*).

Burdie-house, near Edinburgh. Fresh-water coal-measures. *Cyprides* and *Eurypteri*.

Burham, near the banks of the Medway, Kent. Quarry of Mr. W. Lee, a good section of the lower Chalk: fine *Crustaceans*.

Coalbrook Dale. Coal-measures and Silurian. *Limuli* and *Trilobites*.

Coniston, Lancashire. Silurian: *Trilobites*.

Dinley, Wilts. Purbeck. *Isopoda* (*Lign.* 171) and *Cyprides*.

Dover. In the lower Chalk, *Astacus* (*Enoploclytia*) *Sussexiensis*, &c.

Dudley. Upper Silurian: *Trilobites* in abundance.

Durlstone Bay, near Swanage. Purbeck: *Cyprides* and *Isopoda*.

Folkstone, Kent. In Galt: small Crabs (*Lign.* 168), and numerous *Cytheres*.

Grays, Essex. Pleistocene: *Cyprides*.

Gristhorpe Bay, Yorkshire Oolite: *Astacidæ*.

Hastings, Sussex, neighbourhood of. Wealden: *Cyprides*.

Hollington, near Hastings. Wealden: *Cyprides*.

Hordwell Cliff, Hampshire. Upper Eocene: *Cyprides*.

Kildare, Ireland. Carboniferous and Silurian: *Trilobites*.

Langton Green, near Tunbridge Wells. Wealden: *Cyprides*.

Lewes, Sussex. In the Chalk-pits of the vicinity: Astacidæ (*Lign.* 169), and other Crustaceans.

Llandeilo, Caermarthenshire. Lower Silurian: *Trilobites*, *Trinuclei*.

Lyme Regis, Dorset. Green Sand: Hoploparia. Lias: *Coleia*.

Malvern Hills. Lower Silurian. *Trilobites* (*Olenus*).

Meifod Hills, Montgomeryshire. Silurian: *Trilobites*.

Mount Pleasant, Caermarthen. Silurian: *Trilobites*.

Newton Bushel. Devonian: *Trilobites* (*Brontes*).

Rhiwlas, near Bala, North Wales. Lower Silurian: *Trilobites*.

Ringmer, near Lewes. In Galt: small *Crabs*, &c.

Sandown Bay, Isle of Wight. *Cyprides*, in Weald Clay.

Scarborough. Oolite: *Astacidæ*, in clay nodules.

Sheppey. London Clay: *Lobsters* and *Crabs*.

Steyning, Sussex. In Chalk-marl: *Lobsters*, &c.

Tyrone, Ireland. Carboniferous and Silurian: *Trilobites*.

Wenlock, neighbourhood of. Upper Silurian: *Trilobites*.

Westbury, Gloucestershire. Lias: *Estheria* and *Cyprides*.

Wilmington, near Marton, Salop. Silurian: *Trilobites*.

Wistanstow, Salop. Lower Silurian: *Trilobites*.

Worthing, Sussex. Neighbouring Chalk-pits. *Lobsters*, &c.

FOSSIL INSECTS, SCORPIONS, AND SPIDERS.

From the Crustaceans we pass by a natural transition to the other Articulata, viz. the ARACHNIDA (Scorpions and Spiders) and the INSECTA, in the last of which "the highest problem of animal mechanics is solved, and the body and its appendages can be lifted from the ground and propelled through the air" (*Owen*). The skeleton in these animals, as in the Crustaceans, is chiefly external, and consists of a hard shell or case (composed of a peculiar substance, termed *chitine*), divided into segments, and furnished with articulated or jointed hollow extremities. The head is distinct, and has a pair of compound eyes, and of jointed antennæ. To the segments that form the thorax the legs are attached, and these consist of three pieces in the hexapods (insects with six feet), each supporting

a pair of feet. The wings in the flying insects are attached to the middle and third thoracic segments. The legs, or articulated appendages, are hollow, as in the Crustaceans, and contain the muscles and other soft parts. The generic and other distinctions adopted by naturalists, to facilitate the study of this most numerous division of the animal kingdom, are founded on the structure and configuration of the antennæ and wings. The latter consist of flat membranous expansions, supported by hollow tubes or nervures; and in some orders consist of one pair, and in others of two. In burrowing insects, as the Beetle, the front pair of wings constitutes a hard case (*elytron*), which covers and protects the membranous posterior pair, when the animal is in repose or walking. The modifications of the wings furnish the characters by which the class is divided into orders. Thus the *Coleoptera* (sheathed-wings) comprise the beetles and other burrowing insects, in which the membranous wings are folded transversely beneath the elytra, or wing-cases. The *Orthoptera* (straight-wings), those with two pairs of wings, of which the anterior encase the others, the posterior being membranous, and folded longitudinal during repose; as the Earwig, Cockroach, Mantis, and Locusts. *Neuroptera* (nerved-wings), those with two pairs of transparent reticulated wings, as the Libellula, or Dragon-fly, the Ephemera, and the Termites. *Hymenoptera* (membranous-wings), with simply veined membranous wings, as the Gall-flies, the Bee, &c. The Cicas, Aphis, and Coccus constitute the somewhat anomalous group termed *Homoptera* (equal-wings), in which the anterior pair of wings are usually similar to the posterior in consistence, and shut up in a roof-like manner. The *Heteroptera* (different-wings) include the Nepa, Notonecta, &c.

and have the anterior wings coriaceous at the base, membranous towards the point, and shutting up nearly horizontally, partly lapping over one another. *Lepidoptera* (scaly-wings) have wings covered with scales, as the Butterfly and Moth. In the *Diptera* (two-wings) the anterior pair of wings only are the instruments for flying, and the hinder pair are reduced to mere clavate appendages, as the Gnat and Fly. The Phryganeæ (Caddis flies) constitute the order of *Trichoptera* (hairy-wings), related to the Neuroptera, but resembling the Lepidoptera in the distribution of the nervures of the wings, and in many other characters. Lastly, there remain the Wingless Insects, divisible into three orders, of which the Flea, the Parasites, and the Podura are respectively the types. With these few remarks on those durable parts of the structure of Insects which their fossil remains generally present, we must quit this part of the subject, and enter upon the examination of the relics which are the immediate objects of our present inquiry.

From the enduring nature of the elytra, segments, and articulated extremities of insects, the fossil remains of animals of this class might naturally be expected to abound in lacustrine and fluviatile deposits; this, however, is not the case, and except in a few favoured localities, fossil insects are seldom met with, and good specimens rank among the most rare and interesting of the organic remains of the Secondary formations. In certain Tertiary beds, as at Œningen, and Aix in Provence, insects of numerous species and genera have been discovered; and the cream-coloured limestone of Solenhofen, among its numerous other treasures, has yielded some fine examples of this class. The strata in which remains of insects have been found in England[495] are the

Tertiary clays of the Bagshot series, the Hastings beds, Purbeck marls and limestones, Kimmeridge Clay, Oxford Clay, Forest Marble, Stonesfield Slate, Upper and Lower Lias, and the Coal Measures.

[495] Palæontologists are particularly indebted to the Rev. P. B. Brodie, F.G.S. for his compendious and valuable "History of the Fossil Insects in the Secondary Rocks of England" (8vo. 1845); and to J. O. Westwood, Esq. the eminent Entomologist, for the very important and interesting Observations on the Insect Remains, prefixed to the above work. In an interesting paper on the Geology of the vicinity of Ilminster, C. Moore, Esq. has noticed the numerous Insect remains of the Upper Lias of that place. Prof. E. Forbes and W. R. Binfield, Esq. have discovered Insects in the Hastings series; and Mr. Binfield, besides having most successfully searched the Upper Lias of Gloucestershire, has also detected some specimens in the Lias at Lyme. Lastly, Mr. Morris has found Insects in the Upper Lias in Lincolnshire.

ARACHNIDA.

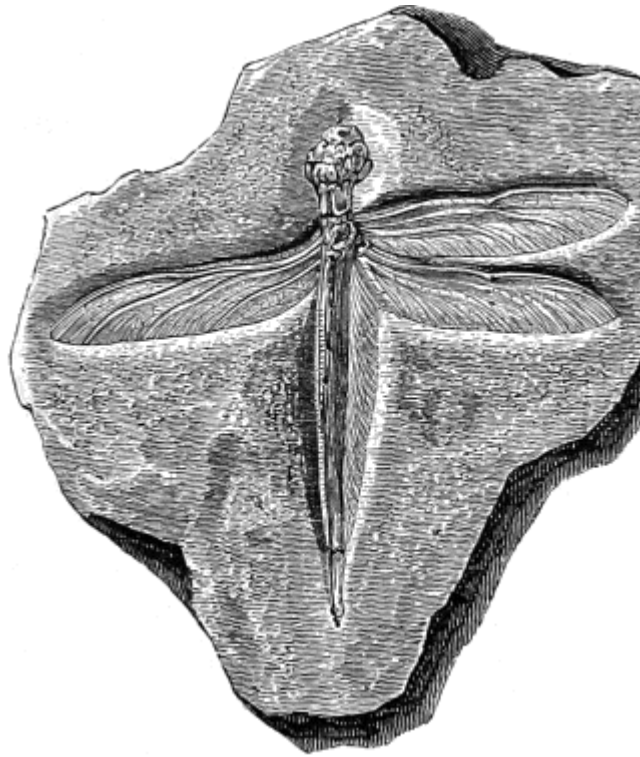
FOSSIL SCORPION. (*Bd.* pl. xlvi′.)—The discover of a fossil Scorpion in coal-shale, associated with leaves, by Count Sternberg, and of Spiders in the limestone of Solenhofen, by Count Münster, proves the existence at a very remote period of both these insectivorous families of *Arachnidans*, or spiders (*Bd.* p. 405). The fossil Scorpion was found in a block of argillaceous shale, at Chomle, in Bohemia. It lies imbedded amidst the carbonized remains of leaves, and a large trifid carpolithe or seed-vessel (see *Bd.* pl. xlvi′.): by a fortunate separation of the shale, the

back or dorsal carapace is shown on one surface; and the thorax, with five or six legs attached, and the abdominal segments, are exposed on the other, together with a fragment of the tail of another and larger Scorpion. The head and eyes, one of the jaws with teeth, and a portion of the skin remain (*Bd.* pl. xlvi. figs. 3, 4, 5, 6). The horny covering seems to have undergone no change; it is still elastic and transient, and consists of two layers, both retaining their texture, and structure, and exhibiting under the microscope hexagonal cells divided by strong partitions.

FOSSIL SPIDERS.—With the numerous insects preserved in the gypseous marls at Aix, of which we shall treat hereafter, Spiders are occasionally found. A beautiful example, showing the under surface of a small spider, with the papillæ of the spinning organs protruded by pressure, from the cabinet of Mrs. Murchison, is figured, *Bd.* pl. xlvi′. fig 12 In the beautiful lithographic stone of Solenhofen the remains of spiders are not unfrequent.

INSECTA.

FOSSIL NEUROPTERA.—Of this order, the insects of which are distinguished by their four finely reticulated membranous wings, several fossil species have been found. Some of these are referable to the family Libellulidæ;—insects so well known from their light and elegant figure, their beautiful and variegated colours, their large lustrous wings, and the velocity and gracefulness of their motions.



LIGN. 179. FOSSIL LIBELLULA, OR DRAGON-FLY. *Solenho*
(*Drawn by Mr. Joseph Dinkel.*)
In the cabinet of the late Marquess of Northampton.

FOSSIL LIBELLULIDÆ. *Lign.* 179.—Of the highly organized family of carnivorous insects, the *Libellulidæ*, five or six specimens have been discovered in the lithographic limestone of Solenhofen; a beautiful specimen from that locality is represented, *Lign.* 179. In this example both pairs of wings remain, but one wing is pressed down beneath the abdomen: the nervures of the wings are admirably preserved.

A few examples of the remains of this family have been found in the British strata. One species of

Libellula and one of *Æshna* have been found by the Rev. Mr. Brodie in the Purbeck beds of the Vale of Wardour. Two species of *Libellula*,[496] two of *Æshna*, and some other allied species have been obtained by Messrs. Strickland, Buckman, Binfield, and Brodie from the Lias. The wing of the *Æshna liassina*, discovered in the Lias, near Binton, in Warwickshire, by Mr. Strickland, is two inches and ten and a half lines in length, and eight and a half lines in its greatest breadth, being one-third larger than the wing of the largest British species. See *Wond. Lign.* 119, and p. 528.

[496] A very interesting specimen of fossil *Libellula*, discovered by the Rev. Mr Brodie in the Upper Lias near Cheltenham, is figured in the Quarterly Geol. Journal, for 1848, vol. v. pl. v.

FOSSIL CORYDALIS. *Lign.* 181, *fig.* 2.—The wing of a remarkable fossil Neuropterous insect was discovered by me in a nodule of ironstone, from Coalbrook Dale, and mistaken for a leaf. The specimen consists of one wing, which, as M. Audoin first ascertained, closely resembles that of the living *Corydalis* of Carolina; see *Lign.* 181, *fig.* 2. The membranous structure and the distribution of the nervures are distinctly preserved; on the portion figured the surface of the wing lies in relief on the stone; and on the corresponding part of the nodule, a sharp imprint remains,[497] I have named this fossil in honour of the eminent French savant, M. Alex. Brongniart.

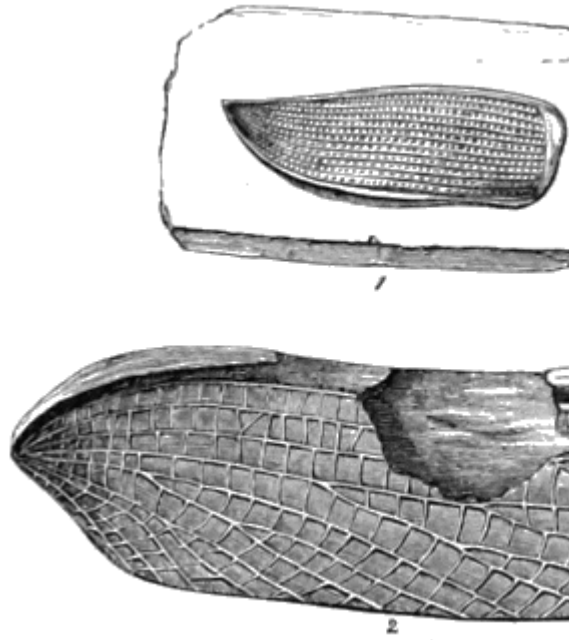
[497] This specimen is now in the collection of the British Museum.

Wings of *Corydalis* have also been found in the

Purbeck beds of the Vale of Wardour, by the Rev. Mr. Brodie, who has also discovered remains of *Phryganeidæ* and a *Termes* in the same group of strata.

PANORPA ? LIASSICA. *Lign.* 180.—In the Lias, on the banks of the Severn, at Wainlode Cliff, Gloucestershire, specimens of minute neuropterous wings have been discovered. I subjoin accurate figures of two specimens in the cabinet of the Geological Society; they are represented twice the natural size; they resemble the wings of a recent genus of Neuroptera, termed *Panorpa*; particularly *P. Germanica*. The transverse lines are not fractures, but nervures, and are faithfully copied from the originals.

To the above notice of British fossil neuropterous insects, I may add that the wing of a large species (*Hemerobioides giganteus*) has been discovered by Dr. Buckland in the Stonesfield slate.



LIGN. 181. FOSSIL WINGS OF INSECT
(*Drawn by S. P. Woodward, Esq.*)
Fig. 1.— ELYTRON, or wing-case of BUPRESTIS BUCKLANDI, *Great Oolite*
2.— Wing of CORYDALIS BRONGNIARTI. (G. A. M.) *Carboniferous*; C

FOSSIL COLEOPTERA.—The *elytra* or wing-cases of coleopterous insects have long since been noticed in the oolitic slate at Stonesfield, near Oxford; a locality celebrated for the only mammalian relies hitherto discovered in the Secondly strata of England. The Stonesfield elytra are always found detached; in no instance, I believe, has any other part of an insect been observed, except a single leg of a *Curculio* (*Bd.* pl. xlvi′. *fig.* 10). The specimen figured *Lign.* 181, *fig.* 1, displays the usual characters of the largest species. These fossils are of a reddish-brown colour, with a finely granulated surface; there appear to be four or five species, all of which belong to *Buprestis*, a family of beetles remarkable for their splendid metallic

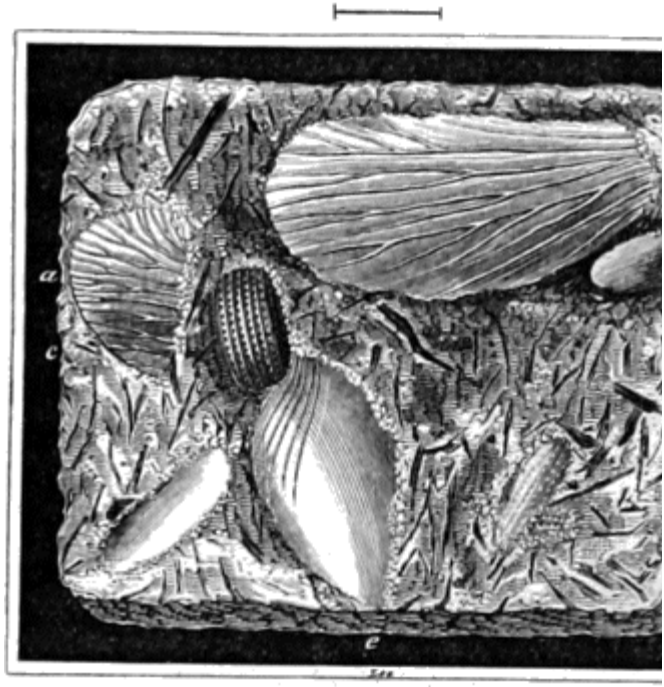
lustre. Remains of *Coleoptera* occur in the Tertiary clays near Corfe, Dorset,[498] and in the Lias of Worcestershire and Gloucestershire; and in the Danby oolitic coal-pits, in the eastern moorlands of Yorkshire, the elytra of beetles have also been discovered, by Mr. R. C. Taylor (*Bd.* vol. ii. p. 78).

[498] See Notice by the Rev. Mr. Brodie, Quart. Geol. Journ. vol. ix. p. 51.

A most remarkable fossil of this kind is described by Dr. Buckland; a unique specimen of *Buprestis*, from Japan, about an inch long, *converted into chalcedony*, with the antennæ and portions of the legs finely preserved. The surface of this insect is covered with clusters of minute concentric rings of chalcedony; an appearance common in silicified shells. Associated with this fossil, were fragments of silicified wood, bored with tubular cavities, apparently by the larvæ of insects of this family; and within these cavities was a quantity of dust produced by the boring, also converted into chalcedony (*Bd.* vol. ii. p. 78).

Of the CURCULIO, a genus of coleoptera distinguished by their splendid elytra, of which the *Diamond Beetle* is a familiar example, the remains of two species have been discovered in the nodular ironstone of Coalbrook Dale, by Mr. W. Anstice, and are figured and described by Dr. Buckland (*Bd.* vol. ii. p. 76; and pl. xlvi′. figs. 1, 2). In one of these specimens (*Curculioides Ansticii*), with the exception of the rostrum and anterior part of the head, all the essential characters of the insect are displayed; namely, the elytra, thorax, and six legs, the hindmost of which exhibits the enlarged femur, or thigh, a character peculiar to the *Curculionidæ*. The legs possess a tufted appearance, which that eminent entomologist, Mr. Curtis, conceives may have been caused by fungi, after the death of the animal, as often happens in tropical climates. In the other example (*C. Prestvichii*), the insect lies on its back, with the left side raised upwards, and exhibiting a

portion of the external surface of the left elytron; there are remains of the antennæ, and indications of the proboscis and of the legs.



LIGN. 182. INSECTIFEROUS LIMESTONE. *Purbeck.*
(*Magnified six diameters.*)

a, b. Membranous wings of the *Corydalis* type.
c. Punctate-striate elytron of a Beetle.
d. Elytron of a Beetle, with a smooth surface.
e. Smooth elytron, the upper part impressed with transverse lines.

The *Orthoptera*, *Homoptera*, and *Diptera* are also represented in the Lias of Gloucestershire, and in the Purbeck strata of the Vale of Wardour, by numerous species, which have been enumerated, and mostly discovered, by the Rev. Mr. Brodie.[499] This observer has, indeed, been very successful in his

researches in the latter locality, for in the deposits of limestone and marl which yielded the isopodous crustaceans, previously described (p. 521, *Lign.* 171), he has discovered the remains of several orders of insects, and states that, for abundance and variety of specimens, the beds may be said to resemble the Tertiary marls of Aix and Œningen. These remains were obtained from a quarry at Dinton, about twelve miles west of Salisbury. They consist chiefly of *Coleoptera*, with the remains of *Neuroptera*, *Trichoptera*, and *Homoptera*, and of several species of *Diptera*. In the cream-coloured laminated Purbeck marls that axe exposed in Durlstone Bay (about one mile from Swanage) insectiferous beds have been found by the Rev. O. Fisher and Prof. E. Forbes, which are the equivalents of those of the Vale of Wardour; and similar beds were met with in the cutting of the railway through the Ridgway Hill, between Dorchester and Weymouth.

[499] See Brodie's Fossil Insects.

In a quarry on the road-side between the village of Stone and Hartwell, Bucks, the Portland Oolite is covered by the Purbeck marls; in these latter remains of Insects occur, together with scales and teeth of small Fishes, and abundance of *Cyprides*.

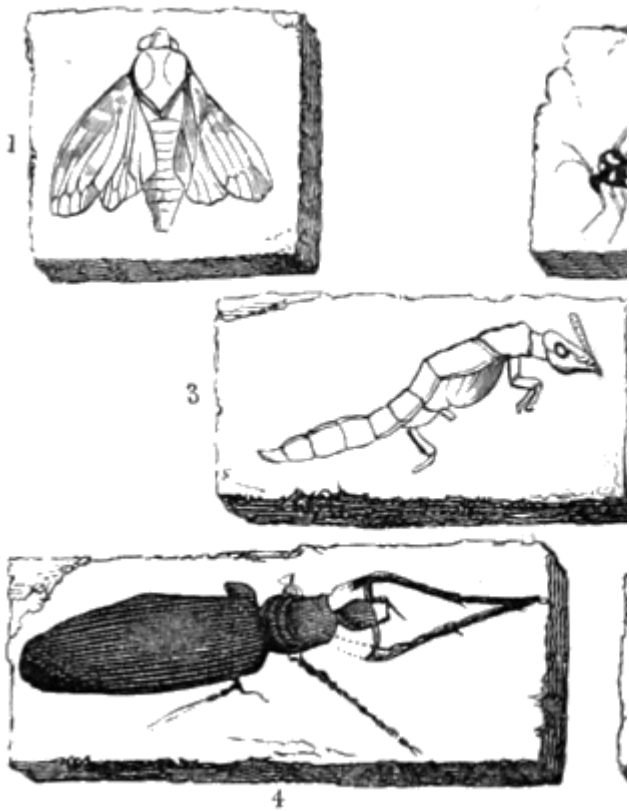
All the British localities of fossil insects have now been alluded to; but on the Continent, independently of the celebrated limestones of Solenhofen, to which reference has been made, p. 550, there are several tertiary deposits exceedingly rich in these interesting fossils.

FOSSIL INSECTS.

FOSSIL INSECTS OF AIX, IN PROVENCE.—The town

of Aix is situated in the lowest part of a deep valley, the immediate flanks of which are composed of a thick fresh-water formation, lying unconformably upon strata of Jura limestone. The fresh-water series consists of white and grey calcareous marls, calcareo-siliceous grits, and beds of gypsum; and the quarries formed in the latter rock have long been celebrated for the prodigious quantity of fish and plants which they contain. M. Marcel de Serres first made known the great abundance of insects in these gypseous marls, and has enumerated nearly seventy genera, chiefly of the Coleoptera, Diptera, and Hemiptera; they are mostly referable to European forms, and to existing genera. An interesting Memoir on these strata, by Sir R. Murchison and Sir C. Lyell,[500] first directed the attention of the English reader to these beautiful fossils. In *Wond.* p. 261, an epitome of this valuable communication is given, and five specimens of insects are here figured, which will convey some idea of their forms and perfect state of preservation.

[500] Edinburgh New Philosophical Journal for October, 1829.



LIGN. 183. FOSSIL INSECTS. *Tertiary. Aix in*

Fig. 1. TETTIGONIA SPUMARIA.

—

2. MYCETOPHILA; the body distended by pressure.

—

3. LATHROBIUM.

—

4. Allied to PENTHETRIA HOLOSERICEA. The hinder legs are broke

— that the *tarsi* nearly touch the thigh; the *palpi* are long and perf distinct.

5. LIPARUS; resembling L. PUNCTATUS.

—

FOSSIL INSECTS OF ŒNINGEN.—In the immediate

vicinity of Œningen, near Constance, on the banks of the Rhine, there is the basin of an ancient lake, filled up with marls and limestones, presenting a fine example of a lacustrine formation, and abounding in fossil Fishes, Reptiles, Plants, Shells, Crustaceans, and Insects.[501] These Insects are often in an admirable state of preservation, and occur in the different stages of larva, pupa, and imago. The pupa of a *Libellula* shows the mask, insertion of the legs, and the spiracula. Some belong to genera, the species of which frequent marshy plants of the same kind as those which are found associated with the insects; and it seems probable that they fell into the lake from the plants which grew on its borders, and became enveloped in the fine mud or sediment. Numerous species of several genera of Ants also occur in these deposits of Œningen and at Radoboj in Croatia.[502]

[501] See the Memoir by Sir R. I. Murchison on the lacustrine formation at Œningen, near Constance, Geol. Trans, new series, vol. iii. p. 277.

[502] See Prof. O. Heer's Memoir, translated in the Quart. Journ. Geol. Soc. vol. vi. pt. ii. p. 61; and his History of Insects, ibid. p. 68.

FOSSIL CADDIS-WORM.

FOSSIL LARVÆ OF PHRYGANEA. *Ly.* p. 185.—The *Caddis-worm*, so well known to all the brethren of the angle, is the larva of the winged insect termed *Phryganea*, and is abundant at the bottom of fresh-water streams and lakes; the cases, like those of the marine *Sabella* (p. 385, *fig.* 6), are always studded over with extraneous bodies, cemented together by a glutinous secretion to the silken integument, or case,

which encloses the lava. Some species are coated with pieces of stick or straw, others with minute shells, as planorbis, bithinia, and the like; and when the larvæ have passed into the perfect state, their cases, or *indusiæ*, remain. Many of the Tertiary fresh-water limestones of Auvergne are almost wholly composed of the *indusiæ* of Caddis-worms, cemented together by calcareo-siliceous matter into stone, which is employed for building, and is called indusial limestone (*Wond.* p. 273). These limestones are associated with marls abounding in fresh-water shells and cyprides; the whole assemblage presenting all the stratigraphical and zoological characters of a lacustrine formation. "If," says Mr. Scrope,[503] "we consider that repeated strata, of five or six feet in thickness, almost entirely composed of these tubes, once extended over a district presenting a surface of many hundred square miles, we may have some idea of the countless myriads of minute beings which lived and died within the bosom of that ancient lake."

[503] On the Geology of Central France, by G. Poulett Scrope, Esq. 4 to. 1827.

On Collecting Fossil Insects.—The localities in which the British collector may reasonably expect to discover fossil remains of Insects, are Stonesfield, where the elytra of beetles are by no means scarce,—Coalbrook Dale, in which relics of this class are sometimes, but very rarely, found in the ironstone nodules,—Bedford, Warwickshire, and the Wainlode and Aust Cliffs, for Lower Lias insects,—Dumbleton and Ilminster, for Upper Lias insects,—Dallards, near Dinton, and Stone, near Aylesbury, and the exposures of similar beds in Dorsetshire, for the Purbeck insects.

The white clays belonging to the Bagshot series of Bournemouth, Poole, and Corfe, so rich in beautifully preserved leaves and other parts of plants, should be carefully searched for insect remains, since these clays at Creech, near Corfe, have already afforded a few specimens.[504]

[504] Quart. Geol. Journ. vol. ix. p. 51.

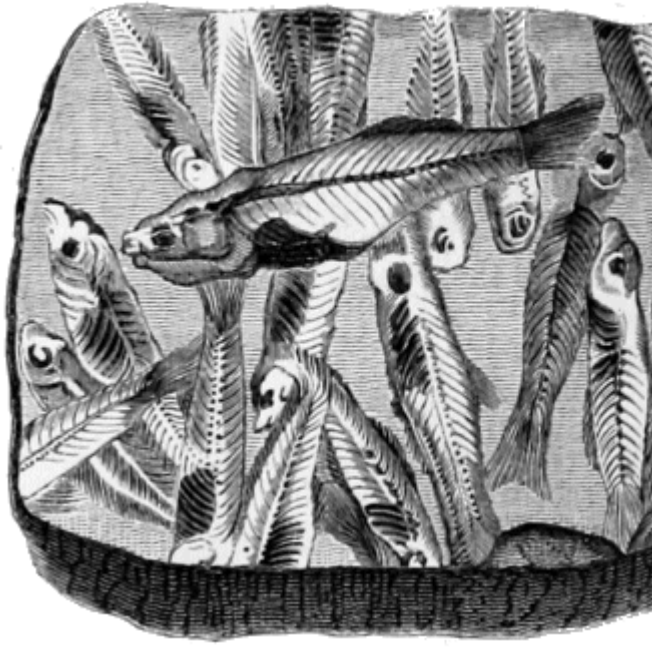
At page 549 a few other English localities yielding these delicate and very interesting fossils are also indicated as having been lately discovered by some of our most acute and active geologists.

Should the student visit the celebrated sites of these fossils in France and Germany, namely, Aix, Œningen, Solenhofen, &c., he will have but little difficulty in obtaining an interesting series, at a moderate expense.

The marls and limestones in which insects occur are often of a laminated character, and in general readily split asunder in the direction favourable for the display of the insects. In some examples, only the form of the animal is seen through a thin opaque pellicle of calcareous earth, which may be removed by a penknife or graver, and the wings, elytra, antennæ, legs, &c. will thus be disclosed. A very thin coating of mastic varnish heightens the colours of such specimens, and renders them more durable.

CHAPTER XIV.

FOSSIL ICHTHYOLOGY; COMPRISING THE SHARKS, RAYS AND OTHER PLACOID FISHES.



LIGN. 184. A GROUP OF FOSSIL FISHES. *Tertiary.* LEBIAS CEPHALOTES (*Agassiz*).

ASCENDING from the two grand subdivisions of the animal kingdom, the *Mollusca* and the *Articulata*, we advance to the VERTEBRATA, animals distinguished from all those which have previously engaged our attention, by the possession of a bony, jointed, hollow column of support, or spine, formed of bones termed *vertebræ* (*turn or whirl bones*), and enclosing and protecting those strands or cords of the nervous system called the spinal marrow; the former classes, being destitute of such a structure, have the general name of *Invertebrata*.

In the beings whose mineralized remains form the subject of our present investigation, the durable parts of the frame-work, or skeleton, are, in most instances, situated internally, and their fossil relics consist principally of the bones, or solid earthy portions of their structures, either imbedded in the rocks in their natural relative position, or in a state of dismemberment and dispersion. In most cases the teeth, and in many the durable parts of their external integument, or skin, are also preserved, in a greater or less degree of integrity.

In the lowest class of *vertebrata*, the FISHES, the skin is covered with numerous pieces or scales, of a dense, durable substance, and strengthened, in some families, by the addition of osseous plates; thus constituting a flexible and almost impenetrable coat of armour, which affords suitable protection to beings peculiarly exposed to external injuries, from the nature of the regions they inhabit, and the state of warfare with each other in which they are constantly engaged. Confined to a fluid medium, they are provided with organs fitted for aquatic respiration, called *branchiæ*, or gills, and with instruments of progressive motion, termed *fins*, by which they are enabled to propel themselves through the water with great velocity. The apparatus for seizing, tearing, and crushing their prey presents numerous and important modifications, corresponding to the habits and economy of the different genera; their teeth offering as great variety of form and structure as those of the higher orders of animals.

The cartilaginous or the osseous nature of the skeleton, and the number and position of the fins, were the characters formerly employed in the

classification of Fishes; but Prof. Agassiz, conceiving the structure of the skin to afford a natural index to the essential modifications of organization and functions, has, with great sagacity, adopted an arrangement founded upon the form and structure of the scales; and he has divided the whole class into four orders, each distinguished by essential differences in the dermal (skin) system. To the geologist this method has proved of inestimable value; for it is simple, easy of application, and, so far as our present knowledge extends, may be relied upon as affording accurate conclusions as to the nature and relations of the originals to which a few detached fossil scales may have belonged. Another important aid has been derived from the microscopical examination of the structure of the teeth; and a splendid work on this subject by Professor Owen has opened a wide field of palæontological investigation, which is yet but very partially explored.[505]

[505] ODONTOGRAPHY; or, a Treatise on the Comparative Anatomy of the Teeth; their Physiological Relations, Mode of Development, and Microscopic Structure; illustrated by upwards of 150 plates. By Prof. R. Owen, F.R.S. &c. 4to. London. 1840-1845.

The living species of Fishes exceed eight thousand; and those found in a fossil state, and determined by M. Agassiz, already amount to upwards of one thousand five hundred; while several hundreds are still undescribed; and the rapid progress of geological research is continually adding to the number: upwards of six hundred British fossil species are enumerated. In an initiatory work like the present, it will be necessary to confine our remarks to an illustration of the mode in which the

investigation of the fossil remains of the animals of this class should be conducted; and, by the elucidation of a few leading principles, prepare the student for the perusal of works expressly devoted to this branch of Palæontology.[506]

> [506] The admirable and important work entitled "*Recherches sur les Poissons Fossiles, par Louis Agassiz,*" stands preeminent in this department of science. It consists of five volumes, 4to. of letter-press, and five volumes, folio, of coloured plates. It must be consulted by all who would acquire a correct view of the present state of fossil Ichthyology. *It is from this work that the commentary in the text has been chiefly derived.*

The fossil remains of fishes rank in the first class of the "Medals of Creation," for they demonstrate the existence of numerous tribes of highly organized beings in some of the most ancient fossiliferous strata, and the continuance of the same type of organization, variously modified, through the entire series of subsequent deposits to the present time. Each geological formation contains peculiar groups of fossil fishes, distinguished by distinct modifications of structure. Thus, according to the data at present obtained, all the osseous fishes anterior to the Chalk belong to genera which have no representatives among existing species; and they are characterised by rhomboidal scales covered with enamel.

The state of conservation in which the fossils of this class occur, appears to have depended on the relative delicacy or firmness of the original structures, and on the nature of the deposits in which the fishes were imbedded. Thus the fossil fishes of

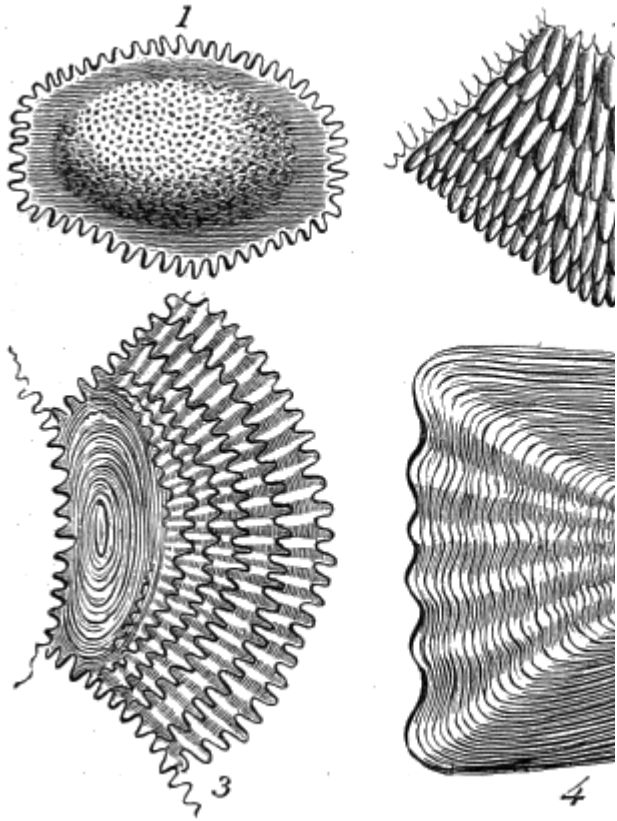
the early formations, which are characterised by their dense integument and enamelled scales, often present the entire forms of the originals, and generally considerable portions of the connected scales, with the fins and other appendages: while the specimens of later deposits, which contain a large proportion of species with delicate scales, more often display the mineralized osseous skeleton, than the dermal structure. Sedimentary strata composed of mud or fine detritus, of whatever age, have been most favourable to the preservation of the entire forms; hence we often find in the pulverulent clays and marls of the Tertiary strata, in the Chalk of England and Westphalia, and in the fine lithographic stone of Solenhofen, fishes perfect in form, and not only individuals, but groups, with the scales, fins, head, teeth, and even the capsule of the eye, in their natural positions. A small slab of marl from Aix, in Provence, in the collection of Sir R. I. Murchison, contains scores of small fishes, as perfect as if recently imbedded in soft mud: a portion of this specimen is represented, *Lign.* 184; and the beautiful fish figured in the frontispiece of vol. i. (pl. i. *fig.* 3), from near Castellamare, will serve to illustrate the state of perfection of some of the ichthyolites of the Jura limestone. In the Chalk, many of the fishes are uncompressed, the body being as perfect in form as if the original had been surrounded by soft plaster of Paris while floating in the water. But in coarse limestones and conglomerates,—in other words, in materials that have been subjected to the action of the waves and torrents,—detached teeth, scales, bones, &c. constitute the principal vestiges of this class of beings.

In illustration of this department of Paleontology, it will be expedient to consider,—1stly, the

characters afforded by the scales and dermal appendages; 2dly, the teeth, or dental organs; 3dly, the osseous and cartilaginous skeletons; and lastly, apply the data thus obtained to the elucidation of some of the principal fossil genera and species.

SCALES OF FISHES.—The dermal plates or scales are composed of two substances, disposed in laminæ or plates; the one cartilaginous or horny,—the other dense and osseous, possessing the structure of bone. In most species the scales are imbricated, *i. e.* lie over each other like the tiles of a roof; the margin of a front row partly covering the series immediately behind. From this arrangement, the apparent shape of the scales is very different from their true form; the processes of attachment and the lateral angles being concealed. The scales that are not imbricated are either very small, and imbedded in the substance of the skin so as to be imperceptible to the naked eye, as in the shagreen of Sharks; or are disposed in the form of bosses or scutcheons, as in the Rays; sometimes bristling equally over the surface of the body, as in the *Diodon*; and sometimes covering it like mosaic work; or forming particular series on certain regions of the body, while the other parts are garnished with different scales, as in the Sturgeon. There are a few genera destitute of scales. In almost all fishes there is a particular series disposed in a gently undulated line along each side of the body, from the head to the tail, and constituting what is termed the lateral line; these scales are tubular, and serve an important purpose in the economy of these animals. Every one must be aware that the body in most living fishes is constantly covered with a kind of mucus, or slime, which serves to lubricate the skin and to defend it from the action of the surrounding medium. This fluid is secreted by a mucous canal or

duct, which extends along the body, and ramifies in all the bones of the head, jaws, &c.; and it is distributed over the surface of the head by numerous pores in the bones, and over the body by the tubes formed by the row of scales above described.



LIGN. 185. FOSSIL SCALES OF FISHES. (*highly magn.*)

Fig. 1.— Scale or plate of the *shagreen* of a SHARK.

2.— Scale of MACROPOMA MANTELLI; the exposed surface.

3.— Scale of BERYX LEWESIENSIS; the exposed surface.

4.— Scale of OSMEROIDES MANTELLI; the entire form.

The four orders into which this grand class of

vertebrata is divided by M. Agassiz, are founded upon the peculiar structure of the scales;[507] and are characterised as follow:—

[507] For illustrations of the scales of fishes, see *Wond.* p. 339, *Lign.* 68, and p. 340, *Lign.* 69; *Foss. Brit. Mus.* p. 419; and *Ly.* fig. 306, figs. 342-347, &c. And for their minute structure, see Prof. Williamson's important paper in the *Phil. Trans.* for 1851.

Order I. PLACOID (*a broad plate*).—The skin covered irregularly with enamelled plates, sometimes of a large size, but frequently in small points, as the shagreen on the dermal integument of the *Sharks* and the tubercles of the *Rays*. *Lign.* 185, *fig.* 1, a fossil *placoidian* scale from the skin of a shark, highly magnified.

Order II. GANOID (*splendid*, from the brilliant surface of the enamel).—The scales are of an angular form, and composed of plates of horn or bone, covered with a thick layer of enamel; their structure is identical with that of the teeth. The *Sturgeon* is an example of this order. *Lign.* 196, figs. 1, 2, 3, 4, are fossil scales of a *ganoidian* fish.

Order III. CTENOID (*toothed, or comb-like*).—The scales are formed of plates, which are toothed or pectinated on their posterior margin or edge, like a comb. As the plates are superimposed on each other, so that the lowermost always extend beyond the uppermost, their numerous sharp points or teeth render the scales very harsh to the touch. The *Perch* belongs to this order. *Lign.* 185, *fig.* 3, represents a fossil *ctenoidian* scale.

Order IV. CYCLOID (*circular*).—The scales are composed of simple laminæ, or plates of bone or horn, without enamel, and have smooth borders; but their external surface is often ornamented with markings. The scales of the lateral line consist of funnels placed one within the other; the contracted part of which, applied against the disk of the scale, forms the tube through which the mucus flows. To this order belong the Mullet, Salmon, and Carp. *Lign.* 185, *fig.* 4, is the scale of a fossil *cycloidian* fish.

FINS OF FISHES.—As the progression of fishes through the water is principally effected by the action of the tail, they have no limbs commonly so

called. The instruments for balancing the body, and for assisting progression, are the fins, which are composed of numerous rays that support a membranous expansion; and the number and situation of the fins present various modifications in the different orders and genera.

The fins are named according to the situation they occupy; for example, *pectoral*, those on each side of the chest, and which correspond to the anterior extremities of other vertebrated animals; *dorsal*, on the back; *ventral*, on the belly; *caudal*, on the tail. (See outlines of Fish, *Ligns.* 186, 187, 195.) The rays are of two kinds; 1st, the *Spinous* rays; these consist of a single osseous piece, usually dense and pointed, sometimes flexible and elastic, and divided longitudinally (*Ligns.* 188, 196); 2d, *Soft* or *articulated* rays, which are composed of numerous small articulations or joints, and divide into branches at their extremities. Many species of fishes have four fins; others six; some but two; and in certain genera they are altogether wanting. In a fossil state the fins are often beautifully preserved; even the soft rays in many of the Tertiary marls and in the Chalk, are found entire, and attached to the body in their natural situation. The large, strong, spinous rays of the dorsal fins of the cartilaginous fishes, as the *Sharks* and *Rays*, are generally found detached, or connected only with a few vertebræ; but they are so abundant in some of the Secondary deposits (and in numerous instances they are the only vestiges of extinct species and genera), that they possess great geological interest; they are distinguished by the term *Ichthyodorulites* (*fossil fish-weapons*), under which head they will hereafter be described (see *Lign.* 188). The first ray in the dorsal fin of some fishes is protected in front by a double row of

enamelled scales, and these often occur in a fossil state (see *Lign.* 196, *fig.* 5).

TEETH OF FISHES.—Of all the durable parts of animals teeth occur in the mineral kingdom, the teeth of fishes present by far the most numerous, varied, and striking modifications of form, structure, composition, mode of arrangement, and attachment; and yet these dental organs, separately considered, do not in many instances, either in their structure or mode of implantation, afford characters by which the natural affinities of the original can be satisfactorily ascertained; and without the aid of other parts of the skeleton it is often impossible to determine, from external characters only, whether an unknown form of tooth belonged to an animal of the class of Fishes or of Reptiles. Although the modifications of form are almost innumerable, they are referable to four principal types; namely, the conical, the flattened, the prismatic, and the cylindrical.[508]

[508] The "ODONTOGRAPHY" of Professor Owen should be consulted by those who would thoroughly comprehend this interesting department of science. See also the *Article* TEETH, by Prof. Owen in the Cyclopædia of Anatomy and Physiology.

The conical teeth are extremely variable in size and form; some are slender, almost invisible points, distributed like the pile of velvet (*villous-teeth*), or set like the hairs of a brush (*brush-teeth*); some are long and slender, or barbed at the point; others are obtuse; and many are long and striated at the base, and closely resemble the teeth of certain reptiles. The depressed teeth are equally diversified; some have the grinding surface smooth; others, deeply grooved; in some it is flat; in others convex. In form they are

either lozenge-shaped, elliptical, square, oblong, semilunar, &c. The cylindrical teeth are hemispherical, or flattened; in some fishes they are short and thick; in others slender and support an obtuse, conical crown. The prismatic form is equally modified; from the compressed, sharp, lanceolate, cutting teeth, to the strong, triangular, three-pointed dentary organs.[509]

[509] For illustrations of the teeth of fishes, see plate iv. figs. 1, 2, 8, 10, and *Ligns.* 189, 191-194, 197, 198, 202, 205; *Foss. Brit. Mus.* p. 449; and *Ly.* figs. 236, 308, 324, and 383.

The mode of arrangement and attachment of the teeth, is as diversified as their forms. In some species all the teeth are of one type, and disposed in somewhat of a serial order on both sides of the jaws; but in a large proportion of fishes there are several kinds of teeth, which are implanted not only in the jaws, properly so called, but on the bones which form the cavity of the mouth, the arches of the palate, tongue, &c.; and it is peculiar to this class of vertebrata to present examples of teeth developed in the median line (*along the middle*) of the mouth, as in certain species of Rays; or crossing the symphysis (the *front line of union* of the two sides) of the lower jaw, as in *Myliobates*[510] (see *Lign.* 194, *fig.* 2). In some species the teeth are implanted in sockets, to which they are attached only by the soft parts, as in the rostral teeth of the *Saw-fish*; some have hollow bases, supported upon bony prominences, which rise from the base of the socket; as in several fossil teeth from the Chalk. "But by far the most common mode of attachment is by a continuous ossification between the dental pulp and the jaw,"[511] the teeth being thus anchylosed to the bone. In the Sharks the

osseous bases of the teeth are attached by a ligamentous substance to the tough, dense crust, which covers the cartilaginous jaws; the teeth of these fishes are therefore generally found detached in a fossil state, in consequence of the decomposition of this substance.

[510] Odontography, p. 5.

[511] Op. cit. p. 6.

The teeth are composed of a dense, osseous material, of a finely tubular structure, termed *dentine*; which, in many species, forms on the external surface of the tooth a layer of firmer texture, with a glossy surface, resembling enamel. The essential character of their organization is to have a pulp or medullary cavity, or cavities, filled with a plexus of blood-vessels and nerves, from which the minute tubes composing the dentine radiate.[512] The differences observable in the size, mode of ramification, and distribution of the medullary cavities or canals, and the *calcigerous tubes*,[513] as revealed by microscopic exploration, constitute important distinctive characters; particularly in the examination of the fossil teeth of extinct fishes. In some teeth the dentine is traversed by equidistant, parallel, medullary canals; in others, these channels frequently subdivide, and their branches anastomose with each other. In some the medullary canals form a reticulated, or net-like structure in the dentine, the meshes of which are occupied by calcigerous tubes, and cells; often producing a dendritical appearance, as in the tooth of a fossil fish named *Dendrodus*. "In the highest type of structure, the dentine consists of a simple medullary cavity or canal, and a single system of calcigerous tubes, which radiate from the central or sub-central pulp-cavity, at right angles to

the periphery of the tooth" (*Owen*), as in the teeth of the extinct Sauroid (*lizard-like*) fishes. A continued succession of teeth takes place during the life of the fish, and we often find in fossil specimens a series of successional teeth beneath the row in use; as in the fragment of a jaw of *Lepidotus*, from Tilgate Forest *Lign.* 107.

[512] See Owen's Odontography; and Tome's Dental Physiology.

[513] *Calagerous tubes*; so named because they are composed of *calx*, or lime.

SKELETONS OF FISHES.—The skeletons of the animals of this class differ so remarkably in their relative degree of firmness and elasticity, in consequence of peculiar modifications of their constituent substance, as to form two grand divisions; one of which is termed the *osseous*, the other the *cartilaginous*. The essential difference in the skeletons of these two groups consists in the presence or absence of earthy matter (*phosphate and carbonate of lime*) in the materials of which they are constructed. In the cartilaginous fishes, the skeleton is cartilaginous and transparent; but in some species, the skin has dense osseous particles or plates on the skin, as in the *Rays*; and in others, the head and body are protected by large osseous scutcheons, as in the *Sturgeon*. There is also an intermediate group of fishes, termed the *fibro-cartilaginous*, in which the skeleton contains lime, but in a much less proportion than in the true osseous fishes. In some genera, certain portions of the skeleton, as the bodies of the vertebra, are cartilaginous, while the spinous processes, ribs, &c. are osseous; these characters are of considerable importance in the investigation of the fossil remains of fishes, as we shall hereafter have

occasion to demonstrate.

The skeleton consists of the *cranium* or skull, which is composed of numerous bones,—the jaws, and bones of the tongue,—the osseous frame-work of the organs of respiration, consisting of the bones, rays, and arches that support the gills, and the *opercula*, or covers which close over the branchial apertures,—and of the vertebral column, formed of numerous dorsal and caudal vertebræ, with the ribs and other appendages; there are no proper cervical vertebræ, or spinal bones of the neck.

The branchial arches are in general four or five on each side, and are attached above to the cranium, and below to a chain of small bones, by which they are connected with the *os hyoides*, or bone of the tongue. The opercular bones, composing the cover or lid of the opening of the gills, consist of three pieces on each side, and are distinguished by the names, *opercular*, *pre-opercular*, and *sub-opercular*, according to the situations which they respectively occupy.

The *vertebræ* are double hollow cones,[514] not unlike an hour-glass in form: the interval between two of these bones is filled up, in the living state, by a gelatinous fluid. Along the upper part of each vertebra, there is an annular cavity, which in the united vertebral column forms a canal for the spinal marrow; the posterior dorsal and caudal vertebæ have also a channel below, for the passage of the large blood-vessels.

[514] There are certain exceptions; thus in the *Lepidosteus* the vertebral column is a series of ball-and-socket joints, the convexity being anterior, as in the land Salamander, and in the fossil reptile known as the Streptospondylus.

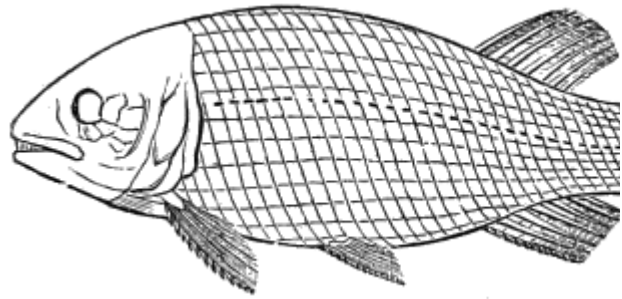
There are likewise bones analogous to some of those which enter into the composition of the extremities, chest or thorax, and pelvis of the higher vertebrata; but which it is not necessary for our present purpose here to describe.

Of the organs of vision some fossil remains also occur. The sclerotic coat, or capsule of the eye, being bony in fishes, is often preserved; and in several chalk specimens I have found it occupying the orbit.

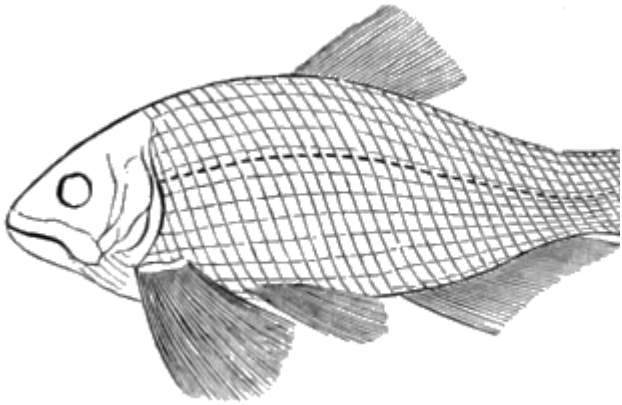
In addition to those durable parts of fishes, already mentioned, as likely to be met with in a fossil state, the bones called *otolithes* (ear-stones) must be enumerated. These calcareous bodies are found in the membranous labyrinth of the organs of hearing; and, although more or less developed in the ear-bulb of all animals, they are larger and of more definite forms in the higher osseous and cartilaginous fishes. The *otolithes* are supposed to assist in communicating more vivid impressions of sounds to the extremities of the auditory nerves; they are stony in most aquatic animals, and friable or pulverulent in those that live on land. Smooth, oblong otolithes are not uncommon in the Crag deposits of Norfolk and Suffolk; and minute ear-bones are found in the Barton Clay.

TAILS OF FISHES.—The tail, as we have previously mentioned, is the chief instrument of progressive motion in these animals; it assumes two principal modifications. In the greater number of the existing species the vertebral column terminates in a triangular plate of bone (formed by the fusion of the last few vertebræ), to which the caudal fin is attached symmetrically; and its figure is either rounded, or divided into two equal lobes or

branches; these tails are termed *homocercal*, i. e. even-tail. In the second modification the vertebral column towards its extremity diverges from a straight line, rises up, and is prolonged into the upper lobe of the tail; the caudal fin appearing like a rudder, and its low'er lobe, being destitute of vertebræ, is proportionably very feeble and small, as in the Shark and Dog-fish: this form of tail is called *heterocercal*, i. e. unequal-tail (see *Foss. Brit. Mus.* p. 421; and *Ly.* figs. 340, 341). In the embryonic state the tail in all fishes is heterocercal, and it becomes homocercal in the progress of development in those genera which have this type of the caudal appendage. But few of the existing species have the heterocercal tail, while it is found in all the fossil fishes that occur in the ancient secondary strata; namely, the Magnesian limestone, and antecedent deposits. The rounded and equal-bilobed, or homocercal, tails, are seen in the fishes from the Chalk, *Wond.* pp. 347, &c.; and in the Wealden Lepidotus, *Lign.* 186; and the unequal or heterocercal tail is shown in the Amblypterus from the Carboniferous strata, *Lign.* 187.



LIGN. 186. LEPIDOTUS. *Wealden.* ($^1/_6$ *nat.*
(Showing the Homocercal Tail.)



LIGN. 187. AMBLYPTERUS. *Carboniferous.* ($^1/_4$
a. The heterocercal tail.

In the Annals of Nat. Hist, for 1848, p. 304, Prof. M'Coy has described and figured an intermediate form of tail, which he regards as characteristic of the *Diplopterus* (of the Old Red Sandstone) and its allies: this the Professor terms the *Diphycercal* tail.

From this brief summary of the essential characters of those durable parts of the organization of fishes, which most frequently occur in a fossil state, we pass to the investigation of some illustrative examples of this class of organic remains. But before describing any entire specimens, it will be expedient to notice the separate fins, and teeth, which abound in many deposits; in some instances occurring in connexion with other parts of the skeleton, but more generally detached, and constituting the only evidence of the existence of numerous extinct species and genera. The greater part belong to the first order —the Placoidians (*Poiss. Foss.* tom. iii.), and to the families of *Sharks* and *Rays*. The osseous dorsal rays of cartilaginous fishes (named *Ichthyodorulites* (*fossil-fish-weapons*) by Dr. Buckland and Sir H. De la Beche) first demand our notice.

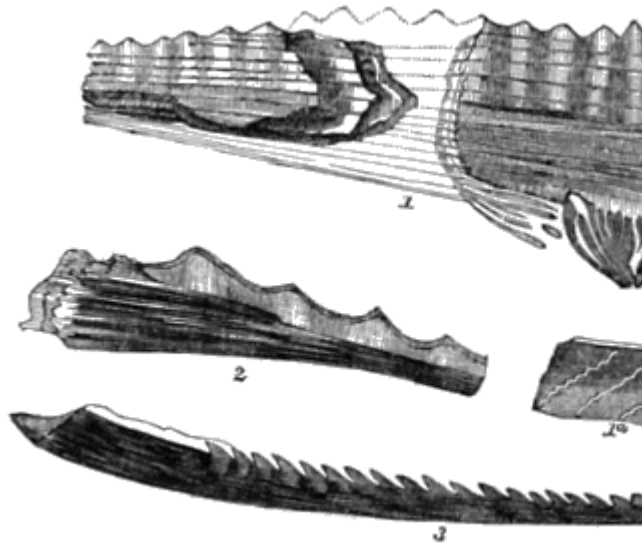
ICHTHYODORULITES. *Lign.* 188.—This name is applied to the fossil spines, or rays, of dorsal fins, of which numerous species occur in the Secondary deposits; they belong, for the most part, to extinct cartilaginous fishes of the *Cestracionidæ* and *Hybodontidæ* groups. In the osseous tribes the dorsal spines have at their base two articular processes, by which they are united to the osselets that support them, as in the *Silurus*; but in the cartilaginous, they have no articulations at the base, and terminate in an obtuse point, which is implanted in the flesh; the posterior margin is grooved almost to the upper extremity. They are of a fibrous, osseous texture. The common Spinax, or Dog-fish (*Acanthias vulgaris*), has a spine of this kind in the front of each dorsal fin. The rays of the Sharks are compressed, and some have rows of teeth on the posterior margin; in the genus *Cestracion* (Port-Jackson Shark), these organs are strong, triangular, straight, pointed, rounded in front, flat at the posterior face, and widest at the base; in the Hays they are flattened or depressed.

These spines are generally capable of being elevated and depressed, and not only serve the purpose of defence, but, in many instances, afford support and protection to the soft rays of the fin; forming, as it were, a moveable mast, by which the sail can be spread out or lowered at pleasure.

In illustration of this subject, I would first direct attention to the beautiful fossil, figured *Lign.* 188, *fig.* 1, which was discovered in the Chalk near Lewes, and is figured, of the natural size, *Foss. South D.* tab. xxxix. This ray, or spine, belongs to one of the Cestraciont fishes (*Ptychodus*), whose teeth are so abundant in the Chalk, and will presently be described. It is composed of fourteen thick, flat,

osseous rods, or strands, intimately united together, with longitudinal furrows or sutures on the surface. The anterior margin is embossed, and the projections form on the sides wide, rounded ribs, and transverse depressions. Towards the base of the posterior part, there are large osseous fibres inserted vertically and obliquely, which appear to have been processes of attachment. The rods, or plates, are parallel With the posterior margin, and each terminates in a rounded extremity, or boss, on the front edge of the spine. This ray is wider at its base than at the superior part the anterior margin is oblique, and the posterior straight. The surface, where entire, is covered with a dense osseous substance, which is finely engrailed. [515]

[515] This specimen is figured in *Poiss. Foss.*; but it is represented too short, from the two portions being drawn as if they were connected, without any interval between them, as in *Lign.* 188. It is in the British Museum. See *Petrifactions*, p. 450.



LIGN. 188. DORSAL RAYS OF SHARKS. *Suss*

Fig. 1.— PTYCHODUS SPECTABILIS. $^{1}/_{5}$ *nat. Chalk. Lewes.*

1*a*.— Portion of a DORSAL RAY, with oblique serrated sutures. *Cha*

2.— PTYCHODUS GIBBERULUS. $^{1}/_{5}$ *nat. Chalk. Lewes.*

3.— HYBODUS SUBCARINATUS. *nat. Weald. Tilgate Forest.*

In 1850 I discovered in the Plastic Clay of Castle Hill Newhaven, a dorsal fin of Ptychodus, with eight vertebræ. A nearly entire fin-ray of this species, three feet in length, has recently been discovered by Mr. Charles Potter, of Lewes, in the Chalk near that town. The remains of another ray, of equal proportions, were found near it; and these dorsal spines might have belonged to the same individual, for there are no reasons to forbid the supposition that the Ptychodus had two dorsal fin-rays. The length of these spines necessarily indicates a very large fish.

A smaller species of Ichthyodorulite, also found in the Lewes Chalk, is distinguished from *P. spectabilis* by its osseous plates contracting towards their

extremities, and terminating more suddenly on the front margin, producing gibbosities less acute and more distant than in *P. spectabilis*; this species is named *P. gibberulus*: see *Lign.* 188, *fig.* 2.[516]

[516] This fossil is figured of the natural size, Foss. South D. pl. xl. *fig.* 3.

The bony plates of these fins are occasionally found lying in irregular groups in the Chalk, as if the fin had partially decomposed and the plates separated. In one example, the rays are split asunder by a piece of bone, apparently a portion of a long pointed tooth, firmly impacted between them; as if the fish had been seized by some enemy, and had escaped, with the tooth of its adversary in its fin. Very fine specimens have been found at Charing, Kent, by W. Harris, Esq. F.G.S.

In the fragment of an Ichthyodorulite from the Lewes Chalk, a remarkable structure is displayed; the osseous plates are united laterally by smooth, longitudinal lines, as in those above described; but they are also traversed by numerous oblique, finely-serrated sutures. *Lign.* 188, *fig.* 1*a*.

The Chalk contains rays of other species of *Ptychodus*, as well as of some allied genera. Of these, the most remarkable are smooth, arched, pointed spines, having a shallow posterior groove, with an enamelled surface, marked with fine longitudinal striæ, and frequent, parallel, oblique lines. These, according to Sir P. Egerton, belong to a true *Cestracion* (see p. 584): they were first figured and described by me (*Foss. South D.* tab. xxxiii. *fig.* 5) as belonging to the *Acanthias major*, and were subsequently assigned to the genus *Spinax* by Prof. Agassiz (*Poiss. Foss.* iii. p. 62).

It may be necessary to remark, that the fins first described have been referred to the fishes which yielded the large grooved teeth so common in the Chalk (see *Pl. VI fig. 2*) in consequence of their affinity to existing species, which have similar fins and teeth; and from the circumstance that the Sharks of the genus *Lamna*, whose teeth also abound in the Chalk, have no dorsal rays of this kind; still the proof of identity remains to be discovered. In one specimen only have I observed indications of any other part of the skeleton; it is a spine of *Acanthias major*, the base of which rests on several dorsal vertebræ (*Foss. South D.* tab. xxxiii.).

HYBODUS SUBCARINATUS. *Lign.* 188, *fig.* 3.—The fishes of another extinct genus of Sharks, termed *Hybodus*, from the gibbous form of the teeth, were also provided with dorsal spines, which may be readily distinguished from the preceding. These Ichthyodorulites are generally long, slightly arched, and terminate in a point at the extremity; the base, which was implanted in the flesh, is deeply grooved, and much prolonged, being sometimes equal to one-third of the entire length. The surface is marked with strong longitudinal ridges, parallel with the anterior margin which is rounded and laterally compressed. The posterior edge, which is more or less flat, has, towards the base two rows of sharp arched teeth, which gradually approach 'each other, and blend into one line on the upper part of the ray There are numerous species of this genus in the Oolite and Lias. I have found one species in the Chalk and a few in the Wealden. The small Ray figured *Lign.* 188 *fig.* 3, is from Tilgate Forest, and displays the usual characters of these fossils. From specimens discovered in the Lias, associated with the teeth, it appears that the *Hybodus* had two dorsal fins, each

furnished with rays, as in the recent Dog-fish.

The microscopic structure of these rays is stated by M. Agassiz to resemble that of the teeth: in some there is a pulp cavity, which occupies the centre of the spine, and is surrounded by dentine, in which the calcigerous tubes radiate direct to the surface; the external enamel is a layer of dentine, in which the medullary canals are wanting.

In the strata below the Lias there are numerous Ichthyodorulites, some of a large size, belonging chiefly to the Cestracion family, and of extinct species, not observed in more recent deposits. Thus there are several species of dorsal rays (named ONCHUS, from their hooked form,) that are wide at the base, and bent backwards, with the posterior margin destitute of teeth, in the Carboniferous, Devonian, and Silurian formations; also immense compressed spines, having small teeth on the posterior margin, and the surface covered with longitudinal striæ, and finely toothed, transversely; hence termed CTENACANTHUS, or pectinated-spine (*Murch. Sil. Syst.* p. 596).

The fossil spine, named ORTHACANTHUS (*Poiss. Foss.* vol. iii. pl. xlv.), and found in the Coal of Manchester, has been discovered in connexion with the body of the fish to which it belonged in the Carboniferous deposits of Ruppersdorf in Bohemia (*Geol. Journal*, vol. v. part ii. p. 23).

Some Ichthyodorulites have the surface richly ornamented with stellular tubercles, and are termed ASTERACANTHUS, or starry-spine; there are very large fin-rays of this kind in the Wealden, Purbeck, Oolites, and Lias.[517]

[517] For particular information on Ichthyodorulites, consult *Poiss. Foss.* tom. iii. chap. i. About seventy species are enumerated.

The Ichthyodorulites of the *Rays* have no cavity like those of the *Sharks*, and are of a depressed form, and more or less flattened; they are armed with teeth along their exterior margins, and not on the posterior edge, as in the latter family.

FOSSIL TEETH OF FISHES.—From the durable nature and striking appearance of many of the fossil teeth of fishes, and their prodigious numbers in some deposits, they are familiar objects to the collector. By far the largest proportion of the detached teeth belongs to various species and genera of that most numerous, and widely distributed family of voracious fishes, the SHARKS. In the Tertiary strata teeth of this kind occur of a very large size; in the Chalk many species abound, particularly of the lanceolate and compressed forms, and of the rugous, mammillated, palatal teeth, commonly termed *palates*. As we pass to the more ancient formations, teeth of different forms prevail; and those which approach the recent types are either very rare or altogether absent. We will select some examples of the different genera in illustration of this subject; the previous observations on the form and structure of the recent teeth render but few introductory remarks necessary.

FOSSIL TEETH OF SHARKS.—The fishes of the Shark and Ray families belong to the *Placoid* order; the scales in the former consist of enamelled plates and tubercles, forming a *shagreen* surface; and in the dermal integument of the latter they appear as spines and bosses, irregularly disposed.

Notwithstanding the diversity in appearance of

the teeth of Sharks, they all possess one essential character of structure, namely, a base, or osseous root of variable form, which is implanted in the integuments; and a crown, or external portion, which projects into the mouth, is covered with enamel or compact dentine, and assumes numerous modifications, by which the fossil genera are characterized. These teeth are never imbedded in sockets, nor united to the dentary margins of the jaws; they only adhere to the integuments of the mouth, and the covering of the maxillæ; they possess, in most of the Sharks, great mobility. They are generally disposed in rows; the anterior ones, being first used, fall out, and are replaced by those on the inner series. New teeth are also continually formed behind those in use, and advance successively towards the anterior rows as the latter are shed, and in their turn occupy the front rank. (See Cyclop. Anat. *Art.* TEETH.) An examination of the fossil and recent teeth of Sharks and Rays proves that the prevailing existing generic types have but few, if any, representatives in the fossils, except in those which belong to the Tertiary and Cretaceous formations; while the genera that appear isolated, as it were, in the present seas have numerous analogues in the Secondary strata.

The fossil teeth of this family may be divided into two grand divisions; namely, those which are more or less of a polygonal, obtusely conical, or depressed form, having a tesselated arrangement in the mouth; and those of a triangular, lanceolate shape, with cutting, or serrated edges, disposed in a series of rows on the jaws. The teeth of the first group (*Cestracionidæ*) have most analogy to those of the living genus CESTRACION (*Port-Jackson Shark*); the second (*Sgualidæ*) to the SHARKS, commonly so

called.

The Cestracion is the only living representative of a family of squaloid fishes of a peculiar type, whose remains occur in almost the earliest fossiliferous deposits; it inhabits the seas of New Holland and the southern coasts of China. The jaws of the Cestracion are relatively very large, and are armed with numerous rows of teeth, essentially of two kinds; those situated anteriorly, or towards the front of the mouth, being adapted for seizing and retaining the food, and the posterior ones for crushing and bruising. The prehensile teeth are sharp, angular, and pointed: the others are obtuse, polygonal, enamelled, and disposed in oblique rows along the margins and inner surface of both jaws; there are sometimes sixty in each jaw (see *Bd.* ii. pl. xxvii 11. *fig.* A). Fossil teeth of this type are exceedingly numerous in the Chalk, Lias, &c. but are very seldom found in juxtaposition; the decomposition of the cartilaginous integuments in which they are imbedded, having, in most examples, occasioned their displacement and dispersion; specimens, however, are occasionally discovered, in which numerous teeth, of various sizes, are disposed in mosaic, in their natural relative positions.

The extinct forms of this family (*Cestracionidæ*) are known almost only by their teeth; and according to the shape, structure, and sculpture of these organs, M. Agassiz has arranged them into several genera. They occur in most of the fossiliferous deposits.

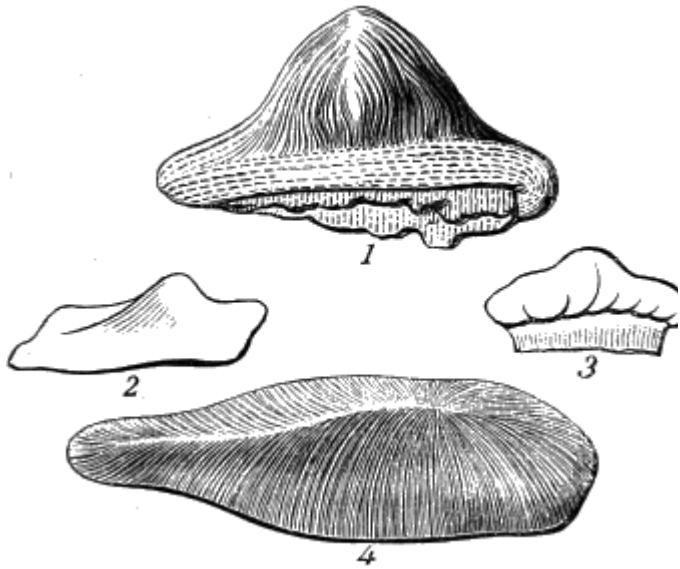
CESTRACION CANALICULATUS.—The teeth of a fish belonging to the existing genus have been discovered in the Chalk of Kent; they are figured and described by Sir P. Egerton in the beautiful work by

Mr. Dixon.[518] This unique specimen consists of a group of thirteen posterior molar and three or four detached prehensile anterior teeth, imbedded in a block of chalk about two inches square. The chief distinction from the teeth of the recent Cestracion is in the presence of a large medullary canal which traverses the base of each tooth: hence the specific name.

[518] Dixon's Fossils of Sussex, &c. p. 365, tab. xxxii. *fig.* 8. From the t examination of a specimen lately found at Lewes, Sir P. Egerton has been led to assign to this species the spine formerly described as *Spinax major*.

ACRODUS (*ridge-tooth*) NOBILIS. *Lign.* 189, *fig.* 4, *Ly.* p. 275, *fig.* 307.—In the Lias and Oolite, oblong enamelled teeth, having the surface of the crown covered with fine radiating grooves and striæ, are well known to collectors, in many parts of England, by the name of *fossil leeches*, from a fancied resemblance to a contracted leech. They belong to an extinct genus of Cestracionts, named *Acrodus* by M. Agassiz. The crown of the tooth is enamelled, and covered with transverse grooves, which diverge from a longitudinal furrow; the base is in the form of a parallelogram inclined on its inner side. These teeth were inserted along the jaws in oblique series, their longitudinal direction corresponding with that of the bones which supported them; in their natural position, the extremity of a hinder tooth was enclosed between the two next anterior teeth. A beautiful group is figured *Bd.* ii. pl. xxvii[e].[519]

[519] The microscopical structure of the teeth of *Acrodus* is well shown in the "Odontography," pl. xiv. xv., and beautifully illustrates the relation of dentine to bone.



LIGN. 189. FOSSIL TEETH OF SHARKS.

Fig. 1.— PTYCHODUS MORTONI. (G. A. M.) *Cret. New Jersey.*

2.— PSAMMODUS CINCTUS. (*Ag.*) *Mt. L. Bristol.*

3.— ORODUS CINCTUS. (*Ag.*) *Mt. L. Bristol.*

4.— ACRODUS NOBILIS. *Lias. Lyme Regis.*

PTYCHODUS (*wrinkle-tooth*). *Pl. VI. fig. 2*; *Lign.* 189, and *Lign.* 191.—The palatal teeth, which occur more or less abundantly in almost every chalk-pit, and are known by the name of "palates," belong to several species of the genus Ptychodus. A very common form is figured *Pl. VI. fig. 2*; and microscopic views of vertical and transverse sections, as seen by transmitted light, are shown in figs. 2^b, 2^c. Groups of these teeth, somewhat naturally arranged, and varying in size and form according to the situations they occupied in the jaws, are occasionally found: one specimen in the British Museum, and formerly in my collection, contains more than 120 teeth. In general they occur in a very perfect state,

with the osseous base and enamelled crown entire. The dorsal rays or spines previously described (p. 577), are sometimes found with the teeth, and belong to fishes of the same genus.

These teeth are of an angular form, and more or less square, the crown is wider than the root, which is obtuse, truncated, and depressed in the centre; the enamelled part of the tooth is expanded at the edges, and forms in the centre a flattened or slightly convex mammillary projection, which is traversed by large, acute, transverse, parallel ridges. The borders are granulated, and the sides of the projection marked with deep vertical plicæ or folds; this description particularly applies to the species named *P. polygurus*, figured in *Plate VI.* Dr. Buckland has represented a fine group of these teeth, *Bd.* ii. pl. xxvi′. Another common species (*P. decurrens*) is distinguished from the former by the connexion between the large furrows on the crown and the granulations on the expanded border, which diverge from the outer edge of the large folds to the margin of the enamel.

The microscopic structure of these teeth presents the same congeries of medullary and calcigerous tubes as those of the recent Cestracion: see *Plate VI. figs. 2[b], 2[c]*.

The teeth of a species of Ptychodus occur in the arenaceous strata of the Chalk-formation in New Jersey, which possess the essential characters of the European types, but differ from them in their configuration; the only specimen I have seen is figured *Lign.* 189, *fig.* 1; it was presented to me by Dr. Morton. The enamelled crown forms a conical projection, traversed by large inosculating ridges,

which radiate from the summit towards the margin. [520]

[520] I have named it *P. Mortoni*, in honour of my distinguished friend, the eminent American naturalist and physician, Dr. George Morton, of Philadelphia, by whom it was discovered.

PSAMMODUS[521] (*sandy-tooth*). *Pl. VI. fig. 1*; *Lign.* 128, *fig.* 2.—To this genus are referred the fossil teeth of the extinct Cestracionts, which have the crown formed of small vertical tubes, with the grinding surface more or less smooth, and presenting only a punctated or sandy appearance.[522] These teeth are generally flat or slightly convex, and of a square or oblong form; the base is osseous, and as large as the crown. Two species are figured, *Lign.* 189, *fig.* 2, and *Pl. VI. fig. 1*[a]. A magnified vertical section of the crown, displaying the medullary canals and radiating calcigerous tubes, is represented *Pl. VI. fig. 1*[b], and a transverse section, *fig. 1*[c]; they are thin slices of a tooth, *P. porosus*, from the Black Rock (Mountain Limestone), near Clifton, viewed by transmitted light. The large, flat, quadrilateral, oblong teeth that abound in the Stonesfield Slate belong to the *Strophodus magnus*.

[521] See Odontography, pl. xviii. xix.

[522] Ibid. vol. i. p. 59.

There are several kinds of fossil teeth which possess the same essential structure as those of Psammodus, but differ in their external characters; these are referred to other genera by M. Agassiz. Thus ORODUS, *Lign.* 189, *fig.* 3, comprises those elongated teeth in which the centre of the crown forms an obtuse transverse cone, traversed by a ridge

from which oblique furrows diverge transversely towards the circumference. Similar teeth, but with a smooth, obtusely conical crown, are referred to the genus HELODUS. Those with the crown compressed and elevated, with a sharp edge, and with the base surrounded by concentric folds, constitute the type of CHOMATODES. A similar crown, but subdivided by deep transverse ridges into dentations, characterises the genus CTENOPTYCHIUS.

CERATODUS (*horn-tooth*) EMARGINATUS. *Lign.* 194, *fig.* 1.—Very curious dental organs, possessing a structure analogous to that of the teeth of Psammodus, are found in the Bone-bed of the Lias; they consist of consolidated plates instead of separate teeth; there was probably but one plate on each side the jaws. The upper margin is generally undulated, and more or less worn by use. These dental plates are composed of two distinct layers; the lowermost portion, or root, is an osseous, reticulated tissue, as in cartilaginous fishes in general; and the upper consists of dentine, with minute parallel vertical tubes, as in Psammodus; these tubes are a continuation of the medullary tissue of the osseous root.

One species occurs in the Great Oolite at Stonesfield, and very many forms abound in the Bone-bed at Aust Cliff, near Westbury on Avon: and in the Trias (bone-bed) of Germany the teeth of several species of Ceratodus are very abundant.

The fishes to which these fossil teeth, referred to *Ceratodus*, belonged were most probably Cestracionts; the ray-spine known as *Nemacanthus* is provisionally assigned to them.

EDAPHODON. *Lign.* 190 and *Lign.* 191, *Ly.* p. 276,

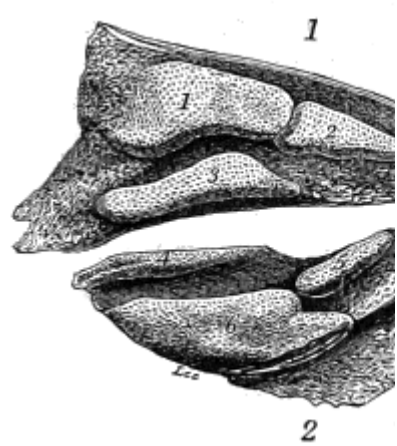
fig. 309.—The Chimæroid fishes, though formerly placed with the Plagiostomes (Sharks and Bays), constitute a distinct group, of which there are but two recent genera, though several occur in a fossil state. Their dental organs are very peculiar. Their mandibles are furnished with two or more pairs of oblong teeth, composed of long hollow cylindrical columns, placed nearly at right angles to the grinding surface, which is pitted with minute depressions. These teeth are never shed, but are persistent, and grow on through life, as in the Rodentia, exhibiting in this respect a striking contrast with those of the Sharks, which are feeble and numerous, and constantly replaced by rows of successional teeth.

Fossil teeth of several species, some much larger than the recent, have been found in the Tertiary, Cretaceous, and Oolitic deposits. The first British specimen was discovered in the Chalk-marl at Hamsey, in 1820, by myself; but its nature was not suspected until more perfect examples were obtained from the Kimmeridge Clay at Shotover by Sir P. Egerton, and were submitted to Dr. Buckland, who subsequently ascertained their characters and relations by an examination of the dental organs of a recent *Chimæra* in the Museum at Leyden in 1835. [523]

[523] Proceedings of the Geological Society of London, vol. ii. p. 209.



LIGN. 190. MANDIBLE OF EDAPHODON MANTELLI.
Chalk. Lewes. ($^1/_2$ *nat. size.*)



LIGN. 191. EDAPHODON LEPT
London Clay. Brac
The Upper and Lower Mandibles of the left si

Fig. 1.— The Upper Jaw; left ramus.
p m.—The premaxillary bone.
1, 2, 3.—The three dental tubercles.

2.— The Lower Jaw.
s.—The symphysial surface, by which this ramus is united to the opposite or right side of the jaw.
4, 5, 6.—The three dental tubercles, or triturating surfaces, of the left ramus of the lower jaw.

Many specimens, both of the upper and lower mandibles, have since been discovered in the Eocene beds, Chalk, Upper Greensand, Galt, Kimmeridge Clay, and Stonesfield Slate. The subject has been carefully investigated by Sir P. Egerton; and this eminent Ichthyologist has tabulated the principal forms, and arranged them under five genera.[524]

[524] Viz. Ganodus, Ischyodus, Edaphodon, Elasmodus, and Psaliodus. See Quart. Journ. Geol. Soc. vol. iii. p. 35; and Dixon's Foss. Sussex.

In some species the external vertical wall of the plate is formed of hard dentine, resembling enamel; in others the dentine is disposed in isolated ramifications, producing a dendritical appearance; the modifications of this structure occasion the differences observable in the dental plates of the various species. In some, compact dentine with parallel canals constitutes the mass of the tooth; in others, the squamous dentine with ramifying tubes prevails.

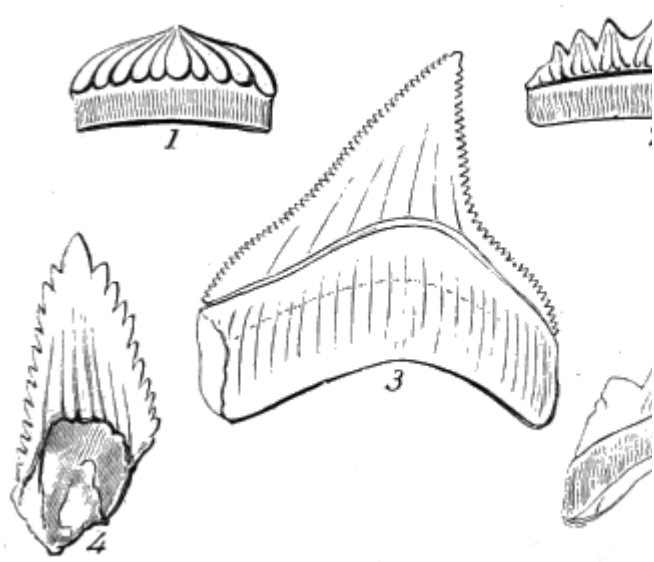
I have figured the right upper and lower mandibles of the type named EDAPHODON (*pavement-tooth*), in which there are *three* teeth or dental tubercles on each ramus of both jaws, *Lign.* 191: the lower mandible is produced anteriorly into a falciform beak:[525] the articulating surface of the symphysis (2 *s*) is broad at the base, and contracts gradually forward until the margins meet at the

apex. In *Ischyodus* the lower jaw is deeper, less produced in front, and the margins of the symphysis are parallel until abruptly truncated at the extremities: the upper jaw has *four* tubercles on each side.

[525] Hence M. Agassiz proposed the name of *Psittacodon* (parrot-tooth) for this genus of Chimæroids.

The upper jaw in ELASMODUS has but three tubercles, as in Edaphodon, but the dentine of which they are composed is confluent, being rolled round like a scroll in the substance of the bone, one edge forming the margin of the tooth, and the other being buried deep in its centre.

The dorsal fin-ray or spine of the Edaphodon is laterally compressed, with the posterior margin grooved, and the edges armed with fine teeth: I have a specimen of the spine, with a pair of inferior mandibles of the same individual, imbedded in a block of chalk from Kent; by favour of Mrs. Smith, of Tunbridge Wells.



LIGN. 192. FOSSIL TEETH OF SHARKS.

Fig. 1.— HYBODUS MEDIUS. *Lias. Lyme Regis.*

2.— HYBODUS RARICOSTATUS. *Lias. Bristol.*

3.— CARCHARODON PRODUCTUS. *Tert. Malta.*

4.— HEMIPRISTIS SERRA (fragment). *Chalk. Ratisbon.*

5.— OTODUS OBLIQUUS. *Tert. Sheppey.*

HYBODUS. *Lign.* 192, figs. 1, 2. (*Bd.* pl. xxvii[d].)— Intermediate between the obtuse crushing teeth of the Sharks previously described, and those sharp, angular, pointed, dental organs of the Squaloids, are those of the fishes which M. Agassiz has arranged in a sub-family or group termed *Hybodonts*; the teeth of which are characterised by their transversely elongated form, and the series of subacute, compressed, conical cusps or points, which compose the crown. The median cone is the principal, the lateral points being shorter and smaller, as in *Lign.* 192, *fig.* 2; in some species the difference between the median and lateral cones is greater, in others

less, as in *fig.* 1. These cusps have a coating of dense enamel, which is plicated longitudinally on both faces. The base, which almost equals the crown in size, is composed of a coarse osseous substance. The internal structure of the crown differs from that of the Cestracionts, in having no principal pulp-cavity, and in being chiefly composed of dendritical dentine, with reticulated medullary canals. The form and organization of these teeth show them to have been instruments for cutting and tearing food. The Hybodonts, as we have already stated (p. 581), possessed two spinous dorsal fins; in their habits and economy they probably did not differ from the ordinary Sharks. Teeth and spines of this genus are common in the Trias, Lias, Oolite, and Walden, and occur in the Green Sand and Chalk. There are several species of teeth and fins in the strata of Tilgate Forest (*Foss. Til. For.* pl. x.). In general the teeth are found detached, but occasionally they occur in their natural position, adhering to the mineralized cartilaginous jaws (*Petrif. Lign.* 97); as in the beautiful fossil figured *Bd.* pl. xxvii.[d]; and in the fine specimen of *H. basanus*, from the Isle of Wight, figured in the *Geol. Soc. Journ.* vol. pl. iv. There are several related genera, founded on the situation, form, and division of the principal cusps of the teeth.

SHARKS WITH CUTTING TEETH.—The jaws of the common squaloid fishes, as the LAMNA (*Porbeagle*) and CARCHARIAS (*Great White Shark*), are so common in collections of natural history, as to render a description unnecessary. The numerous vertical rows of angular, laterally compressed, pointed teeth, with sharp or serrated edges—in some species consisting of a simple trenchant cusp, in others with small lateral teeth, or denticles, at the base, are characters with which all are familiar.

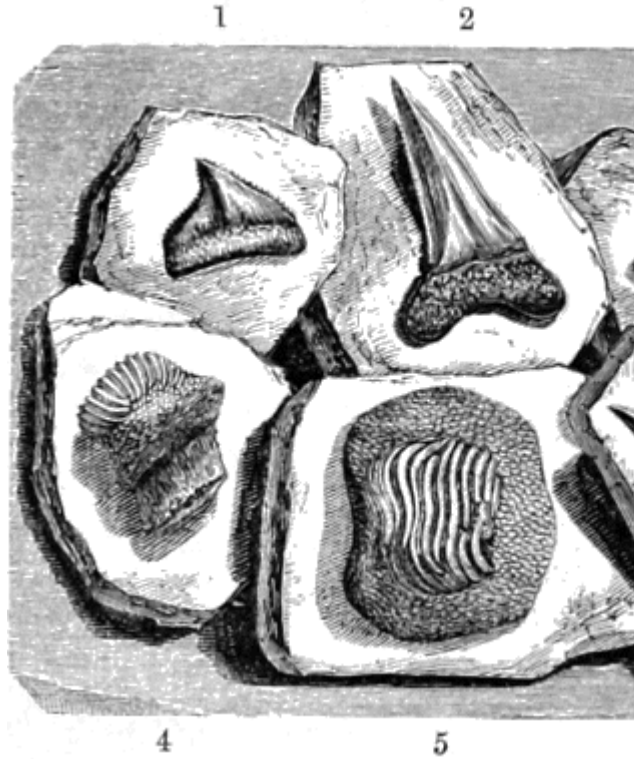
Fossil teeth of this form are extremely abundant in the Tertiary and Cretaceous deposits; and are commonly in a beautiful state of preservation. The genera of these fossil teeth are founded on the solidity or hollow structure of the cusps, their possessing cutting or serrated edges, and the presence or absence of lateral denticles. But the last character cannot in every instance be relied upon, for some recent Sharks have rows of teeth both with and without denticles.

CARCHARODON PRODUCTUS. *Lign.* 192, fig 3.—The genus Carcharias comprises the large Sharks with cutting triangular teeth, crenated (*notched*) on their margins, and having a broad base. In *Carcharodon*, the teeth differ from those of Carcharias in being solid in the centre, while in the latter they are hollow; but in both genera the teeth exhibit the same reticulated structure of medullary and calcigerous tubes. The *White Shark* and other large species belong to these genera; some of which are upwards of forty feet in length. But even these colossal fishes must have been far surpassed in magnitude by the extinct species of the Tertiary deposits, if the teeth afford a scale of proportions; for some of the fossil teeth from Malta and the United States are six inches long, and five wide at the base; [526] being twice the size of the teeth in the largest living species. The specimen figured in illustration, *Lign.* 192, *fig.* 3, is of a small size.

[526] For instance, some of the Maryland specimens of *Carcharodon megalodon*. See an admirable memoir on the Fossil Squalidæ of the United States, by Dr. R. W. Gibbes, Journ. Acad. Nat. Science, Philadelphia. At the meeting of the British Association in 1851, J. S. Bowerbank, Esq. F.R.S. read some interesting

observations on the comparison of these large fossil fishes with the recent *Carcharias glaucus* of Australia. See also Owen, Cyclop. Anat. *Art.* TEETH.

HEMIPRISTIS SERRA. *Lign.* 192, fig 4.—The fossil teeth of this genus are distinguished by serrated edges, that do not extend to the summit, which is a sharp angular point; as in the fossil represented.



LIGN. 193. FOSSIL TEETH OF SHARKS. *Chalk*

Fig. 1.— CORAX PRISTODONTUS.
2.— LAMNA CRASSIDENS.
3.— NOTIDANUS MICRODON.
4.— PTYCHODUS POLYGURUS; seen laterally.

5.— PTYCHODUS POLYGURUS; viewed from above.

6.— LAMNA ELEGANS.

LAMNA ELEGANS. *Lign.* 193, *fig.* 6.—The fishes of the genus *Lamna* (to which the recent shark called the *Porbeagle* belongs) have teeth with smooth trenchant edges, and a small sharp denticle (*little tooth*) on each side the base, as in the fossil, *Lign.* 193, *fig.* 6. The specimen, *fig.* 2, although devoid of denticles, probably belongs to the same genus, for reasons already explained. Several species abound in the Chalk; and they are associated with teeth, which are relatively wider and shorter, and have large compressed denticles; the latter are arranged in a separate genus, named OTODUS (*eared-tooth*), by M. Agassiz. The specimen figured *Lign.* 192, *fig.* 5, represents *O. obliquus*; another species, *Otodus appendiculatus*, is abundant in the Sussex Chalk. The large, wide, triangular, smooth teeth, with trenchant edges, and destitute of lateral denticles, so common in the Chalk, are related to Lamna, and are comprised in the genus *Oxyrhina* (*Poiss. Foss.* tom. v. tab. xxxiii.).

NOTIDANUS MICRODON. *Lign.* 193, *fig.* 3.—These teeth differ remarkably from those of the other genera of Sharks. The crown of each tooth is composed of a series of sharp angular enamelled points, the first of which is the largest, and is notched on its anterior edge; the base or root is osseous, flat, with a slight longitudinal depression below the border of enamel. These teeth are comparatively rare in the Chalk. One species has been found in the Oxford Clay; and several in the Tertiary strata. Specimens occur in Hordwell Cliff.

CORAX PRISTODONTUS. *Lign.* 193, *fig.* 1.—The teeth of the fossil *Corax* chiefly differ from those of the recent genus *Galeus*, to which the *Tope*, or Grey Shark, belongs, in being solid; they are of a triangular form, with a deep concavity or notch on the posterior margin, the base of which is prolonged and forms three or four angular points: the anterior edge of the tooth is finely serrated. The root of the tooth, as in *Notidanus*, is a broad osseous plate. There is much diversity of form in the Chalk specimens, which are all of a small size, as in *Lign.* 193, *fig.* 1. In Sussex they are more common in the Chalk-marl than in the Chalk.

The only fossil teeth of the Shark family resembling those of the tertiary Carchariodonts, that have been discovered in the strata below the Chalk, are from the carboniferous deposits of Yorkshire and Armagh. These teeth are compressed, triangular, crenated on the edges, with large plaits or folds on the enamelled surface, towards the base of the crown. M. Agassiz refers them to a new genus, viz. CARCHAROPSIS, with the specific name of *Prototypus*.

FOSSIL VERTEBRÆ OF SHARKS.—As the cartilaginous nature of the skeleton in this family renders it unfavourable to preservation in the mineral kingdom, the durable parts already described, and those which are ossified, are almost the only relics found in a fossil state. The dermal integument is, however, sometimes preserved; and I had a beautiful example of shagreen, composed of irregular minute hexagonal scales, one of which is represented highly magnified, *Lign.* 185, *fig.* 1.

In the *Galeus* and *Carcharias* the vertebræ are more ossified than in many other genera of

cartilaginous fishes, and fossil vertebræ of these sharks often occur in the cretaceous and other strata. Groups of vertebræ of a large size occasionally occur in the Sussex Chalk; they are circular, biconcave, and very short; one specimen is four inches in diameter, and one inch long; their concavities are consequently shallow. These vertebra: are composed of two shallow conical disks, which are united by their summits, at the axis, and are connected and supported by numerous wedge-shaped plates, that radiate from the centre to the periphery (see *Foss. South D.* pl. xxxiii. *fig.* 10). My collection contained a connected series of forty small vertebræ from the Chalk near Lewes, which probably belonged to the same species of Shark as the dorsal spine named *Spinax major* (*Poiss. Foss.* tom. iii. pl. xl[a] *fig.* 6).

SQUALORAIA. In the Lias of Lyme Regis, that inexhaustible storehouse of fossil treasures, a considerable portion of the skeleton of a very remarkable fish, partaking of the characters of the Sharks and Rays, was discovered by Miss Mary Aiming, and is now in the Museum of the Bristol Institution.[527] In this fish the jaws are prolonged into a beak, like the Pristis (*Saw-fish*). It has the head of a Shark, with a long beak; vertebræ of the Rays; with pectoral and ventral fins, almost equally developed; a tail armed with, a spine; and spinous bosses, as in the true Rays.

[527] It is figured and described by Dr. Riley, Geol. Trans. 2d ser. vol. v. pl. iv. See also Poiss. Foss. tom. iii. pl. xlii.

FOSSIL PRISTIS, OR SAW-FISH.—This well-known predatory fish, which is allied to the Rays and Sharks, and referred by M. Agassiz to the family of *Raiidæ*, has projecting from its snout an osseous, flat,

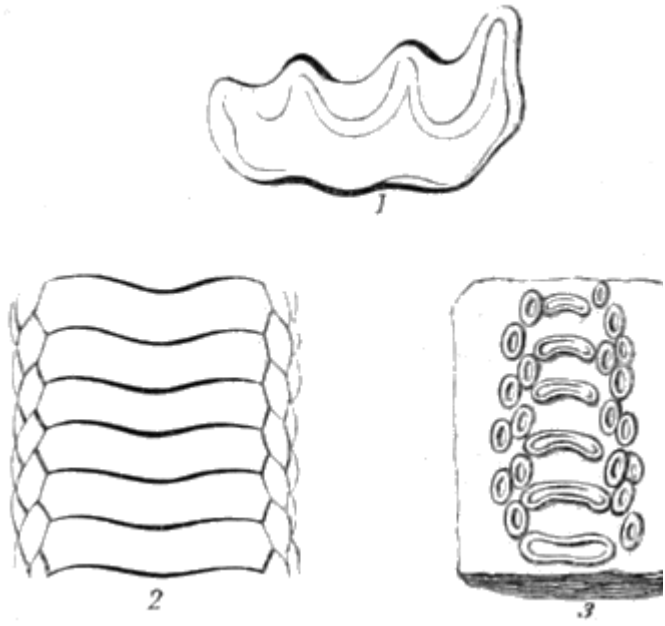
horizontal plate, or beak, equal in length to one-third of the fish, and armed on each side by a row of elongated, compressed, pointed teeth, implanted in sockets; the front margin of these teeth is convex, the posterior concave; this defence is termed the saw, and constitutes a most powerful weapon. The *Pristis* has also numerous small obtuse teeth on the jaws. The remains of the beak, or saw, of an extinct species of Pristis have been discovered in the Bagshot Sand at Goldsworth Hill, Surrey,[528] and three other species have been found in the London clay of the Isle of Sheppey, and the Eocene beds at Bracklesham and Hordwell.[529]

[528] Proc. Geol. Soc. vol. ii. p. 687.

[529] Two teeth are figured in Dixon's Fossils of Sussex, pl. xii.; the specimens are in the British Museum; see *Petrifactions*, p. 414.

FOSSIL RAYS.—The teeth of these fishes are characterised by the extraordinary transversal development of the median teeth in both jaws. Instead of pointed teeth, they have wide, flat, tesselated dentary plates in each jaw, composed of distinct pieces, juxtaposed and connected by their margins, and united by fine sutures. In some species the teeth are equal, in others of various sizes; they present numerous modifications of arrangement, and are always disposed in symmetrical rows. In the genus MYLIOBATIS (*Eagle-ray*) the teeth of the median row are of an extraordinary width, while their length does not exceed that of the lateral plates, or chevrons, which are of an irregular hexagonal form, and disposed in two or three rows on each side. There are five living species of *Myliobatis*, and eighteen fossil species have been found in the Tertiary strata at the Isle of Sheppey, Hordwell Cliff,

and Bracklesham Bay. I have figured a specimen of part of the upper jaw of a species (*M. micropleurus*, *Lign.* 194, *fig.* 2), in which the median teeth are very wide, and have two lateral rows of small, irregularly hexagonal, plates. The surface of the teeth in this species is smooth; but in others it is striated longitudinally (*Bd.* pl. xxvi[d]. *fig.* 14). In an allied genus, ÆTOBATIS, from the Tertiary beds at Bracklesham, the lower jaw projects beyond the upper, and in each there is a row of flat, transverse teeth, *without* lateral plates.



LIGN. 194. FOSSIL TEETH OF FISHES

Fig. 1. CERATODUS EMARGINATUS: $^1/_2$ *nat. Lias Bone-bed. Aust Cliff.* A
— plate.

2. MYLIOBATIS MICROPLEURUS: $^1/_3$ *nat. Tert. Isle of Sheppey.* A seri
— median teeth, with the corresponding lateral teeth.

3. PYCNODUS MANTELLI. *Weald. Tilgate Forest.* This specimen cons
— *vomerine* bone, with a median row of flat, arched teeth, and tw
side of elliptical teeth, arranged alternately.

To this notice of the fossil Rays, we may add, that a gigantic TORPEDO has been discovered in that celebrated locality of Ichthyolites, Monte Bolca: and that Sir Philip Egerton has recently enriched his matchless collection of fossil fishes, by a perfect Ray, from Mount Lebanon. It is figured and described in the *Quarterly Geol. Journ.* vol. i. pl. v. p. 225, under the name of CYCLOBATIS OLIGODACTYLUS. It is a small species, resembling the common Rays in its general appearance, but is surrounded by a broad, flexible, cartilagino-membranous fin; the skin is smooth, the teeth and eyes are small, the tail is slender; there are no traces of dermal spines, tubercles, or defensive weapons. In many points of structure it resembles the Torpedo; and may possibly, like that fish, have possessed an electric organ. It is $3^1/_2$ inches long, and 3 inches wide across the expanded fins.

CHAPTER XV.

FOSSIL ICHTHYOLOGY; COMPRISING THE GANOID, CTENOID, AND CYCLOID FISHES.

THE fishes we have hitherto examined belong to the first order, the *Placoidians*; we now pass to the

fossil remains of the second order, the *Ganoidians*, which are distinguished by their brilliant angular scales, formed of osseous or horny plates, densely covered with enamel. This order contains six or more families, comprising many genera and numerous species; our investigation must be restricted to a selection from the principal genera of the *Ganoids*, properly so called, and of the *Sauroids*, or lizard-like fishes.[530]

[530] The fishes of these orders are described in *Poiss. Foss.* tom. ii.

The first family, termed LEPIDOIDES, contains several genera, which are defined as possessing either numerous rows of brush-teeth, or of obtuse conical teeth; flat, rhomboidal scales, arranged parallel with the body; and an osseous, or partially osseous, skeleton. In one division of this family, the body is either elongated or fusiform, the mouth furnished with brash-teeth only, and the tail heterocercal, or unequally bilobed (see p. 576). To this group belong several genera, which are restricted to the Secondary formations more ancient than the Oolite; while the other group, with homocercal tails, lived in the Oolitic and Cretaceous seas. Two genera, in particular, abound in the Permian and Carboniferous strata; namely, *Amblypterus* and *Palæoniscus*.[531]

[531] For the characters, affinities, and distribution of these and the allied genera of the Heterocerque Ganoid fishes, see Sir P. Egerton's Memoir in the sixth volume of the Quarterly Geological Journal.

AMBLYPTERUS. *Lign.* 187. *Wond.* p. 740. *Bd.* pl. xxvii.^{b}.—The fishes of this genus, as the name

indicates, have very large and wide fins, composed of numerous rays. The scales are rhomboidal and finely enamelled; the tail is heterocercal. The figures referred to convey a correct idea of the form and external characters. Beautiful pyritous imprints of Amblypteri occur in the Carboniferous slate of Saarbrück, in Lorraine; and fine specimens in the ironstone nodules of the same locality. On the shore at Newhaven, near Leith, similar fossils occur in nodules washed out of the cliffs of coal-shale (*Bd.* p. 278).

PALÆONISCUS. *Ly.* p. 304.—The fishes of this genus differ from those of Amblypterus in the relatively moderate size of the scales, and the numerous little rays on their margins. They have rhomboidal scales, which in some species are very small, and in others large. They have numerous brush-teeth. Several peculiar species, found in the marl-slates and magnesian limestones of the Permian system, are very widely distributed, occurring in the British Isles, Germany, and the United States.

In some localities the small species occur in groups; on a slab of red sandstone, in the Museum of the Geological Society, from Tyrone, between two and three hundred perfect fishes (*P. catopterus*) are imbedded on a space not exceeding two feet square.

A remarkable circumstance relating to the fishes of this genus is the almost constant absence of the bodies of the vertebræ in otherwise well-preserved specimens, and in which the spinal processes and the ribs are entire: occasionally, however, examples occur with some of the vertebræ perfect. An explanation of the above phenomenon may perhaps be found in the probable originally cartilaginous

nature of the bodies of the vertebræ, and the osseous structure of the enduring apophyses and ribs;[532] while those rare specimens which possess a few bony vertebræ may be regarded as exceptions, in which ossification took place in a structure essentially cartilaginous.

> [532] Professor Owen states that a similar condition of the spinal column obtains in the fossil Microdonts.—*Rep. Brit. Assoc.* 1846.

The fishes found in the copper-schists of the Zechstein, at Mansfeld in Saxony, are generally impregnated with copper pyrites, and their scales are as brilliant as burnished gold. These ichthyolites are almost always in contorted and twisted positions; which appearance M. Agassiz attributes to contraction of the muscular tissues after death, during the progress of decomposition, and before the fishes sank down and became imbedded in the mud. (*Poiss. Foss.* tom. ii. p. 70.)

The fishes of the genus Palæoniscus are often found in the shales and marls of the Permian and Carboniferous systems of England and Scotland. At East Thickley, in the county of Durham, numerous specimens have been found.[533] The lower Carboniferous strata at Burdie-house, a locality we have before mentioned, have yielded several species of Palæoniscus, associated with teeth and other remains of large sauroid fishes.[534] On the continent also they prevail in deposits of the same epoch; Eisleben and Mansfeld, iii Saxony, are well-known localities. In North America they have been discovered in strata of probably the same age.[535] In fine, the genera Amblypterus and Palæoniscus may be regarded as characteristic "medals" of the geological epoch which intervened between the

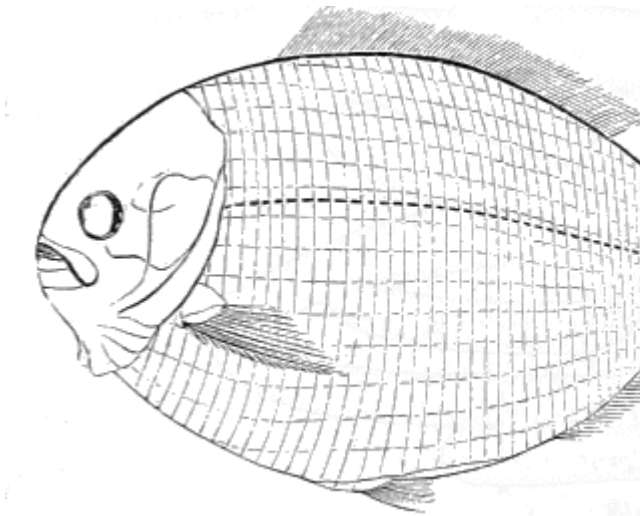
Devonian and Triassic formations.

[533] See Professor Sedgwick on the Magnesian Limestone. Geol. Trans. 2d ser. vol. iii.; and Prof. King's Monograph on the Permian Fossils, published by the Palæontographical Society.

[534] Dr. Hibbert's Memoir on the Fossils of Burdie-house.

[535] Geology of Massachusetts, by Professor E. Hitchcock.

We will next examine a few genera of the homocercal Lepidoids and Pycnodonts, whose relics are chiefly distributed in the Lias, Oolite, Purbeck, and Wealden.



LIGN. 195. OUTLINE OF THE DAPEDIUS. *Lias.* (

DAPEDIUS. *Lign.* 195.—At Lyme Regis, and other productive localities of the fossils of the Lias, large masses of angular enamelled scales, and occasionally

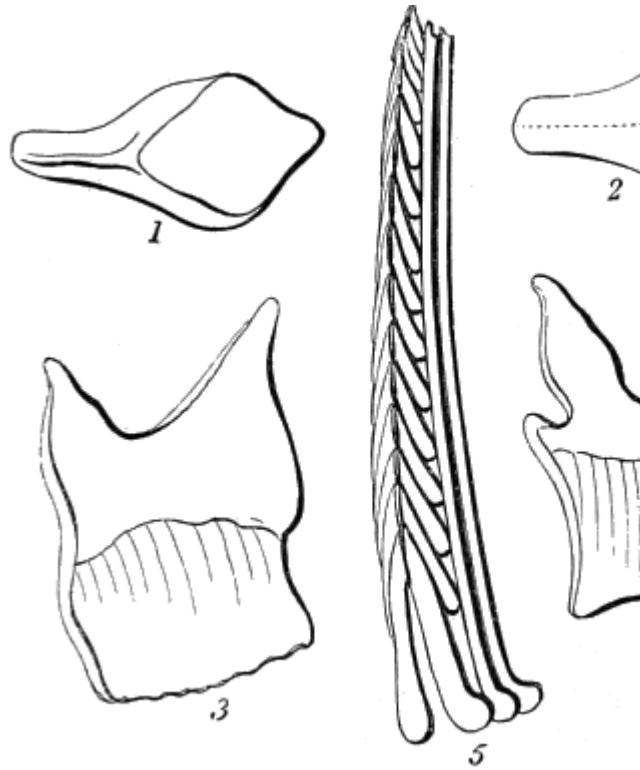
entire specimens of the fishes to which they belonged, have for many years been collected. Sir H. De la Beche first scientifically investigated the structure of these Ichthyolites, and pointed out their characters and relations. The Dapedius (of which a restored figure is given in *Lign.* 195) is a flat, laterally compressed fish, with a rounded head, and fins of moderate size. The body rapidly contracts towards the root of the tail, the fin of which is large and symmetrically lobed. The mouth is furnished with several rows of small conical teeth, which are crenated at their summits, and has brush-teeth on the palatine bones; the jaws are short. The scales are rhomboidal, highly polished, and united laterally by short processes; as in many other ganoid fishes. It belongs to the Lepidoids.

The TETRAGONOLEPIS is a Liassic fish, very similar in shape to the Dapedius. It was formerly grouped with the *Lepidoidei*, but Sir P. Egerton has lately discovered that it essentially differs from those fishes in the character of its scales and teeth, and that it belongs to the Pycnodonts.

LEPIDOTUS.[536] *Lign.* 186, 196, 197.—Scales of a dark-brown, almost black colour, with a glossy enamelled surface, and of a rhomboidal or lozenge form, and teeth equally dark and glossy, of an obtuse hemispherical figure, are very common in the Wealden strata of the south-east of England and in the Isle of Purbeck. They are called by the quarry-men *fishes' scales* and *eyes*. The collectors of the last century used to term the obtuse circular teeth of this and the related genera *Bufonites*, from a supposition that they were formed in the heads of toads. These relics belong to an extinct genus named *Lepidotus*, which contains numerous species, that are

distributed in the Oolite, Purbeck, and Wealden formations. These fishes resembled the Carps in their general form, but they have no anatomical relations to that family. The body is covered with large rhomboidal scales, which are protected on the external surface by a thick plate of enamel (Lign 196, *fig.* 3). The lateral line, which is slightly arched, passes direct from the operculum to the middle of the insertion of the caudal fin. The head, and even the face, are cased with osseous and enamelled plates. The bones of the surface of the skull are very large, and are connected by sinuous sutures. The jaws are short and rounded, and furnished with a row of obtuse, conical, circular teeth (see *Lign.* 197), and several rows of sessile teeth, more or less contracted at the base, which forms a very short pedicle that is anchylosed to the bone. The fossil Lepidoti are found, for the most part, in fluviatile deposits, as in the Purbeck and Wealden strata; and it is probable they inhabited the rivers or sea-coasts, and not deep waters.

[536] *Poiss. Foss.* tom. ii. p. 233.



LIGN. 196. SCALES AND FIN OF LEPIDOTUS MANTELLI. *Tilgate Forest.* (*Nat. size.*)

Fig. 1. Scale, with a single process of attachment.

2. One of the scales of the dorsal line.

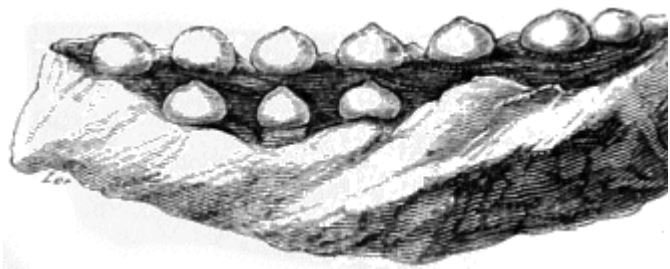
3. Scale (external surface), with a bifurcating process of attachme
— (which alone is visible when the scales are in their natural posi
longitudinal grooves or folds.

4. Scale (viewed on the inner surface), having a bifurcating proce
— tooth or projection on each side, to connect the scale laterally v

5. The front ray of the dorsal fin, covered with two rows of enam
— ray behind it.

The scales and teeth figured *Lign.* 196, 197, belong to the larger species of the Wealden. The

remains of this fish were first collected in Tilgate Forest, and several teeth and: scales are figured *Foss. Til. For.* pl. v. and x.; considerable portions of connected scales have since been found; also the head entire, and the fins more or less perfect. A specimen in my collection retained a mass of the scales near the insertion of the tail, a foot wide; indicating the original to have been twelve feet long, and its body three feet broad. The scales are distinguished from other species by the folds or grooves on their enamelled surface; and the teeth by the contracted base, or pedicle, which is a little narrower than the crown (*Lign.* 197, and *Pl. VI. fig. 10*). A species (*L. Fittoni*) closely related to the above is equally abundant in the Weald of Sussex; the scales are not striated, and the teeth have no pedicle.



LIGN. 197. PORTION OF THE JAW OF LEPIDOTUS. *Wealden. Tilgate For*
This specimen shows three successional teeth beneath a row of te

The intimate structure of the teeth of the Lepidotus is beautifully preserved, and may be easily examined in thin transverse and vertical sections, viewed by transmitted light: see *Pl. VI. fig. 10*. The dentine is composed of bundles of tubes, continued from the cells of the osseous base, radiating in a vertical direction to the surface of the tooth, as seen in *Pl. VI. fig. 10*, and giving off branches at an acute angle; but when more highly magnified, the finer

branches are seen to be spread out and arched at their extremities, "presenting the appearance of the stems of corn, beaten down by heavy rain."[537]

[537] Odontography, p. 70. See the beautiful representation of this structure, pl. xxxi.

The dorsal and pectoral fins of these fishes are very strong, and consist of several bony rays. There is a double row of acuminated enamelled scales, arranged more or less obliquely, on the anterior margin of the dorsal and anal fins, and on both margins of the caudal: part of the first ray of a dorsal fin, with scales, is represented *Lign.* 196, *fig.* 5.

A small species of Lepidotus (*A. minor*) is common in the Purbeck limestone, and specimens may often be procured from the quarries near Swanage;[538] it has also been found at Hildesheim, in Saxony, by M. Roemer. The detached scales abound in the limestones; and the splendid fossil reptile from Swanage, figured *Petrif. Lign.* 38, is sprinkled with the scales and minute teeth of this fish.

[538] Fine specimens of this fish are in the British Museum (*Petrifactions*, p. 429), and in the Museum at Dorchester.

The majority of the species of Lepidotus belong to the Lower Oolites and the Lias. The habits of the Lepidoti, as indicated by the form and structure of the teeth, were those of fishes whose food consisted of crustaceans, shelly mollusca, &c.; for the dental organs are peculiarly adapted for the crushing and grinding of such substances; and the teeth of the adult fishes are generally worn down by use.

PYCNODUS. *Pl. I. fig. 3*; *Lign.* 194, *fig.* 3.—The fishes of the family of Pycnodonts, so named from the thickness of their teeth, have an osseous skeleton, a flat body covered with rhomboidal scales, and flat or rounded teeth disposed in several rows on the palatine, vomerine, intermaxillary, and premandibular bones.[539] As in the Lepidotus, these teeth are constructed for crushing, and have generally a smooth, dense, convex or flattened crown, with a highly polished surface. This genus belongs chiefly to the Oolite; it is found also in the Lias, Chalk, and Wealden. A perfect fish of the genus PYCNODUS (*P. rhombus*), from the Jura limestone, at Torre d'Orlando, near Castellamare, is figured in the frontispiece of the first volume of this work; and a vomerine bone, with teeth, from Tilgate Forest, in *Lign.* 194, *fig.* 3. In the last fossil there is a median row of flat,, elongated, transversely arched, smooth, glossy teeth, with a double alternate row of small sub-circular teeth on each side, attached to the bone, which is imbedded in Tilgate grit. Specimens of this kind, belonging to one or more species of Pycnodus, occur in the Wealden of Sussex; they were among my earliest discoveries in Tilgate Forest (*Foss. Til. For.* pl. xvii. figs. 26, 27). Examples are met; with in which all the teeth are shed, and the bony plate of the vomer alone remains.

> [539] The intermaxillary, palatine, and vomerine bones compose the vault or roof of the mouth; the vomer occupying the middle; the intermaxillary the front; and the palatine bones the sides; the premandibular bones belong to the lower border of the mouth.

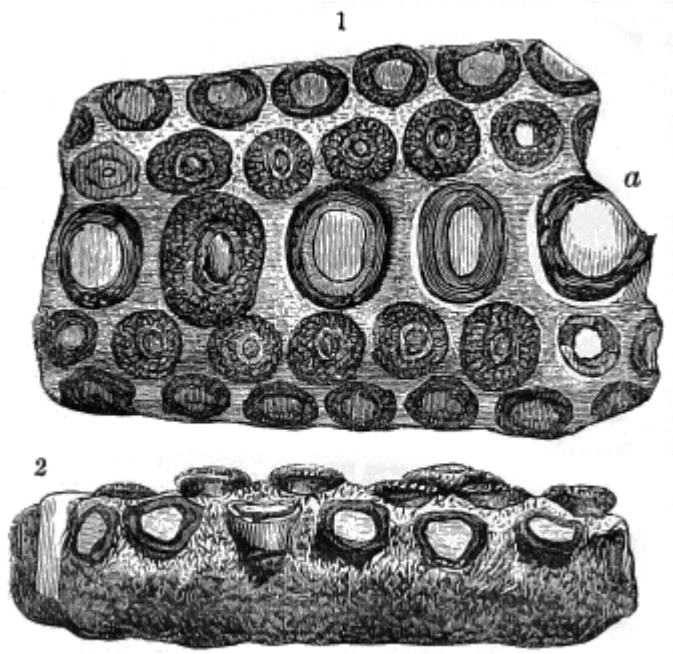
GYRODUS. *Lign.* 198.—In another genus of the Pycnodonts, termed Gyrodus, the crowns of the teeth are deeply furrowed, the structure of the dentine is

very dense, and the pulp-cavity large and simple. One species occurs in the Speeton clay of Yorkshire, and another in the Sussex weald; but the teeth are chiefly found in the Oolite and Chalk. As in Pycnodus, the teeth are distributed in rows on the bones composing the roof, floor, and sides of the mouth.[540]

[540] An extraordinarily perfect lower jaw of a Gyrodus is to be seen in the British Museum (*Foss. Brit. Mus.* p. 439).

These characters are beautifully displayed in the Russian specimen, *Lign.* 198. This interesting fossil was presented to me by the late Stephen Cattley, jun. Esq., who collected it in 1839, in a valley near RJEff, a village on the banks of the Volga. Mr. Cattley informed me "that many fossils are found in that and the neighbouring valleys; and the locality is frequented by Russian geologists when the season permits, which is but seldom, owing to the long duration of the snow, and the heavy rains which accompany the thaw." This specimen consists of the vomerine bone, which is of a coarse texture, and five rows of teeth; the median row consists of very large elliptical teeth; those of the lateral rows are much smaller and arranged alternately. The peculiar structure of the teeth of this genus[541] is finely displayed in this fossil. The ample, deep, and simple pulp-cavity is seen in several teeth, where the crown of dentine has been worn off, filled with a pure white calcareous spar; one of these cavities is marked a. The dentine is extremely dense, consisting of very minute calcigerous tubes, and passes into an external layer of enamel.

[541] Odontography, p. 72.



LIGN. 198. GYRODUS MURCHISONI[542] (G. A. M.) *Oolite? Russi* (*Collected by the late Stephen Cattley, jun. Esq.*)

Fig. 1. The vomerine bone of a fish, with five rows of teeth; seen from — many of the crowns of the teeth are worn away by use, and the pulp-cavities, filled with white spar, are exposed; as at *a*.

2. Lateral view of the same.

— *a.* One of the pulp-cavities filled with spar.

[542] It is with peculiar pleasure that I inscribe this new species of *Gyrodus* to Sir R. I. Murchison, in commemoration of those extended and successful geological researches in the Russian empire, which have conferred additional honour on his distinguished name.

The fishes of the genus *Gyrodus* have the body large, flat, and elevated; the dorsal and anal fins are very long; and the tail is forked, with equal

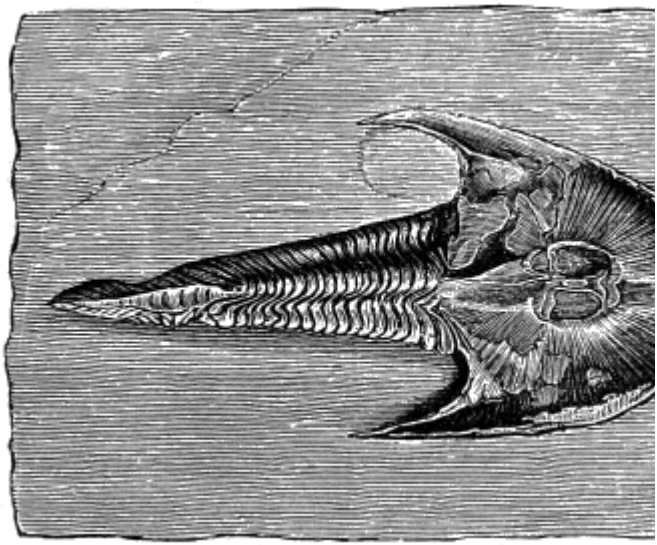
elongated lobes. The scales are laterally connected by strong processes, as in Lepidotus.

Other genera related to the foregoing occur in the Oolite; as for example, Microdon, thus named from the smallness of its very numerous flat angular teeth, arranged in many rows; PLACODUS, in which the teeth are few, flat, and of great size;[543] and PLATYSOMUS (*flat-body*), with orbicular, clavate, teeth.

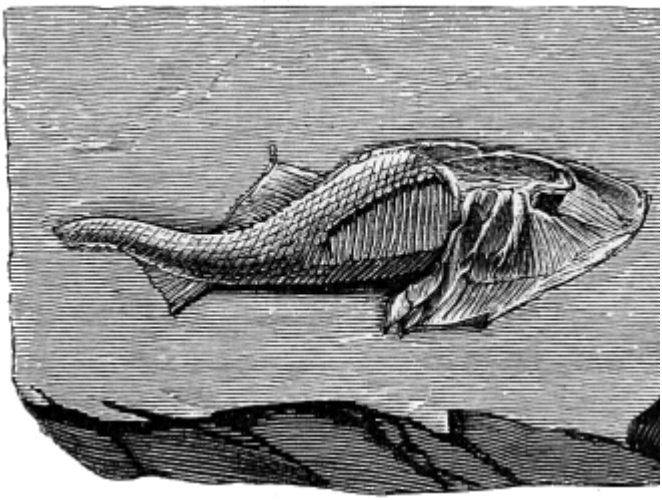
[543] Odontography, pl. xliii. *fig.* 1, and pl. xxx. *fig.* 2.

In these fishes, also, the dental organs are well adapted for the comminution of shell-fish, and other hard bodies.

CEPHALASPIDES OF THE DEVONIAN SYSTEM.—The remains of the three genera of Ganoid fishes that we have now to notice are of a very remarkable character, and are found exclusively in the Devonian or Old Red system; most frequently in Scotland, but also in other parts of the British Isles, and in Europe and America. These fishes agree in one general character, that of having extensive osseous plates, or scutcheons; their general aspect will be understood by reference to *Lign.* 199, 200, 201. There are no vestiges of the bodies of the vertebræ, which, therefore, were probably cartilaginous. These fishes constitute a distinct family with the name *Cephalaspides*, from the character of the first genus we propose to describe.



LIGN. 199. CEPHALASPIS LYELLII. ($^1/_4$ *nat. size*.)
Devonian. Forfarshire.
Crushed specimen; seen from above.



LIGN. 200. CEPHALASPIS LYELLII. ($^1/_4$ *nat. size*.)
Devonian. Glammis, Forfarshire.
Lateral view, showing the produced dorsal lobe of the ta

CEPHALASPIS LYELLII. *Lign.* 199, 200.—The most striking feature in the Ichthyolites of this genus is the enormous scutcheon, or buckler, which forms the head, and is prolonged posteriorly into two lateral horns or points; this part so closely resembles the cephalic shield of certain trilobites (see *Lign.* 175), that the first found specimens were supposed to be the remains of unknown crustaceans. The name *Cephalaspis* (*buckler-head*) is derived from this character. This remarkable appearance is occasioned by the intimate anchylosis of all the bones of the cranium. The body of these fishes is relatively smaller than the head; it has one dorsal fin, and terminates in a tapering tail, supporting a fin. There are two small eyes, placed towards the middle of the head. The body is covered with rhomboidal scales; and the head with discoidal scales, which are highly ornamented with radiated markings[544] (*Ly.* p. 344, *fig.* 396). There are four species of Cephalaspis at present known.

[544] Poiss. Foss. tom. ii. p. 135.

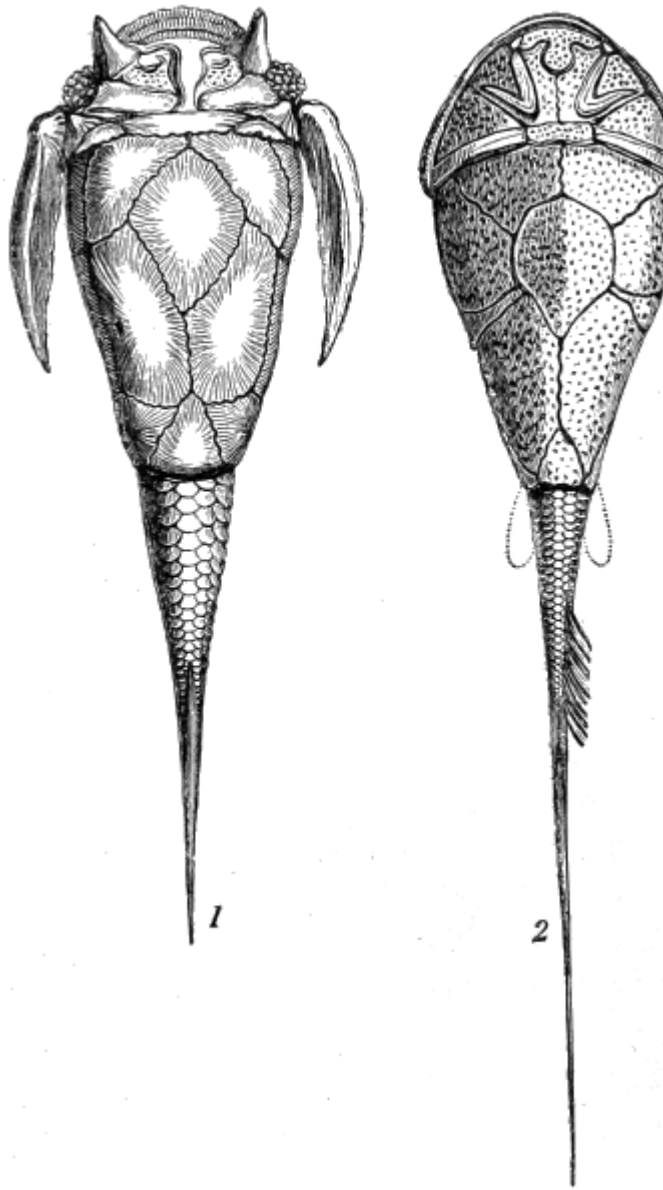
The other genera are equally unlike any recent types of the class of fishes. No perfect examples have been found, and some parts of their structure are still unknown; the annexed figures, *Lign.* 201, have been drawn by Mr. Dinkel (the eminent artist employed by M. Agassiz), with scrupulous accuracy, no part being introduced which is not clearly demonstrated in some one specimen; and the form of the scutcheons is made out very distinctly, to aid the collector in discriminating the detached plates, which are the most common relics of these singular beings.

PTERICHTHYS CORNUTUS.[545] *Lign.* 201, *fig.* 1.—This fish is distinguished by its two wing-like lateral

appendages; whence the name of the genus (*winged-fish*). These processes, like the spines on the gill-covers of the common Bullhead (*Cottus gobio*), are weapons of defence. In some specimens they are extended at right angles to the body (*Ly.* p. 345, *fig.* 400).

> [545] The first fish of this genus was discovered by Mr. Hugh Miller, in whose charming little work, "The Old Red Sandstone; or, New Walks in an Old Field," will be found a very graphic description of the Old Red fishes; I know not a more fascinating volume on any branch of British geology. Consult also Sir P. Egerton's elaborate paper on the *Pterichthys* in the Geol. Journal, vol. iv. p. 302.

The head and anterior part of the body are covered with large angular tuberculated scutcheons. The under surface of the body is flat and protected by five plates, a quadrangular plate occupying the centre. The upper part of the body is convex; the form and disposition of the dorsal scutcheons are shown in *Lign.* 201, *fig.* 1. There are two eyes, which are placed in front of the lateral spines: see *fig.* 1. The tail is of an angular form, and as long as the body; it is covered with scales, and considered by M. Agassiz to have been the only instrument of locomotion. The British species of this genus, of which ten are known, are all very small, varying in length from one to ten inches.



LIGN. 201. FOSSIL FISHES OF THE DEVONIAN SYSTEM.
(*Drawn by Mr. Joseph Dinkel.*)

Fig. 1.— PTERICHTHYS CORNUTUS, seen from above.

2.— COCCOSTEUS OBLONGUS.

These figures are restored with great care, from the best preserved hitherto discovered.

COCCOSTEUS OBLONGUS. *Lign.* 201, *fig.* 2.—The fishes of this genus, as may be seen by the lignograph, very much resemble those of Pterichthys; in both the osseous scutcheons of the body are very similarly disposed. In *Coccosteus*, the head[546] is somewhat rounded; slight rounded notches on the edge of the buckler indicate the place of the eyes on the sides of the head. There is no indication of lateral spines. The tail is very long, covered with scales, and supports a fin. The plates of the body are tuberculated, as in Pterichthys. There are six or eight teeth on each half of the lower jaw (and probably as many on the upper), with a curious group of teeth situated on its symphisis. The teeth are chiefly composed of bone, passing into dentine at their surface.[547]

[546] This is of course only the cranial buckler of the animal, for, as Mr. Hugh Miller observes, "of the true internal skull there remains not a vestige. Like that of the Sturgeon, it must have been a perishable cartilaginous box."—*Miller's Foot-prints*, p. 50.

[547] Miller, Rep. Brit. Assoc. 1850. Transact. Sect. p. 92. In the Annals of Natural History for November, 1848, Professor M'Coy has given a corrected outline of the carapace, or bony cephalo-thoracic casing, of the Coccosteus. See also Miller's Foot-prints, *fig.* 11.

These fishes are from a few inches to two feet in length; six species have been discovered; and their

remains are the most abundant of the Ichthyolites of the Old Red. Patches of detached scales, and isolated osseous plates, are very frequent in the sandy cornstones, and the subcrystalline masses of limestone. These fragments are usually of a brilliant blue or purple colour; and, strongly contrasting with the dull red tint of the surrounding rock, are easily recognised. The colour is supposed to be due to the presence of phosphate of iron, which has communicated a similar tint to the Ichthyolites of the Caithness Schist.[548]

[548] Murch. Sil. Syst. p. 588; see also a detailed description of the Cephalaspis, Holoptychius, and other Devonian Ichthyolites, by M. Agassiz, ibid. p. 589-601.

FOSSIL SAUROID FISHES. (*Poiss. Foss.* tom. ii.)—The family of Ganoid, fishes termed *Sauroid*, or lizard-like, by M. Agassiz, are so named in consequence of certain peculiarities in their organization which are found in no other animals of this class, but exist in reptiles. There are but two living genera; namely, the *Lepidosteus*, of which there are many species that inhabit the rivers of America; and the *Polypterus*, that contains two species, one inhabiting the Nile, and the other the rivers of Senegal. In these fishes the bones of the skull are closely connected by sutures; the teeth are large, conical, and longitudinally striated, as in the crocodile, plesiosaurus, &c.; the spinous processes are united to the bodies of the vertebræ by suture, as in most reptiles; and the ribs are articulated to the extremities of the transverse processes; the skeleton is osseous. Even in the soft parts many analogies to reptilian structure are seen; thus the Lepidosteus has a glottis, as in the *Siren*; and a cellular air-bladder,

with a tracheal vessel, resembling the lungs of an Ophidian (*serpent*). These fishes are the only living representatives of those voracious tribes of the most ancient marine fauna, whose remains abound in the Secondary formations. Their relics have often been mistaken for those of reptiles; particularly the teeth, which from their large size, conical figure, enamelled and striated surface, and internal cavity, were generally supposed to belong to crocodiles. The scales are flat, rhomboidal, and parallel to the body. The recent *Lepidosteus osseus*, of North America, affords a good illustration of the fossil genera; a reduced figure of this fish, from *Poiss. Foss.*, will be found in *Bd.* pl. xxvii[a].; and teeth of some fossil Sauroids are represented *Bd.* pl. xxvii.

The teeth of the Sauroids consist of two kinds; namely, large pointed striated cones, and numerous small brush-teeth. The intricate structure of the conical teeth of the *Stony-gar*, or Lepidosteus, is very remarkable, and presents some analogy to that observable in the dental organs of the Labyrinthodon, an extinct genus of reptiles, of which we shall treat in a subsequent chapter. The tooth consists of a large conical pulp-cavity, surrounded by a mass of dentine, which is plicated longitudinally, its folds giving to the pulp-cavity an appearance of being divided into parallel longitudinal branches; resembling, in this respect, the base of the tooth of Ichthyosaurus, as shown in a transverse section, *Pl. VI. fig. 9*. If we imagine these folds to be multiplied, and to have more inflections, and the pulp-cavity to be reduced in its proportions, we shall have the elegant organization of the teeth of the *Labyrinthodonts* (see *Pl. VI. fig. 3b*). The dentine is composed of very minute calcigerous tubes, which pass off at right angles from the pulp-cavity to the

periphery; and it is covered by a layer of cement, or coarser dentine, which is encased in a coat of enamel, forming the external investment of the tooth.[549] The long conical teeth are implanted in *alveoli* or sockets, to the walls of which they are anchylosed at their base.

[549] These remarks are based on M. Agassiz's description and my own observations. An interesting paper, "On the Microscopic Structure of the Teeth of the *Lepidostei*, and their analogy with those of the *Labyrinthodonts*, with a plate," by *Dr. Jeffries Wyman*, will be found in Amer. Journ. of Science, October, 1843, p. 359.

LEPIDOSTEI.—This family, having the above described recent *Lepidosteus* for its type, comprises several genera, and is represented in all the formations from the Tertiary to the Coal-measures inclusive. The *Lepidosteus* itself has left its remains in the Eocene tertiary of England. The Lepidotus (before described, p. 604,) ranges from the Chalk to the Lias; the *Pholidophorus* and *Dapedius* (p. 603) abound in the Lias; the latter being found also in the Wealden, and the former in the Oolite and Purbeck; and the *Palæoniscus* (see p. 601) is a well-known Permian and Carboniferous form.

SAUROIDEI.—The remains of the Sauroids proper occur in the Chalk, Purbeck, Oolite, Lias, Permian, and Carboniferous rocks. The great strength and size of some of these teeth prove that the seas of those remote periods were inhabited by voracious fishes of enormous magnitude. See *Petrif.* pp. 432, *et seq.*

The teeth and jaw of a gigantic sauroid (*Megalichthys*), from the Carboniferous strata at

Burdie-house, are figured *Bd.* pl. xxvii.; the sections of the teeth shown in figs. 13, 14, of that plate, illustrate the size of the pulp-cavity and the thickness of the layer of dentine. These remains were associated with the plants and crustaceans previously described; an assemblage of fossils indicating a lacustrine or estuary formation. Similar teeth have been found in the cannel-coal of Fifeshire.

In the Upper Lias of Ilminster, Somerset, the nodular calcareous rock is rich with the remains of the *Pachycormus*, many fine specimens of which Mr. C. Moore, of that town, has successfully worked out from their stony encasement, exhibiting the gaping, contorted fish, as it died in the convulsive throes of suffocation in the muddy sea. The little sauroid *Leptolepis*, of the Lias and the Purbeck, is also abundant in the above mentioned locality.

In the lithographic stone of Solenhofen, and in the Purbeck strata, Oxford Clay, and Lias of England, occur specimens of a sauroid fish remarkable for the extreme shortness of the lower jaw, and the prolongation of the upper into a beak; it is named *Aspidorhynchus* by Agassiz. The figure of this fossil fish is contrasted on pl. xxvii[a]. *Bd.* with that of its recent ally, the *Lepidosteus*.

In the Shanklin sand and in the Galt of Kent and Sussex, large, conical, striated teeth belonging to sauroid fishes are occasionally found. They invariably occur detached, and no portion of the jaws has been observed. In the Chalk of Sussex several fine sauroid fishes have been discovered; such as the *Lophiostomus*,[550] *Belonostomus*,[551] and *Caturus*; the last two of which are found in the Oolite and Lias also. These have been described and figured

in the late Mr. Dixon's "Geology and Fossils of Sussex."

[550] *Geol. Surv.* Dec. 6. pl. x. xi.

[551] *Petrif.* p. 431.

The SAUROIDEI-DIPTERINI[552] are found almost exclusively in the Devonian formation. *Osteolepis*, *Diplopterus*, and *Dipterus* are characteristic members of this family. Interesting descriptions and instructive figures of the structure of these genera are given in Mr. Hugh Miller's late work, "Foot-prints of the Creator, or the Asterolepis of Stromness," at pp. 50 to 61.

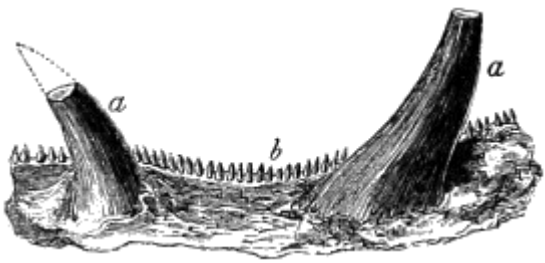
[552] The characters of the scales of this and the next family, as well as of the Acanthodei, are succinctly given in Miller's Foot-prints of the Creator, pp. 30, *et seq.*

CŒLACANTHI.—This is a numerous family of sauroid fishes, that have derived their name, *hollow-spine*, from the central cavity in the fin-rays, which, however, may have had originally cartilaginous cores. They are found from the Devonian to the Cretaceous series. In the former, one of the most remarkable is the genus *Holoptychius*, distinguished by the peculiar structure of the scales; the enamelled surface of which is covered by undulated furrows. The whole body is covered by thick enamelled scales of this kind. A splendid specimen, twenty-eight inches long, and twelve wide, is figured *Murch. Sil. Syst.* pl. ii.*bis.* Scales have been found exceeding three inches in length, by two and a half in width; which must have belonged to a fish of great magnitude. *Ly.* fig. 395.

In the Old Red Sandstone of Elgin, at a quarry at

Scat-craig, some peculiar teeth occur, which possess a very remarkable structure, and have been referred to a genus of sauroid fishes, which, from the dendritical or arborescent disposition of the calcigerous tubes, Prof. Owen has named *Dendrodus*. These teeth are of a conical form, slightly curved, and solid throughout. On the external surface they are finely striated longitudinally, and have two opposite vertical ridges; the base is rough, and its margin rounded, as if for attachment to a shallow socket. The largest specimen is one and a half inch in length. In thin sections, viewed microscopically by transmitted light, there is a central pulp-cavity, of small size; the medullary canals pass into a few short ramifications, like the branches of a shrub, and these are distributed into irregular dilatations, simulating leaves, which resolve themselves into radiating bundles of calcigerous tubes; a portion of a transverse section[553] is shown *Pl. VI. fig. 8*.

[553] Odontography, pl. lxii. B *fig.* 2; and Cycl. Anat. *Art.* TEETH.



LIGN. 202. ASTEROLEPIS. *Devonian.* ($^1/_2$ *nat. size*)
Inner side of portion of the lower jaw.
(After Miller.)

ASTEROLEPIS.

In Mr. H. Miller's charming work just referred to we have a full and clear account of the singular fossil

fish the ASTEROLEPIS. Remains of this gigantic Ganoid were first found in Russia.[554] Its name is derived from the stellate markings on the dermal plates of the head, which are of great size, and form a strong expanded buckler, the orbits of the eyes being situated near the anterior border. (See Miller's *Asterolepis*, pp. 74, *et seq.* figs. 27-29.) *Lign.* 202 shows a part of the lower jaw of this fish, seen on the inside. Along the upper margin are seen a "thickly set row of small broadly-based teeth,"—these are ordinary *fish*-teeth; and behind this edge-row of small teeth, *b*, there occur "a thinly set row of huge *reptile*-teeth, based on an interior platform of bone, which formed the top of the cartilage enclosing box composing the jaw." (Miller.) These large teeth, *a a*, are longitudinally striated, and generally bear two sharp lateral cutting edges.[555]

[554] Casts of the fossil bones from Russia are in the British Museum; *Petrif.* p. 435.

[555] The microscopic structure of both kinds of teeth is elegantly figured in Mr. Miller's work, pp. 81, 82.

MACROPOMA MANTELLI. *Wond.* p. 348. (*Foss. South D.* tab. xxxvii. xxxviii.; *Petrif.* p. 436, *Lign.* 89.) —This Cœlacanth fish is from one to two feet in length, of an elongated fusiform shape, with a large head and two dorsal fins; the anterior fin is imbedded, and has seven or eight strong spinous rays, the first two of which have numerous spines. The opercula are very long and large (hence its name); the scales[556] are garnished with adpressed spines, disposed in semicircular rows (see *Lign.* 185, *fig.* 2). The teeth are small, conical, and numerous.

[556] See Prof. Williamson's Memoir,

Philos. Trans. 1849, p. 435; pl. xliii. figs. 27, 28.

Several specimens of this fish are almost perfect. The bones of the cranium, the jaws, teeth, opercula, branchial rays, palatine arches, the surface of the body covered with scales, all the fins, the pelvic bones, the vertebræ and their apophyses, all remain.

In one example, the vomer, covered with minute teeth, is exposed. But the most extraordinary fact relating to these Ichthyolites, is the preservation, in every specimen, of the air-bladder;[557] even its membranes remain, and separate in flakes; and the ramification of the minute vessels is visible under a high magnifying power. In some instances this bladder is displaced and much distended; but in general it occupies its natural position, and retains its elongated, sub-cylindrical form, with a few annular constrictions or folds.

[557] See Williamson, *op. cit.* pp. 462-165, and figs. 29, 30.

COPROLITES. COLOLITES.

COPROLITES. *Lign.* 139, *figs.* 1, 2.—In more than one example the solid earthy residue of digestion, in small lumps or pellets, of a conical form and spirally convoluted, lies in the abdomen of these fossil fishes. Fossil excrementitious substances of this kind are termed *Coprolites* (*Bd.* p. 198, pl. xv.); they occur in many deposits, and belong not only to fishes, but to large reptiles and other animals. *Lign.* 139, p. 432, *fig.* 1, represents the coprolite of a *Macropoma*; and *fig.* 2, that of a species of *Shark*, from Hamsey. The convoluted appearance of these bodies arises from the peculiar organization of the intestinal canal of the original fishes, in which, as in the recent Dog-

fish, a portion of the intestine was spirally twisted, the tube forming several gyrations; and the passage of the calcareous substance through this constricted canal gave rise to the structure observable in the coprolites. In the Macropoma the gyrations appear to have been few; seldom more than five or six turns being apparent. In the fossil Sharks the convolutions are more numerous, ten or twelve occurring in the length of an inch. In many of the coprolites, the impression of the mucous or lining membrane of the intestinal canal may be detected. Some of the coprolites of the Macropoma are not convoluted; probably from having occupied the upper part of the digestive tube, and therefore not having been moulded in the spiral part. (See *Geol. S. E.* p. 145. *Foss. South D.* tab. ix.) Minute scales and bones of fishes are occasionally imbedded in the substance of the coprolites, affording evidence of the carnivorous habits of the Macropoma.

COLOLITES. *Bd.* pl. xv^{a}—It will be convenient to notice in this place those curious fossils which occur in detached masses in the limestone of Solenhofen, and used to be known to collectors by the term *lumbricaria*, from the supposition that they were petrified earth-worms. An excellent representation of a fine specimen is given by Dr. Buckland in the plate referred to above. These convoluted bodies M. Agassiz, with his wonted sagacity, has ascertained to be the intestines of fishes; and has therefore named them *Cololites*. Although generally found isolated, specimens occur in which they are imbedded, like the coprolites of the Macropoma, in the abdominal region of fishes. The frequent occurrence of the *Cololites* apart from the body, is explained by the usual process of decomposition in fishes. M. Agassiz remarks that dead fish always float on the surface of

the water with the belly uppermost, until the abdomen bursts from distention. The small intestines are then expelled by the evolved gases through the aperture, and soon become detached from the body. I have observed indistinct traces of similar remains in the beds of chalk in which fossil fishes most prevail. Dr. Buckland mentions the discovery, by Lord Greenock, of a mass of petrified intestines distended with coprolite, and surrounded by the scales of a fish, in a block of coal-shale from the neighbourhood of Edinburgh (*Bd.* p. 199).

DERCETIS ELONGATUS. *Wond.* p. 349.—Before proceeding to the investigation of examples of the next order, I will describe a highly interesting Ichthyolite, which in a mutilated state is extremely common in some of the chalk strata of the South-east of England; it is noticed in *Foss. South D.* p. 232. This fish is placed by M. Agassiz in his family of ganoidians, termed *Scleroderms*; and he mentions that another species has been found in the chalk of Westphalia. The *Dercetis* has a very elongated body, with a short head terminating in a pointed beak; the upper jaw is a little longer than the lower, and both jaws are armed with long, conical, elevated teeth, and several rows of very small ones. On each side of the fish there are three rows of osseous scutcheons like those of the Sturgeon (see *Wond.* p. 349); the body was also covered with numerous small scales. From the form of the body somewhat resembling that of the eel, being very long, and sub-cylindrical in uncompressed examples, the specimens are generally called "*petrified eels*" by the quarry-men. The examples usually found consist of the elongated body, more or less compressed, and irregularly covered with patches of scales confusedly intermingled; among which traces of the scutcheons

may sometimes be distinguished. These specimens occasionally exceed two feet in length, by one or two inches in breadth; with neither extremity perfect, and without any vestige of the fins.[558] The example figured *Wond. Lign.* 74, is the only instance in which I have seen the cranium perfect. The scutcheons in the Westphalian species have a prominent longitudinal ridge or keel, and their surface finely granulated; they are so large that the whole body of the fish is covered with them.

[558] See *Foss. South D.* pl. xl. *fig.* 2, and pl. xxxiv. figs. 10 and 11.

CTENOID FISHES.

FOSSIL CTENOID FISHES (*Poiss. Foss.* tom. iv.).—The fishes of this order have imbricated laminated scales, the posterior margins of which are round and finely pectinated; *i. e.* divided into little teeth, like a comb. These scales are nearly circular, but more or less elongated; and, as the laminæ of which they are composed successively diminish from the lowermost to the uppermost, the pectinated margin of each being apparent, the surface is very scabrous; the front edge is sinuous. The common PERCH is the type of the Ctenoidians. The teeth of these fishes are invariably small, and either villous or brush-like.

From the numerous fossil genera I select, in illustration of the characters of this order, the *Beryx*; of which four species occur in the English Chalk, and three others in the Chalk of Bohemia and Westphalia. Of this genus, which is closely related to the Perch (*Perca*), two living species inhabit the seas of Australia. The bones of the skull have dentated crests; the dorsal fin has spinous rays in front, which are united to the soft rays; the margin of the caudal

fin has little spinous rays.

The Beryx is one of the most ancient representatives of the Perch tribe, and of the Ctenoid order.

BERYX LEWESIENSIS.[559] *Wond.* p. 351; *Petrif. Lign.* 90.—This is one of the most common of the Ichthyolites of the Chalk of the South-east of England; it is called "*Johnny Dory*" by the quarry-men; the specimens are from six to twelve inches long. It occurs also in the Chalk of Westphalia. The outline of the perfect form of this species, *Wond.* p. 351, by Mr. Dinkel, conveys an accurate idea of its external characters. It has one dorsal fin, with several spinous rays in front of the soft ray. The head is very large, and the opercular pieces are ornamented with sculptured rays; the margins of the jaws are covered with a broad band of brush-teeth. The orbit is large, and often contains the capsule (*sclerotica*) of the eye. The rays of the gills are short and thick, five are preserved in some examples. The scales are very large; about twenty-five in the median row; their posterior margins have several concentric rows of spines (see *Lign.* 185, *fig.* 3, p. 567). The lateral line is often distinctly apparent, in the form of a tube, contracted behind and expanded in the centre of the scale. The vertebral column is composed of large short vertebræ, with very long apophyses; the ribs are slight.

[559] The fossil discovered by me, and figured in *Foss. South D.* tab. xxxvi. was the first perfect fish obtained from the Chalk. This fish was first described by me, *Foss. South D.* tab. xxxv. xxxvi. as ZEUS *Lewesiensis*; M. Agassiz has very properly referred it to the genus *Beryx*; but he has also substituted

another specific name; which is wholly unwarrantable, for that first imposed ought to be retained; see p. 518, note.

BERYX SUPERBUS.—This is a larger species, sometimes thirteen inches long, with very large and broad scales. It has been found in the lower chalk at Lewes. See Dixon's *Foss. Sussex*, tab. xxxvi. *fig.* 5.

BERYX RADIANS. *Wond.* p. 350.—This species is smaller, and relatively longer, than *B. Lewesiensis*; it generally occurs in the Chalk-marl, and is invariably of a very dark colour, the scales having a polished or glossy aspect. The scales are small, with a simple row of diverging spines on the posterior edge. The scales of the lateral line are peculiar; the mucous canal is not formed of a series of simple tubular cylinders, as in *B. Lewesiensis*, but is divided into several branches, as may be seen with a lens of moderate power. There are more than thirty scales in the length of the lateral line.

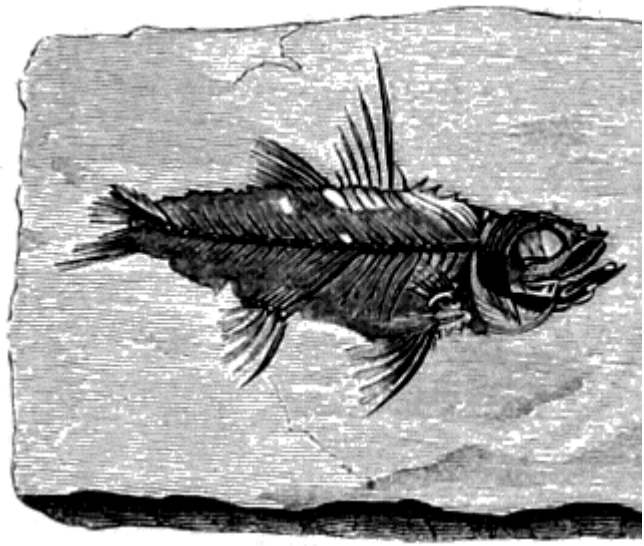
BERYX MICROCEPHALUS (*Poiss. Foss.* tom. iv. tab. iv^{c}.; and Dixon, *Foss. Sussex*, tab. xxiv. *fig.* 3).—This fish is distinguished by its slender form, and the extreme smallness of the head, as the name implies. The scales have one row of very thick spines on the posterior margin; they are more elevated, and shorter than in *B. radians*; those of the lateral line are pierced by an elongated conical tube, and are not ramified as in the last species. This ichthyolite, like the *B. radians*, occurs in the Chalk-marl, and in a similar state of mineralization.

SMERDIS MINUTUS. *Lign.* 203.—A pretty ctenoidian fish, from one to three inches long, about the dimensions of a perch a year old, is very common in the marls of Aix in Provence, *Wond.* p. 260; and

many are often found grouped together in every variety of position. This species is characterised by the elevated anterior rays of the dorsal, and the wide and very forked caudal fin.

Several ctenoidian and cycloidian fishes have been found in the north of the Brazils, by Mr. Gardiner, in strata probably of the Cretaceous epoch.

FOSSIL CYCLOID FISHES. (*Poiss. Foss.* tom. v.)—This order comprises the fishes possessing scales of a cycloid, or circular, form, with smooth margins, and composed of plates of horn or bone, without enamel. It contains numerous families, including the *Scaroids*, or Parrot-fishes, and the *Scomberoids*, or Mackerel tribe, which are Acanthopterygians, the *Lucioids*, or Pikes, *Clupeoids*, or Herrings, *Salmonoids*, or Salmon tribe, and the *Cyprinoids*, or Carps, which are Malacopterygians, as well as other families. The fossil remains of this order are exceedingly numerous, particularly in the Tertiary and upper Secondary deposits. A genus of *Salmonidæ*, discovered in the White Chalk of Sussex, will serve to exemplify the characters of the fossil cycloidian fishes.



LIGN. 203. SMERDIS MINUTUS. *Eocene.* (*nat. si*
Aix in Provence.

OSMEROIDES. *Plate II.* and *Wond.* p. 344, 347.—Two species of this genus occur in the Chalk, near Lewes; and principally, if not exclusively, in the Lower Chalk, without flints. They are exceedingly beautiful Ichthyolites, and are almost invariably found with the body but little compressed; the fish, in many examples, is as round and perfect as when living. The entire cranium, the opercula and branchial rays, and all the fins are preserved in some examples. These fishes belong to the Salmon family, [560] and are nearly related to the SMELT (*Osmerus*); whence the name of the genus. There are two species, easily distinguishable. The first (*O. Mantelli*, *Pl. II.*) has a short, sub-cylindrical body, and seldom exceeds eight or nine inches in length; the other (*O. Lewesiensis*) has an elongated and elliptical body, and sometimes attains a length of fourteen inches. The dorsal fin too in this species has more rays than in

the other. The fossil figured in *Pl. II.*. is a very remarkable specimen of the first species. It is nine inches in length; and the chalk has been cleared away, so as to expose the entire fish, six inches in relief above the surface of the block, *Petrif. Lign.* 92, p. 445. The fish is lying on its back, with the mouth open, and the opercula, or gill-covers, and the branchial arches expanded; the pectoral and ventral fins, and the dorsal fin, are in their natural position; the five rays of the dorsal are erect; of the caudal fin, or tail, but slight indications remain. There is but one dorsal fin; but in a specimen of *O. Lewesiensis* there is a trace of the little adipose process observable between the dorsal fin and the tail, as in the recent species of *Salmonidæ*. A magnified view of one of the scales is represented *Lign.* 185, *fig.* 4, p. 567.

[560] They were first described by me in *Foss. South D.* p. 235, tab. xxxiii. and xl. as *Salmo Lewesiensis*.

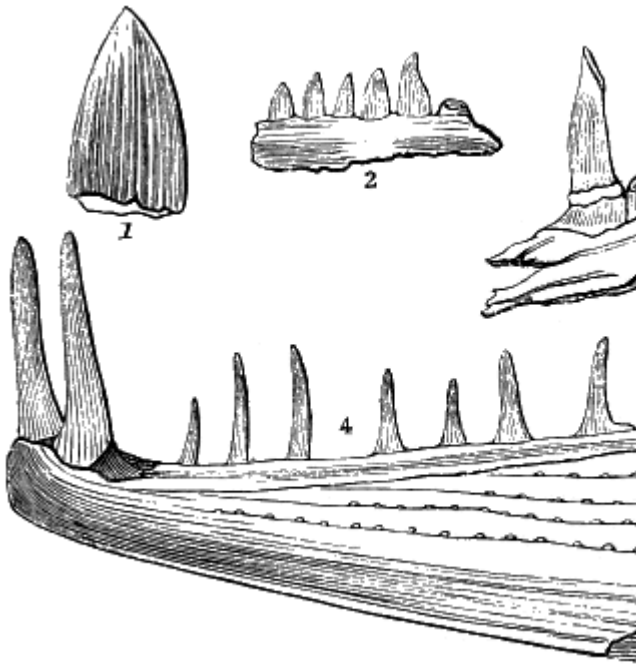
Of the CYPRINOIDS, or fishes of the Carp family (Malacopterygians), the recent species of which are inhabitants either of fresh-water, or the brackish waters of the mouths of rivers, many fossil species occur in the fluviatile and lacustrine deposits of the Tertiary formations. In their character of omnivorous fishes, the Carps then, as now, formed the principal mass of the finny population of the lakes, and in their turn served as food to the carnivorous tribes, as the pikes, eels, &c. Several species are found in a beautiful state in the schists of Œningen, and in the Tertiary marls at Aix. Many of the layers of marl at the latter locality are covered with groups of fishes of the family *Cyprinodonts*, the recent species of which are of a small size, and inhabit the fresh-water lakes of temperate zones. *Lign.* 184, p. 562, represents a

portion of a large slab of marl in the cabinet of Sir R. Murchison, which is covered with scores of a species resembling a recent fish (*Lebias*) in the profile of its head, and the form of its fins. It is named LEBIAS CEPHALOTES, from the relative largeness of its head. The black appearance of the abdomen in many of these Ichthyolites indicates the original situation of the intestines and of the liver, which is largely developed in the fishes of this family, and contains much colouring matter.

SAUROCEPHALUS AND SAURODON. *Lign.* 204.—In the same quarry, near Lewes, from which the first entire fish of the Sussex Chalk was obtained, teeth of a very peculiar character were, many years since, occasionally discovered.[561] These teeth are of a lanceolate form, much compressed; with entire, sharp edges, terminating in a point; the fang is single, and broad; the surface of the crown is glossy, and marked with fissures filled with chalk (see *Lign.* 204, *fig.* 1). Teeth of this kind, attached to portions of the jaw, were subsequently found in the Chalk at Brighton and Lewes. Similar remains were collected from the Cretaceous marls of Missouri and New Jersey, in the United States. The American specimens comprised two closely allied genera, which, from the supposition that the fossils were the relics of reptiles, were respectively designated *Saurocephalus* and *Saurodon*.[562] Examples of the teeth and jaws of both genera have been discovered in the Sussex Chalk (see *Lign.* 204).

[561] Foss. South D. tab. xxxiii. p. 228.

[562] American Phil. Trans, vol. iii. new series, pl. xvi. on the Saurodon, by Dr. Hays; and Journal Acad. Sciences, Philadelphia, vol. iii. on the *Saurocephalus*, by Dr. Harlan.



LIGN. 204. FOSSIL TEETH AND JAWS OF FISHES. *Chalk*

Fig. 1. Tooth of SAUROCEPHALUS LANCIFORMIS. *Lewes.*

— 2. Teeth of SAUROCEPHALUS STRIATUS. *Brighton.* Portion of the ja

— 3. Fragment of a jaw, with two perfect teeth, and the base of ano
— LEANUS. *Kemptown, Brighton.*

4. ENCHODUS HALOCYON. Left branch of the lower jaw, with teet
— the opposite portion. *Lewes.*

M. Agassiz retains the names imposed by the American naturalists, and has placed these genera in the family of Scomberoids (*Mackerel*, *Swordfish*). They belong to the *Pharyngognathi* of Muller. The teeth are disposed in a single row, and fixed in deep sockets by a simple root, or fang, which is frequently somewhat excavated by the pressure of a successional tooth. In *Saurodon Leanus* the crown of

the tooth is angular, and barbed, and supported on a sub-cylindrical shank, or stem (see *Lign.* 204, *fig.* 3). The microscopical structure of these teeth presents that peculiar reticulated disposition of the medullary canals throughout the entire body of the tooth, which is only found in the dental organs of fishes.

HYPSODON LEWESIENSIS. (*Foss. South D.* tab. xlii.)—The Sussex and Kentish Chalk also contain the remains of a very large fish, belonging to the Pharyngognathi, with extremely upright, long, conical, compressed, pointed teeth, which, like those of the Saurodon, are implanted in sockets. These teeth are commonly of a delicate fawn colour externally and of a dark brown internally; having a large simple pulp-cavity. In *Foss. South D.* (tab. xlii.) are represented portions of an intermaxillary and jaw-bone with teeth; a vertebra, deeply biconcave; and a large bone, apparently a branch of the *os hyoides*; all found in the same block of chalk.[563]

[563] A magnificent specimen (now in the British Museum) displays, on the same slab of chalk, a large portion of the cranium, teeth, several vertebræ, ribs, and many other bones, belonging to a fish of considerable magnitude. *Petrif.* p. 444.

ENCHODUS (*sword-tooth*) HALOCYON. *Lign.* 204, *fig.* 4. (Poiss. Foss. tom. v. tab. xxv^{c}.)—The specimen figured is a portion of the lower jaw, with one row of elongated, conical, slightly curved, pointed teeth; the two anterior teeth being much longer and larger than the others; it affords a good illustration of the dental organs of *Enchodus*; a genus of Acanthopterygian fishes, the jaws and teeth of which are often found in the Sussex Chalk. The teeth are of various sizes, and attached by anchylosis, one row on the

premandibular bone, and another irregular row of smaller teeth to the inside of the lower jaw. The two anterior teeth are very large, and of a peculiar form: their base is wide and solid, and the shank of the tooth is suddenly contracted immediately above, and becomes elongated into a point. These teeth are generally of a dark colour, have a glossy aspect, and are very brittle; differing so remarkably in this respect from the shark's teeth, with which they are usually collocated, that mere fragments can be readily identified. The external surface of the lower jaw is marked with finely granulated, longitudinal ridges or striæ.[564]

[564] A fine example of the lower jaw, with twelve teeth, is figured *Foss. South D.* tab. xli. and another, with the upper jaw and teeth, *Geol. S. E.* p. 140. Beautiful figures of the remains of Saurocephalus, Enchodus, Hypsodon, and many other fine Chalk fishes, are given in Dixon's *Fossils of Sussex*, 4to. 1850.

Mr. Toulmin Smith, of Highgate, has in his Museum a portion of the lower jaw with fifteen teeth of a small individual, imbedded in the centre of a flint nodule, from Gravesend, which was discovered by accidentally breaking the stone. The bone of the jaw and the teeth are of a dead white colour, and appear not to be in the slightest degree silicified; but in those teeth which are broken the pulp-cavity is filled with quartz, which must have transuded through the walls of the teeth.

ICHTHYOLITES OF RECENT SPECIES.—The distinguished naturalist to whose labours in fossil Ichthyology we have been so largely indebted, states, that of the many hundred species submitted to his notice, but one can be identified with any fish now

living. This conclusion must, however, be received with some reservation; for, among the fossil genera, founded on the teeth, there are species which certainly cannot be distinguished from recent forms. And in the diluvial drift at Breslau, associated with the bones of the fossil elephant (*Elephas primigenius*), the remains of a pike, closely resembling the common European species, have lately been discovered.[565]

[565] Agassiz, *Poiss. Foss.* tom. v. p. 68.

The exception above alluded to, is a little Malacopterygian fish, rather larger than a Sprat, called the Capelan (Mallotus villosus), which inhabits the banks of Newfoundland, and other parts of the coasts of the northern seas. Fossil specimens of this fish.[566] occur in nodules of indurated marl or clay, on the coast of Greenland.[567] It is supposed that these Ichthyolites are of very recent date: and that similar fossils are in the progress of formation.

[566] See *Poiss. Foss.* tom. v. pl. lx., in which the skeleton of the recent fish, and specimens of the fossil species, are represented.

[567] Similar fossils have been obtained from the "Drift" on the Saco River, thirty miles north of Portsmouth, New Hampshire. See Lyell's Second Visit to the United States, vol. i. p. 29.

ICHTHYOPATOLITES, or imprints of the pectoral fin-rays of certain fishes. Under this name Dr. Buckland described certain problematical markings observed on a flag-stone from a coal-pit at Mostyn, in Flintshire, and now in the Geological Society's Museum. It consists of curvilinear scratches or imprints, disposed symmetrically at regular intervals

on each side a smooth level space, about two inches wide, which may correspond to the body of a fish, the pectoral fins of which Dr. Buckland suggests were the instruments by which the markings in question were formed.

These scratches follow each other in nearly equidistant rows of three in a row, and at intervals of about two inches from the point of each individual scratch to the points of those next succeeding and preceding it; they are slightly convex outwards, three on each side the median space, or supposed track of the body of the fish. Dr. Buckland, in the memoir referred to, shows that these markings cannot be referable to the imprint of the feet or claws of reptiles, and points out the structure of the bony anterior rays of the pectoral fins, as in certain Siluroid and Lophoid fishes, and in the Climbing Perch (*Anabas scandens*), or the *Hassar* (*Doras costata*), and refers also to the ambulatory movements of the common Gurnard, in corroboration of this opinion.[568]

[568] Proceedings of Geol. Society, vol. iv. p. 204.

Geological Distribution of Fossil Fishes.—From the incidental notices of the geological habitats of the fossil fishes enumerated in our survey of this class of beings, the reader cannot fail to have remarked, that the most recent strata abounded in forms related to the inhabitants of the existing seas and rivers; while the most ancient teemed with species and genera of families altogether extinct, or of prodigious rarity in the recent fauna.

In general terms, it may be stated, upon the

authority of M. Agassiz, that the Ichthyolites of the Tertiary deposits approach in their characters to the living genera, but all the species are extinct. The newer Tertiary, as the Crag, contain genera common to tropical seas, as the large sharks (*Carcharias*), and eagle-rays (*Myliobates*), &c. In the Eocene, or most ancient Tertiary, as the London and Paris basins, Monte Bolca, &c., many of the Ichthyolites are closely related to recent genera. Of the Chalk fishes, a few only are of recent genera, but the majority are still allied to Tertiary forms. In the Chalk, the *Pharyngognathi*, *Acanthopteri*, and *Malacopteri* are met with as new types; and indications of the *Hybodontidæ*, *Sauroidei*, and *Cœlacanthi* (the last derived from the Devonian, and the other two from the Carboniferous Limestone) appear for the last time.

The ichthyic fauna of the Cretaceous deposits is closely related by the majority of its *family* groups with that of the series of strata from the Lias to the Wealden, inclusive. In and above the Lias all the ganoid fishes are *homocercal*. Below the Lias, the genera and species are far more removed from existing types, and almost all are *heterocercal*.

Of the eight thousand living fishes known to naturalists, three-fourths belong to the Cycloid and Ctenoid orders, and of these no species are known below the Chalk; the other fourth is referable to the Placoids and Ganoids, of which there are comparatively but few existing species. Yet fishes of these two orders almost solely flourished during the ancient Secondary formations; for below the Lias, the predominant recent orders are altogether absent. Beneath the Coal, true carnivorous fishes, with trenchant teeth, are almost unknown; but

omnivorous species, with either brush or obtusely conical teeth, and great sauroid fishes, are the prevailing representatives of the class.[569] In fine, the Ichthyolites of the different formations constitute two grand groups, which have their boundary line at the base of the Cretaceous deposits. The first and most ancient comprises the Ganoids and Placoids; the second, more intimately related to existing types, comprehends forms more diversified; these are principally Ctenoid and Cycloid, with a small number of the two preceding orders, which insensibly disappear; and their few living analogues are very distinct from the ancient species. Now, although deductions of this nature may require to be modified with the progress of knowledge, yet the generalizations thus obtained are founded on so vast an accumulation of facts and observations, as to render it improbable that they will be materially invalidated by future discoveries; for they remarkably accord with the results derived from the investigation of the fossil remains of all the other classes of animals. The most modern deposits contain the remains of animals allied to the existing species; the most ancient, of forms altogether extinct, or of excessive rarity in the recent faunas. The discovery of existing species, or genera, in the most ancient strata, would modify, but not destroy, the inferences deduced from the facts hitherto obtained; and every geologist is prepared to find that such may be the case.

[569] In the several chapters on the different formations, as arranged in the *Wonders*, the student will find succinct notices of the distribution of the *genera* of fishes throughout the fossiliferous deposits. A list of the Chalk species known in 1848 is given at

pp. 356-359, *Wond.*

Thus of the Sharks, with triangular notched teeth, which are so common in the Tertiary formations, and were formerly unknown in the ancient Secondary, one representative has been found in the Carboniferous system (see p. 595). But, if teeth of this type should hereafter be discovered in every Secondary deposit, the great preponderance of these fishes over the Sauroid in the Tertiary, and in the existing seas, would not be the less remarkable.

ON COLLECTING AND DEVELOPING FOSSIL FISHES.—From what has been advanced, the reader will have obtained a general knowledge of the fossil remains of this class that are likely to be met with in particular deposits. Thus, he will expect to find the teeth of large sharks and rays in the Tertiary clays and sands; and skeletons and perfect specimens of numerous Ctenoid and Cycloid fishes in the laminated marls and fine limestones of the same formations. In the Chalk, with numerous teeth of sharks, he may discover splendid examples of Cycloid and Ctenoid fishes; and, in the Wealden, large Ganoidian forms. Passing to the ancient Secondary strata, the extraordinary buckler-headed and Sauroid fishes will arrest his attention; and their vestiges will be found, more or less perfect, in the shales and limestones, and in the indurated nodules of clay and sandstone.

The detached teeth of fishes in Tertiary sands and clays may be easily obtained entire, and should be arranged in the same manner as the shells (see p. 442), either in trays, or on boards. The triangular teeth, with lateral denticles, must be carefully

extracted, so as to preserve those appendages on which the specific and generic distinctions of many Ichthyolites depend. M. Agassiz particularly recommends the preservation of all the specimens collected together in the same locality, as many may probably belong to the same individual, and thus the dental organization of the original be determined. Teeth collected from the same stratum in different places, should not, therefore, be mixed together. Several series of the same kind of teeth should be preserved, and as many as possible of each kind; for specimens apparently identical may prove to be highly instructive as a series. I have often had occasion to regret the disposal of supposed duplicates, in my earlier researches, which would have tended to elucidate the characters of those specimens which were retained.

The Ichthyolites, and their detached teeth and fins, in the Chalk and other soft limestones, may be cleared by means of a penknife or graver and small sharp chisels. It is preferable to leave the teeth attached to small blocks of the chalk; as in the examples, figured *Lign.* 193. But to develop the beautiful Chalk Ichthyolites, particularly those of the Osmeroides, Macropoma, &c. some practice and considerable dexterity are required. The compressed fishes, as the Beryx, like those in the Tertiary limestones, often lie in the sedimentary plane of the stone, and may be sufficiently exposed, by a blow of a hammer or a pick, to show the nature of the fossil, and admit of being easily developed. But the fishes with sub-cylindrical bodies very commonly split asunder in a transverse direction: and those with spinous scales, as the Macropoma, adhere so firmly to the chalk, that, to display the external surface of their scales, the surrounding stone must be removed

piecemeal, in the manner described for the Chalk crustaceans (see p. 544). The collector who sees the splendid Chalk fishes in the British Museum,[570] and learns that they were found in the Chalk of Kent and Sussex, will be grievously disappointed, upon visiting the quarries from which they were obtained, if he expects to discover specimens with any considerable portion of the scales, or body, exposed. It was many years before the quarry-men acquired the tact they now possess, of detecting, from very slight evidence, the presence of an Ichthyolite in a block of chalk: patches of scales, which the quarry-men called "*bran*," and detached sharks' teeth, "*birds beaks*," and "*snakes' tongues*," and teeth of Ptychodus, "*slugs*," being the only remains of fishes generally observed and laid aside by the workmen.

[570] *Petrifactions*, pp. 441, 444.

The fossil *Salmon* or *Smelt* (see p. 626), which may be considered as one of the most extraordinary of the Chalk fishes found in England, affords an excellent illustration of the mode of developing the Ichthyolites of this formation. This interesting fossil is delineated on a small scale, in three different states, in *Plate II.*; and affords a good practical lesson for the young collector. Among some blocks of chalk which a recent fall in one of the quarries near Lewes had brought to light, was a large mass split asunder, and exposing on each corresponding surface an irregular oval marking of a yellowish brown colour; this appearance is represented *Pl. II. fig. 1*. Presuming that these markings were produced by a transverse section of the body of a fish, the two blocks were trimmed into a portable size, and accurately cemented together with very *hot, thin, fresh* glue. When consolidated, some of the chalk was chiselled

off in the supposed longitudinal direction of the enclosed fish, and part of the body, covered with scales, was exposed, as *Pl. II. fig. 2*. With the view of ascertaining the extent of the Ichthyolite, some of the surrounding stone was then removed towards each extremity of the block, and traces of the fish were discovered, as shown in the same figure. The task of completely developing the fossil was thus rendered comparatively easy; the chalk was chiselled, cut, and scraped away, till the perfect fish, as seen in *fig.* 3, was developed.[571] The block was then reduced to a convenient size, and the edges sawn smooth. The chalk is easily cut with a carpenter's saw; the instrument should be short and strong, and the teeth of moderate size.

[571] The figure in *Pl. II.* is too small to convey an accurate idea of this Ichthyolite, which is now in the British Museum; see *Petrifactions*, pp. 445, 446. M. Agassiz's figure very inaccurately represents the original. A beautiful lithograph of this fish, by Mr. Pollard, of Brighton, was published in the Catalogue of the Mantellian Museum, 1836.

When a *portion* of the body of an Ichthyolite of this kind is found in a block of chalk, and the fracture of the block appears to be recent, diligent search should be made for the corresponding piece; for it may probably be found to contain the other part of the fish. A splendid specimen of *Osmeroides Lewesiensis*, more than a foot long, was thus obtained. The quarry-men, in a block of chalk which a recent fall had thrown down, discovered a few inches of the caudal portion of the body of a fish; on the broken surface of the stone, a section of the body was distinctly seen, as in the specimen previously described. Search was made among the fallen masses

for the corresponding piece, but without success. Upon observing the face of the quarry exposed by the recent fall, on a projecting block, many yards above our reach, a discoloured spot was indistinctly seen, and it was conjectured that this might prove to be the other moiety of the Ichthyolite. The workmen were directed to preserve this block if possible; but it remained *in situ* several months, and until the rock was again blasted; when the stone so long coveted rolled away from the fallen mass, and fortunately was soon discovered. It proved to be the corresponding portion of the fish; with the head, opercula, branchial arches, pectoral fins, and the anterior part of the body covered with beautiful cycloid scales. In the preparation of fossils of this kind, glue as the cement, and a paste made of plaster of Paris with thin glue, to fill up the crevices and strengthen the block, are the materials I have employed. The fossil remains of fishes in other rocks require to be extracted and developed in the manner previously directed for the Echinoderms, Cephalopoda, &c. (pp. 332, 497.)

The collector may be reminded, that *Otolithes*, or ear-stones (p. 574), are found in the Crag of Norfolk, and other Tertiary strata; and that Coprolites, associated with minute scales, bones, &c. of small fishes, constitute, in some localities, layers of considerable thickness and of great extent. The "*bone-bed*" of the Lias, near Westbury, and that of the Ludlow series on the banks of the Teme, near Ludlow,[572] are well-known examples of such a deposit.

[572] See Mr. Strickland's interesting notice of the distribution and contents of this "bone-bed," in the Quart. Geol. Journ. vol. ix. p. 8

MICROSCOPICAL EXAMINATION.—A few words on the microscopical examination of the remains of fishes may be useful. The structure of the large, and the forms of the minute scales, may be seen by a common lens, and without preparing the specimens. But for the examination of the intimate organization of scales, teeth, &c. the microscope is required; and the method directed for the investigation of flint (p. 373) should be employed. The scales, portions of the membranes of the air-bladder, stomach, &c. and thin chips of the teeth, rendered temporarily transparent by oil of turpentine, or permanently so by Canada balsam, should be viewed by transmitted light. But the intricate structure of the dental organs, the medullary canals, and the calcigerous tubes, cannot be successfully investigated without the aid of the lapidary, or the adoption of the process described at page 67 for the preparation of fossil wood for microscopical examination.

BRITISH LOCALITIES OF FOSSIL FISHES.

⁂ The detached teeth, scales, vertebræ, &c. of fishes are so extensively distributed, that there is scarcely a cliff or quarry of fossiliferous rock in Great Britain, that does not contain some examples. The following list of localities must, therefore, be regarded as merely directing the student to a few places, in which particular fossils of this class have been discovered.

Abergavenny. *Mt. L.* Teeth of *Psammodus*, *Orodus*, &c.

Armagh, Ireland. *Mt. L.* Numerous teeth and spines.

Arundel, Sussex. *Cret.* Quarries in the neighbourhood; beautiful Chalk fishes.

Aust Cliff, near Westbury, Somersetshire. *Lower Lias. Pholidophorus*, &c. *Base of Lias.* In a layer called the bone-bed, containing bones, scales, teeth, and Coprolites of fishes. Teeth

of *Ceratodus*, &c.

Axmouth. *Base of Lias: Bone-bed.* Numerous scales, bones, and teeth. *Saurichthys*, &c.

Barrow-on-Soar. *Lias. Dapedius.*

Bracklesham Bay, Sussex. *Eocene.* Magnificent specimens of Rays, as *Myliobatis*, *Aëtobatis*, and of *Chimæroids* were collected by the late F. Dixon, Esq., and are now in the British Museum.

Brighton. Cret. Chalk quarries in the vicinity. *Beryx*, *Dercetis*, *Saurocephalus*, *Saurodon*, and the common species of teeth, &c.

Bristol. *Mt. L.* The usual species of *Psammodus*, *Orodus*, *Onchus*, &c.

Burdie-house, near Edinburgh. *Carb. Palæoniscus*, *Megalichthys*, *Holoptychius*, &c.

Caithness, Scotland. *Old Red. Dipterus*, &c.

Charing, Kent. Many fishes in the Chalk.

Chatham, Kent. *Cret. Beryx*, *Hypsodon*, and the usual teeth, &c.

Cheltenham. *Base of Lias.* In the bone-bed teeth, scales, Coprolites.

Clayton, Sussex. *Lower Chalk. Beryx microcephalus*, and other rare Ichthyolites.

Clifton, near Bristol. *Mt. L. Psammodus*, *Orodus*, &c.

Cromarty, Scotland. *Old Red. Coccosteus*, *Pterichthys*, &c.

Cuckfield, Sussex. *Wealden. Lepidotus, Hybodus, Acrodus.*

Cullercoats, Durham. *Permian. Palæoniscus*, &c.

Dinton, Vale of Wardour. *Purbeck. Leptolepis*, *Ceramurus*, &c.

Downton Hall, near Ludlow. *Devonian. Cephalaspis*, *Dipterus*, &c. *U. Sil.* In a quarry on the banks of the Teme, a fish-bed composed of scales, teeth, and Coprolites, in Upper Ludlow limestone.

Dudley. *Sil. Ichthyodorulites*.

Dungannon, Ireland. *Permian.* Quarry at Rhone-hill; numerous small *Palæonisci*, *P. catopterus*.

East Thickley, Durham. *Magnesian Limestone. Palæonisci.*

Glammis, Forfarshire. *Devon. Cephalaspis, Gyrolepis, Dipterus.*

Gravesend and Northfleet. Chalk-pits rich in fish-teeth, &c.

Hastings. *Wealden. Lepidotus, Hybodus.*

Ilminster, Somerset. *Upper Lias. Pachycormus* and *Leptolepis*.

Leeds, Middleton Quarry. *Carb.* Layers of *fish-coal*, abundance of remains of *Megalichthys*, *Holoptychius*, &c. (*Geol. Proc.* iii. p. 153.)

Lewes, Sussex. *Cret.* All the fishes of the British Chalk. See *Wond.* pp. 356-359.

Lyme Regis. *Lias. Dapedius*, *Hybodus*, *Squaloraia*; and numerous other species and genera.

Newhaven, near Leith. *Carb.* On the shore, nodules of ironstone with fishes and Coprolites. *Amblypterus, Palæoniscus.*

Sheppey, Isle of. *Tert.* Numerous teeth of Rays, Sharks, &c., and other Ichthyolites in great abundance.

Shotover, near Oxford. *Kimmeridge Clay. Ischyodus*, *Hybodus*, &c.

Southend, Essex. *Eocene.* Fish-bones and teeth (*Pisodus*, &c.) are found on the shore along the foot of the cliff.

Speeton, Yorkshire. *Galt. Macropoma Egertoni*; and many other fishes.

Steyning, Sussex. *Cret.* In the marl-pits, Coprolites and teeth of Sharks are abundant.

Stonesfield. *Great Oolite. Hybodus*, *Lepidotus*, *Leptacanthus*, &c.

Swanage. *Purbeck. Lepidotus*, *Hybodus*, *Ophiopsis*, &c.

Thurso, Scotland. *Devonian. Asterolepis*, &c.

Westbury, near Bristol. *Base of Lias.* Bone-bed with numerous remains.

Worthing. *Cret.* Beautiful Chalk fishes in the neighbouring quarries.

FOREIGN LOCALITIES.

⁂ Although the present work is expressly designed as a guide to the British collector, I am induced to subjoin a few foreign localities of Ichthyolites, that lie within the reach of the

continental tourist. A detailed account of the most celebrated sites is given by M. Agassiz, Poiss. Foss.

Aix, in Provence. *Tertiary*. Some of the beds of gypseous marl contain numerous species in abundance.

Eisleben, Upper Saxony. *Permian*. Numerous Ichthyolites in dark shale.

Glaris, Switzerland. *Cret*. Immense numbers of fishes in dark schist. The specimens are often contorted, from the contraction of their bodies, during decomposition.

Maestricht (St. Peter's Mountain). *Upper Cret*. Numerous teeth, vertebræ, &c. of fishes of the Cretaceous epoch. See *Wond*. p. 309. Mansfeld, in Thuringia. Permian. Fishes in copper-slate, in great numbers; many extremely beautiful.

Monte Bolca, or Vestena Nova. *Tert*. The richest mine of Ichthyolites in the world. A catalogue of the numerous genera and species found in this celebrated locality, is given in *Poiss. Foss*. tom. iv. pp. 33-52.[573] See *Wond*. p. 265.

Mount Lebanon, Asia. *Tert*. Numerous Ichthyolites, in great perfection.

Œningen. *Tert. fresh-water*. Many kinds of fishes of the same genera as those which inhabit the great European lakes; as the Perch, Salmon, Eel, Pike, Carp, &c. A list of these Ichthyolites will be found in *Poiss. Foss*. tom. ii. part ii. p. 78. See *Wond*. p. 263.

Saarbrück, in Lorraine. *Carb. Amblypterus*, and other Carboniferous fishes.

Seefeld, in the Tyrol; on the principal road from Insbruck to Munich. *Lias*. Abundance of fish in bituminous slate.

Stabia, Italy, at Torre d'Orlando, near Castellamare. *Oolite*. Beautiful fishes in fissile limestone.

Solenhofen. *Oolite*. Numerous Ichthyolites; many in great perfection. See *Wond*. p. 513.

[573] It is necessary to caution the collector against the frauds practised by the quarry-men, and dealers in fossils, at this and other celebrated foreign localities. Specimens,

apparently perfect, are ingeniously constructed from the fragments of various examples. The head of one fish, the body of another, decorated with the fins of a third, and perhaps the tail of a fourth, of different species, or even genera, are dove-tailed together, coloured, and varnished, so as to deceive the common observer, and, occasionally, even the experienced collector. Sponging the specimens with cold water will often detect the imposition; for the colour if artificial will be removed, or rendered paler, while the same process will heighten the natural tints. At Pappenheim, Solenhofen, and other places, where fossil crustaceans, as Shrimps, Prawns, &c. are found in such perfection, the imprints of good specimens are often coloured, and offered for sale; a wet sponge will speedily detect the imposture.

CHAPTER XVI.

FOSSIL REPTILES; COMPRISING THE ENALIOSAURIANS AND CROCODILES.

"Nous remontons done à un autre âge du monde; à cet âge où la terre n'étoit encore parcourue que par des reptiles a sang froid—où la mer abondoit en ammonites, en bélemnites, en térébratules, en encrinites, et où tous ces genres, aujourd'hui d'une rareté prodigieuse, faisoient le fond de sa population."—CUVIER, *Oss. Foss.* tom. v. p. 10.

WE advance now to the investigation of the fossil remains of the more highly organized classes of the VERTEBRATA; the Fishes being the lowest in the scale amongst the beings characterised by an osseous skeleton, with a flexible spinal column, composed of articulated bones, and presenting, in the various classes, orders, genera, and species, numerous modifications of form and structure. The mineralized relics of the vertebrated animals consist, for the most part, of single and displaced bones, or groups of bones and teeth, and the durable portions of the dermal integuments; entire skeletons being of rare occurrence. A knowledge of anatomy and physiology, and access to anatomical and zoological libraries and collections, are therefore indispensable for the cultivation of this most attractive department of Palæontology. Fortunately for the English student, this branch of the science, which a few years since was but little cultivated in this country,[574] has been greatly advanced, by the liberal support afforded by the British Association of Science to Professor Owen, whose Reports on the British Fossil Reptiles and Mammalia, published in the Transactions of the Association,[575] should be referred to for more precise and detailed information than can be given in these unpretending volumes. Our remarks will be limited to a general notice of the fossil remains of Reptiles, Birds, and Mammals; with descriptions of such characteristic examples, as will serve to illustrate the nature of the specimens that may probably come under the notice of the collector; or which, from their peculiar characters, are objects worthy his special attention.

[574] See *Petrif.* p. 226, note.

[575] Report of the Brit. Assoc. 1839 and

1841; see also Trans. Geol. Soc. 2d ser. vol. v. p. 515 (1838).

THE AGE OF REPTILES.[576]—The announcement by the illustrious founder of Palæontology, in the quotation prefixed to this chapter, that there was a period when the lakes, rivers, and seas of our planet were peopled by reptiles, and when cold-blooded oviparous quadrupeds, of appalling magnitude, were the principal inhabitants of the dry lands, was a proposition so novel and startling, as to require the prestige of the name of CUVIER to obtain for it any degree of credence, even with those who were prepared to admit that a universal deluge could not account for the physical changes, which the crust of the earth had evidently undergone. Subsequent observations and discoveries have, however, fully confirmed the truth of this induction, and the "*Age of Reptiles*" is no longer considered fabulous.

[576] "*The Age of Reptiles*" was the title given by the author to a popular summary of the evidence bearing on this question: it was published in the Edinburgh Philosophical Journal, 1831. This name is now generally employed to designate the geological epochs characterised by the predominance of oviparous quadrupeds; namely, from the Permian to the Chalk, inclusive.

In some of the ancient fossiliferous deposits,[577] indications of the existence of Reptiles are visible, in the indelible markings left by their footsteps on the muddy banks of rivers, and on the wet sands of the sea-shores, now in the state of layers of marl and sandstone. Here and there in the Devonian,[578] Carboniferous, and New Red formations, teeth and bones are found, presenting unequivocal proofs of

the presence of extinct forms of cold-blooded oviparous quadrupeds. As we ascend in the secondary formations, we are suddenly surrounded by innumerable marine and terrestrial reptiles, belonging to species and genera, and even orders, of which no living representatives are known. Throughout the Liassic, Oolitic, Wealden, and Cretaceous epochs, the class of Reptiles was at its fullest development. In the Tertiary periods which succeeded, the Reptiles approach the recent types, and their relics are found intermingled with the bones of mammiferous quadrupeds; thus indicating the commencement of the present condition and relations of the animal kingdom. Referring the reader to *Bd.* p. 165, and *Wond.* pp. 409-444 and 567-588, for a more comprehensive view of this subject, we advance to the examination of some of the fossil genera and species; and we propose, in the first place, to explain a few essential characters of form and structure observable in those durable parts of the skeletons which are most frequently met with in a fossil state; namely, the teeth, jaws, vertebræ, &c., and the osseous appendages of the dermal system.

[577] Devonian rooks of Elgin, North Britain; and the Lower Carboniferous of Pottsville, Pennsylvania.

[578] The most ancient Reptile hitherto discovered is the *Telerpeton Elginense*, from the Old Red of Scotland, which will be described in the sequel.

The animals comprehended in the Class of REPTILIA constitute, according to Prof. Owen's arrangement, eight principal groups, or Orders, as follow:—

The *Batrachia*; Frogs: the body naked, with only rudimentary ribs; and with two or four feet. Most of these reptiles breathe by branchiæ or gills in their young state, and by lungs in the adult (as for example the Frog); in some (the *perenni-branchiata*), the branchiæ are persistent through life.

The *Ophidia*; Serpents: the body destitute of feet.

The *Lacertia* or *Sauria*; Lizards: the body supported by four or two feet, and covered with scales.

The *Chelonia*; Tortoises: the body supported by four feet or paddles, and enveloped in two osseous bucklers, composed of the expanded bones of the sternum and thorax.

The *Enaliosauria*; Sea-saurians (*extinct*): body furnished with four paddles, and destitute of scaly covering.

The *Pterosauria*; Wing-saurians (*extinct*): body supported on four feet, the outer finger of each fore-foot greatly lengthened, and forming a support for the wing.

The *Crocodilia*; Crocodiles: body supported on four partially webbed feet, and encased with an armour of bony plates or scutes.

The *Deinosauria*; Great-saurians (*extinct*): body supported on four feet.

TEETH OF REPTILES.—The teeth of the animals of this class exhibit considerable diversity of form, but the characteristic type is that of a conical, pointed

tooth, with a simple root or fang; for, *in no reptile does the base of the tooth terminate in more than one fang, and this is never branched*. "Any fossil, therefore, which exhibits a tooth implanted by two fangs in a double socket, must be mammiferous, since the socketed teeth of reptiles have but a single fang; and the only fishes' teeth which approach such a tooth in form, are those of a bifurcate base, belonging to certain sharks." (*Owen.*)

These dental organs are only fitted for seizing and retaining the prey or food; for no living reptiles have the power of performing mastication. In the Crocodiles the tooth has a cylindrical shank, with a conical, longitudinally striated, enamelled crown, having a ridge on each side (*Pl. VI. fig. 5*). In the *Labyrinthodon* (a fossil reptile), the cone is more curved and pointed (*Pl. VI. fig. 3*); in the *Hylæosaurus*, the shank is cylindrical, and the crown expanded and lanceolate, with blunt margins (*Pl. VI. fig. 6*); in the *Megalosaurus*, the tooth is laterally compressed, trenchant, and slightly inclined backwards like a sabre, with serrated edges (*Pl. VI. fig. 7*); in the *Iguanodon*, the shank is cylindrical, and the crown of a prismatic form, greatly expanded, with broad denticulated edges, and longitudinal ridges on one side (*Pl. VI. fig. 4*, and *Ligns.* 221, 223). In the Serpents, the teeth are very long and pointed; in the Crocodiles and Lizards, may be seen every modification of the conical form, down to a mere hemispherical tubercle or plate. In the fossil *Dicynodon*, to be hereafter described, the dental system consists of but two tusks or canine teeth, like those of the Walrus, implanted in the upper jaw. The Turtles and some fossil Lacertians are edentulous, *i. e.* destitute of teeth; their dental organs consisting of the horny trenchant sheaths with which the jaws are

covered.

The teeth are very numerous in reptiles; the individuals of some species have more than two hundred. In some genera, they are implanted on the jaws alone; in many, they occupy the palatine, vomerine, and other bones composing the vault of the mouth, as in certain fishes. The teeth are generally anchylosed to the bone; but in some genera they are implanted in distinct sockets, as in the Crocodile and Plesiosaurus; in others, as in the Ichthyosaurus, they are arranged in a deep furrow, and retained only by the integuments; in some, they are supported upon an elevated osseous base. In the Labyrinthodonts, and in the greater part of the Serpent tribes, the tooth is implanted by the base in a shallow socket, with which it is confluent.

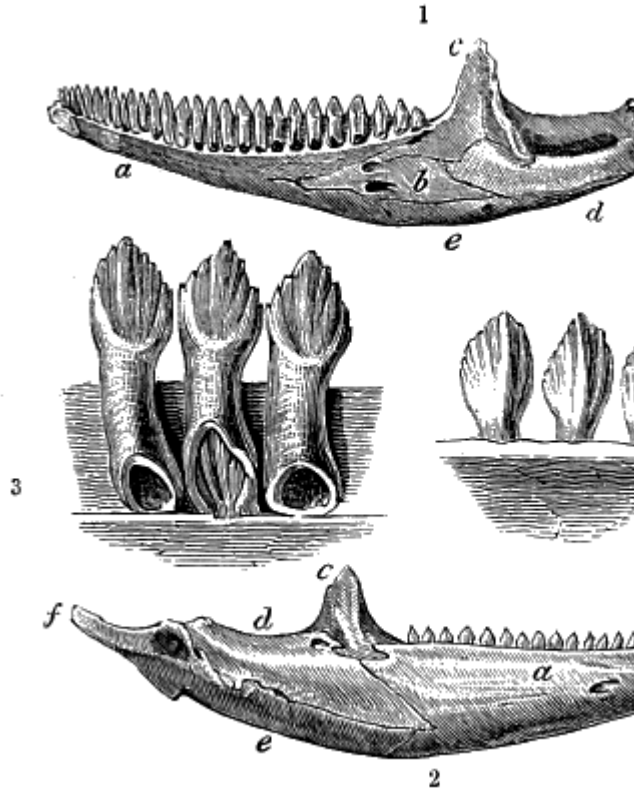
In most of the Lacertians, or true Lizards, the attachment of the teeth presents a peculiar modification, of which the lower jaw of the Iguana, *Lign.* 205, p. 649, affords a good illustration. The teeth are not placed in sockets, but are attached by the shank to an alveolar plate, or parapet, that extends along the margin of the jaw, as shown in *figs.* 1 and 3; the crowns of the teeth project above this plate, as seen in *figs.* 2 and 4. From the anchylosis of the teeth to the side of the jaw, the Lizards possessing this dental structure are termed *Pleurodonts*.[579]

[579] The *Pleurodonts* are those lizards in which the teeth are anchylosed to the *side* of the dentary bone; *Acrodonts*, those with the teeth fixed to the upper margin or *ridge* of the jaw-bone; *Thecodonts*, those having the teeth implanted, either loosely, or anchylosed to the walls of their sockets. Lacertians are also said

to be *Pleodont* (having solid teeth), or *Cœlodont* (hollow-toothed).

In reptiles, we have, therefore, five essential modifications in the attachment of the teeth; namely, in distinct sockets; in a continuous groove or furrow; attached laterally by the shank to an alveolar parapet; anchylosed by the base to a shallow socket; and attached to an osseous support, without sockets or an alveolar plate.[580]

[580] See the beautiful exemplification of this subject, and the comparison between the transitory stages of the human teeth in their progress of development, discovered by Mr. Goodsir, with the permanency of these conditions in reptiles. Odontography, p. 182.



LIGN. 205. THE LOWER JAW OF AN IGUANA
(*From Barbadoes.*)

Fig. 1. The right branch of the lower jaw of an Iguana; viewed on its inner aspect. *Nat. size.*
a. Dentary bone.
b. Opercular bone.
c. Complementary or coronoid bone.
d. Surangular bone.
e. Angular bone.
f. Articular bone.

2. The external aspect of the same.

3. 3.—Inner aspect of three teeth (*magnified*) attached to the alveo of a successional tooth at the base of the middle tooth; and the bases of the outer two fully formed teeth.

4. External view of the crowns of three teeth; slightly magnified. —

The intimate structure of the teeth consists of a simple pulp-cavity, surrounded by dentine, which is permeated by extremely minute calcigerous tubes, radiating at right angles to the periphery, or external surface of the tooth. One essential modification of this structure consists in the intermingling of cylindrical processes of the pulp-cavity, in the form of medullary or vascular canals, with the finer tubular structure; as in the tooth of the Iguanodon, *Pl. VI. figs. 4b* and *4c*. But another modification is that to which allusion was made when describing the teeth of the Lepidosteus (see p. 616); in this mode, the dentine preserves its normal character, but the external cement and surface of the tooth are deeply inflected in longitudinal folds around the entire circumference; and this structure is accompanied with corresponding extensions of the pulp-cavity and dentine into the interspaces of these inflected and converging folds.[581] This organization is shown, in its simplest form, in the transverse section of the base of a tooth of the Ichthyosaurus, *Pl. VI. fig. 9*; and attains its most complicated condition in that of the Labyrinthodon, *Pl. VI. figs. 3a, 3b, 3c*.

[581] There is a marked difference between the internal structure of the teeth of true Saurians and of Sauroid Fishes. In the former, as well as in the *Enaliosauria*, the dentine consists of tubes radiating from a slender central pulp-cavity to the periphery of the tooth, without any intermixture of vascular canals. In the sauroid fish (*Dendrodus*) the central pulp-cavity is produced into numerous irregular canals, from which vascular sinuses radiate to the periphery, sending off branches

> generally at right angles throughout their entire course; thus, there is an extensive distribution of the vascular system through the body of the tooth, which does not exist in any saurian reptile; the nearest analogy is in the labyrinthine teeth of the gigantic fossil batrachians. (*Owen*: Odontography; and Art. TEETH, Cyclop. Anat.)

With regard to the mode of development of the teeth, we must briefly state, that the germ of the new tooth is always produced at the side of the base of the old one; that in its progress of growth it presses against the tooth it is destined to supplant, occasions the progressive absorption of the fang, and ultimately displaces its predecessor; in some instances, by splitting the crown of the tooth; in others, by casting it off, according to the oblique or direct position the new tooth attains in its progress, in relation to its predecessor. Thus, in the teeth of the Crocodile, the new tooth is generally found immediately under the conical apex of the crown, and beneath the former a second successional tooth appears, like a series of thimbles of various sizes placed one upon another; for in reptiles the production of new teeth is unlimited. But in the *Pleurodont* lizards, the new tooth makes its way obliquely, and the crown is often shed entire. *Lign.* 205, *fig.* 3, exemplifies the situation of the successional teeth in the Iguana.

LOWER JAW OF REPTILES.—It is well known that the lower jaw in mammiferous animals is composed of a single bone on each side; and that in many genera these pieces become united in front, and form but one bone in the adult state. But in reptiles, the lower jaw consists of six distinct bones on each side, as in *Lign.* 205; and these undergo various

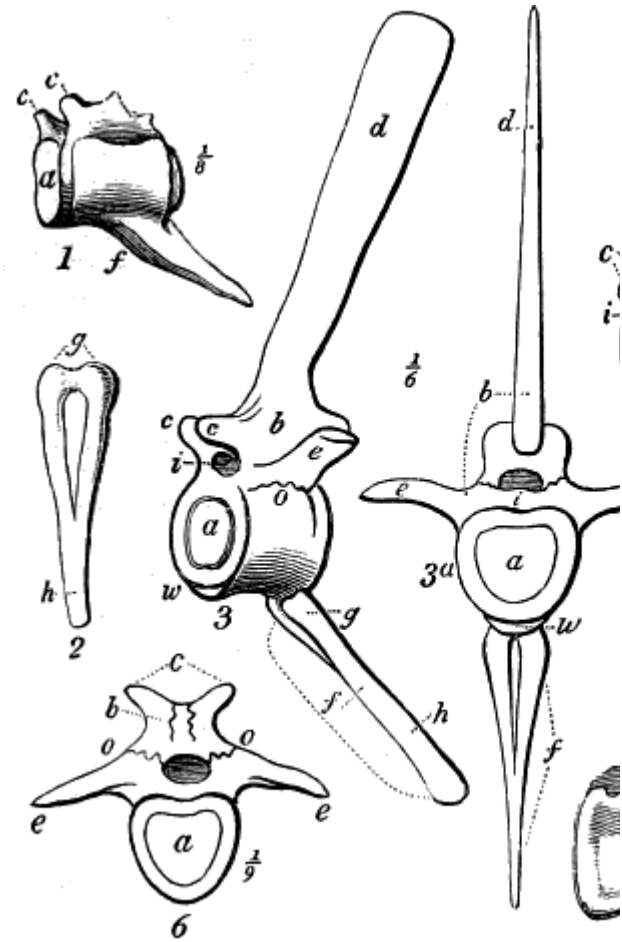
modifications of form and arrangement in the different genera. These bones are distinguished by names which have reference to their office and situation, and are as follow:—*Lign.* 205, *a*, the *dentary* bone, supporting the teeth; *b*, the *splenial* or *opercular*; *c*, the *coronoid* or *complementary*; *d*, the *sur-angular*; *e*, the *angular*; *f*, the *articular*, which forms the upper portion of the jaw, and includes the condyle. The form and disposition of these bones in the Iguana, and other true lizards, are shown in *Lign.* 205; but they differ materially in the Crocodile, Ichthyosaurus, and other genera. We must restrict our comments to this short notice, which, however, will suffice to enable the collector who discovers a fragment of a lower jaw, with any traces of the structure above described, to determine that it is reptilian; and if any portion of the *dentary* bone remains, indications may be obtained of the family, and perhaps genus, to which it belonged.[582]

[582] To obtain a correct knowledge of the osteological structure of fossil Reptiles, the student should consult Baron Cuvier's *Ossemens Fossiles*, tom. v. To the English reader, the translated abridgement of Cuvier's "Fossil Remains of the Animal Kingdom," by E. Pidgeon, 1 vol. 8vo. with plates, 1830, will be found a very instructive volume. See also Penny Cyclopædia, Art. SAURIANS.

VERTEBRÆ OF REPTILES.—The bones of the vertebral column of this class of animals present such numerous and important modifications in the different orders and families, that reference to the works already cited must be made for satisfactory information on this topic. From the great number of vertebræ in many reptiles, amounting in the individuals of some species to nearly two hundred,

these bones are the most abundant fossil relics of these animals to be found in our collections. The vertebræ are commonly detached, and deprived of their processes; the solid *centrum*, or body, alone remaining in most examples (as in *Lign.* 206, *fig.* 8). Connected series, more or less complete, are occasionally discovered; and the entire column, in connexion with other parts of the skeleton, is preserved in many specimens in the British and other museums.[583] Although, for the reasons previously stated, minute osteological details cannot be attempted in this work, some acquaintance with the elementary characters of the bones composing the spinal column, and of the nomenclature employed to distinguish them, is necessary to guide the student, and even the amateur collector, in their researches. I have, therefore, selected a few specimens from Tilgate Forest in illustration of the elements of Saurian vertebræ, and of the terms by which the different processes are distinguished; the general reader will thus be enabled to comprehend the descriptions of these structures in other works on Palæontology.

[583] See *Petrifactions*, pp. 136-352, and pp. 362-387.



LIGN. 206. FOSSIL VERTEBRÆ OR REPTILES. *Ti*
The figures are reduced in the proportions specified b

Fig. 1. Caudal vertebra of an unknown reptile.

2. Chevron bone of IGUANODON: seen in front.

3. Caudal vertebra of IGUANODON, viewed laterally in an oblique

3*a*. —Front view of the same.

4. Caudal vertebra of IGUANODON, without either transverse proc
— marks the deep hollow left by the removal of the transverse pr
part.

5. Vertebra of Streptospondylus: $^{1}/_{16}$ *nat.*

—

6. Lumbar vertebra of Iguanodon, with the neural spine broken o

—

7. Vertebra of STREPTOSPONDYLUS: $^{1}/_{16}$ *nat.*

— *c.* The pair of posterior oblique processes (*zygapophyses*).

8. The bodies of two dorsal vertebræ of Iguanodon: viewed latera

— The same letters refer to the same parts in the respective figur

a. The body, or centrum, of the vertebra: the letter denotes

b. The annular part, formed of the two *neurapophyses*, whic

c, c. The articular or oblique processes (*zygapophyses*), which

d. The spinous process or neural spine of the annular part.

e, e. The transverse process of the annular part.

f. The chevron-bone, formed of the two *hæmapophyses* and

g. The double articulating head of the chevron: the passage *arch*), seen in the front view, figs. 2 and 3, is for the pass which supply the tail.

h. The spine of the chevron-bone; the inferior spinous proc

i. Denotes the medullary cavity of the annular part.

o, o. Mark the sutures which connect the annular part with th

w, w. Indicate the place of attachment of the chevron-bone.

The bones composing the spine, are not only designed to form a flexible column of support to the trunk, but also to afford protection to the grand nervous chords constituting the spinal marrow, and which extend from the brain to the tail, and give off numerous lateral branches in their course, conferring sensation and motive power to every part of the frame. To effect this purpose, there is attached to the upper or dorsal part of each vertebra a bony ring, called the neural-arch, which is composed of two processes (*Lign.* 206, *b*.), arising from each side of the body or centrum (*Lign.* 206, *a*.), and which unite

above into a solid piece, termed the spinal process, ox neural spine (*Lign.* 206, *d*.). On each side of the annular paid there is a process, called the transverse (*Lign.* 206, *e, e*.), for the attachment of muscles; and in the middle and the posterior dorsal regions of some reptiles, as, for example, in the existing Crocodiles, these processes articulate with the ribs. The vertebræ of the tail have, in addition to the above, an inferior spinous process, termed the chevron-bone (*Lign.* 206, *fig.* 2, and *fig.* 3, *f*.), which gives support to the inferior layers of the caudal muscles; and, bifurcating at its attachment to the body of the vertebra, leaves a channel for the passage of the large blood-vessels, by which the circulation of the tail is effected.

In the generality of living reptiles (as, for example, in the Crocodile) the bodies of the vertebræ are concave in front, and convex behind; the bones of the spine being united by ball-and-socket joints; but, in most fossil reptiles, both faces are either flat, or more or less concave. In mammalian quadrupeds, the annular part is anchylosed to the vertebral centre; but in reptiles, it is united by suture, although, in old subjects, the connecting line is often obliterated. By reference to *Lign.* 206, and its description, the form, arrangement, and connexion of the different vertebral elements, in certain fossil reptiles, may be easily understood. The bones in the vertebral column of the same animal are considerably modified in the several regions of the neck (*cervical* vertebræ), back (*dorsal* and *lumbar*), and tail (*caudal*). The cervical are generally of the most complicated structure; and the caudal, the most simple.

From this exposition, the reader will perceive that

every vertebra consists of the following essential parts: first, the body, or *centrum*; and secondly, the annular part, or *neural arch*, so named, because it protects the nervous chord; while a caudal vertebra has, in addition, the chevron-bone, called also the *hæmal arch*, from its affording a passage to the large blood-vessels. The bodies of the vertebræ are in general solid, and consist of the ordinary osseous structure; but in certain fossil vertebræ the centre of the bone is filled with calcareous spar, indicating an irregular medullary cavity, as in the caudal vertebræ of the Ox.[584]

[584] See *Petrifactions*, p. 166, *note*.

The *Sacrum*, which may be termed the key-stone of the pelvic arch, is formed in existing reptiles by the union of two vertebræ; but in the Iguanodon and the Hylæosaurus the sacrum is composed of six anchylosed vertebræ; in the Megalosaurus probably of but five.[585]

[585] Report, Brit. Assoc. 1841, p. 105, and p. 130.

From the sides of the two anchylosed vertebræ which form the sacrum, strong, short, rib-like processes are given off in those Saurians which occasionally walk on dry land, and these constitute a firm support to the hinder extremities.

In the Crocodiles, the four or five vertebræ preceding the sacrum have no ribs attached to them, and are termed *lumbar*; in the Lizards, there are but two lumbar vertebræ. A peculiar modification exists in the first caudal vertebra of the adult Gavial and Crocodile; the *centrum* is *convex* both in front and behind, as was first demonstrated by me in 1836. See

Wond. p. 419, and *Petrif.* p. 167. The last of the anchylosed vertebræ forming the sacrum is concave posteriorly; hence the necessity of an anterior ball in the first joint of the tail. (See *Lign.* 217, p. 676, illustrative of *Crocodilus Hastingsiæ*.) The last *cervical* vertebra in the Turtles and Tortoises has a similar construction. This mechanism confers freedom of motion without risk of dislocation.

RIBS.—The Ribs, which are regarded as appendages to the vertebræ, (homologues of the pleurapophyses,) are generally slender and round in the Lizards, and articulate with the spinal column by a single head, supported on a short convex process or tubercle. In Crocodiles only of all existing Reptiles, but in several extinct genera, the proximal end of the rib forms a double articulation, by a distinct head and a tubercle, with the vertebræ in the cervical and anterior dorsal region of the spinal column; in the posterior dorsal region the ribs are attached to the elongated transverse processes of the vertebræ.

As this double articulation of the ribs is invariably associated in existing reptiles with a heart having double ventricles, while the lacertian single-headed ribs are in like manner connected with a heart having but one ventricle, the student will perceive the important physiological inferences that spring from the discovery of a mere fragment of a rib, when interpreted by the profound anatomist. [586] In some fossil reptiles the ribs are flat and very broad; as, for example, in the Hylæosaurus.[587]

[586] See Brit. Assoc. Report, 1841, and Memoirs, Palæont. Soc.

[587] In Crocodiles the abdominal region is strengthened by slender ribs (*hæmapophyses*,

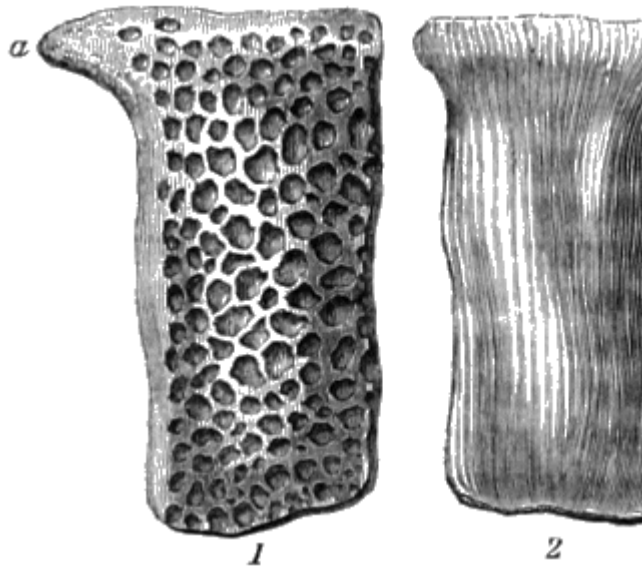
> Prof. Owen), that are affixed to a ligamentous extension of the cartilaginous sternum, analogous to the *linea alba* in man; and the Hylæosaurus appears to have possessed a similar development of the costal elements, for I observed many fragments of long, slender, sub-cylindrical rib-like bones whilst chiselling off the stone from this species, and portions of similar bones occur in the stone around the spinal column from Bolney. In the Maidstone Iguanodon there are likewise some long slender bones of this character, which I think must be prolongations of the ordinary dorsal ribs.

EXTREMITIES.—The locomotive extremities are variously constructed, according to the adaptation of the animals to a terrestrial, fluviatile, or marine existence. The bones of the limbs in the extinct colossal terrestrial species much resemble those of our large pachydermata, the Rhinoceros and Hippopotamus. The cylindrical bones of the extremities in the Crocodilians, and other recent reptiles, are solid. *i. e.* have no cavity filled with marrow; such also is the case in the fossil Enaliosaurians; but the thigh-bones and leg-bones of the Iguanodon, and of other extinct land saurians, h ave a large medullary canal. Our limits will not admit of further osteological details; and we are compelled to omit the description of the bones composing the thoracic and pelvic arches.

DERMAL BONES. *Ligns.* 207 and 208. In many of the reptile tribes, particularly of the Crocodilian or loricated (*mailed*) group, there are immediately under the external integument or skin a series of osseous scutes, or scutcheons, variously arranged, which serve as supports to the integumental scales

and spines. In the gigantic Gavial, that inhabits the Ganges and other rivers of India, and which is remarkably distinguished from the common Crocodile and Alligator by an extremely elongated slender muzzle, the nape of the neck is protected by sixteen or eighteen transverse rows of dermal scutes; and there are likewise six rows which extend down the back. These bones are deeply corrugated or sculptured on their upper surface; a structure adapted for the firm adhesion of the horny integument.

Detached bones of this character occur in the Purbeck strata; and the first fragments I collected were supposed by me to belong to the soft-skinned turtles (*Trionyces*); but the subsequent discovery of perfect scutes demonstrated their analogy to the dermal bones of the Gavial, and enabled me to determine their true character.



LIGN. 207. DERMAL BONE OF THE SWANAGE CROCODI

Purbeck.
(GONIOPHOLIS CRASSIDENS.)

Fig. 1.— The external aspect.
2.— The inner surface.
a.—The lateral connecting process.

In the splendid specimen of the fossil remains of a Crocodilian reptile (*Goniopholis*), found at Swanage (*Wond.* pp. 415; and *Petrif.* p. 170), there are numerous dermal examples dispersed among the bones, as shown in *Petrif. Lign.*

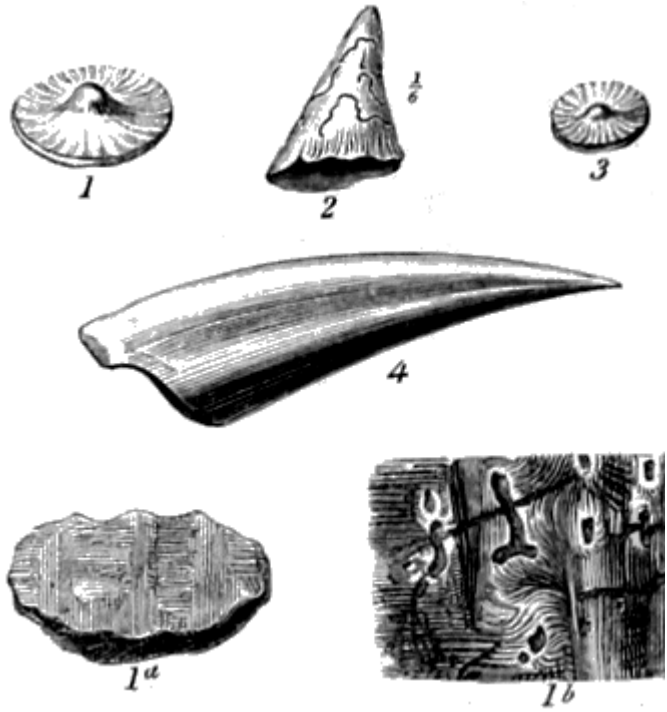
One of these is figured *Lign.* 207; *fig.* 1 represents the external surface, which is deeply sculptured by irregular roundish pits or excavations; the under or inner surface, *fig.* 2, is smooth, but marked with very fine striæ, decussating each other at right angles, as in the dermal bones of the Hylæosaurus (*Lign.* 208, *fig.* 1*a.*). These scutes differ from those of other recent and fossil Crocodilians, in a lateral conical projection, marked *a*, *figs.* 1, 2, *Lign.* 207, which fits into a depression on the under surface of the opposite angle of the adjoining plate; resembling, in this respect, the scales of the Lepidotus (see *Lign.* 196, p. 605). Numerous hexagonal and pentagonal scutes, articulated together by marginal sutures, also entered into the composition of the osseous dermal cuirass of this reptile, which must, therefore, have possessed a flexible, yet impenetrable, coat of armour, capable of affording protection against the attack of any assailant.

In the Oolite, the dermal bones of other slender-nosed Crocodilians (*Teleosaurus*) are occasionally met with; the outer surfaces of which are marked with small circular distinct pits; these scutes are thicker and more rectangular than those above described,

and slightly overlapped each other laterally; they have no connecting process. In another species one half of the outer surface is smooth, proving that it was covered to that extent by the adjoining scute. [588]

[588] A description of the dermal bones of British fossil reptiles is given in Brit. Assoc. Report for 1841, pp. 70, 79, &c.

DERMAL BONES OF THE HYLÆOSAURUS.—Elliptical and circular dermal scutes, having the under surface flat and the upper convex with a conical tubercle, were first noticed in the specimen of the *Hylæosaurus*, figured *Wond.* pl. iv.; and I have since discovered similar bones associated with other remains of that extraordinary reptile; reduced figures of two specimens are represented in *Lign.* 208, *figs.* 1, 3.



LIGN. 208. DERMAL BONES OF REPTILES. *Tilgate Fores*

Fig. 1, and 3. Dermal bones of the HYLÆOSAURUS: $^{1}/_{3}$ *nat.*

—

1*a*.— The under surface of a fragment of a dermal bone, displa
decussating each other at right angles, and indicating a s
that of the Curium, in which the bones were imbedded: ı

1*b*.— A portion of the same, highly magnified, and viewed by

2.— HORN of IGUANODON: $^{1}/_{6}$ *nat.*

4.— A DORSAL SPINE of the HYLÆOSAURUS; the original is th

The structure of these bodies is very remarkable; upon closely inspecting the under side, and the surface exposed by a transverse fracture, very minute osseous spicula, decussating each other at right angles, are distinctly seen; as shown in *Lign.* 208, *fig.* 1*a*. In *fig.* 1*b*, a thin slice of the same, highly

magnified, and viewed by transmitted light, displays medullary canals, with very fine lines radiating from them. The peculiar character of this organization consists in the disposition of the straight bony spicula; an appearance which first attracted my attention when developing the original specimen of the Hylæosaurus (see *Geol. S. E.* p. 327), and led to the discovery of some perfect examples, which otherwise would have been destroyed. This structure closely resembles that presented by the ligamentous fibres of the *corium*, or skin, and seems to have resulted from an ossified condition of the dermal integument. These bones vary from half an inch to three or four inches in diameter, and were disposed in one or more longitudinal series on each side the spine, diminishing in size as they approach the end of the tail.

DERMAL SPINES OF HYLÆOSAURUS. *Lign.* 208, *fig.* 4.—With the dermal bones above described there are associated in the first discovered specimen of the Hylæosaurus, flat, thin, angular, osseous plates, from three to seventeen inches in length; one of which is figured *Lign.* 208, *fig.* 4. The manner in which they are imbedded in the rocks, in connexion with other parts of the skeleton, is shown Wond. pl. iv. and *Geol. S. E.* pl. v. These very remarkable processes appeared to me to have formed part of a serrated fringe, which extended along the back of the reptile, analogous to that observable in certain living lizards (*Wond.* p. 436, *Lign.* 108); and were provisionally described as such in my first memoir on the Hylæosaurus. This conjecture has been substantiated by subsequent discoveries, and the true nature of the large, flat, angular spines, and the conical bones resembling the horn-cones of ruminants, which occur in the Wealden, is now established.[589]

[589] See *Fossils, Brit. Mus.* pp. 298, 320.

HORN OF IGUANODON.—In this category may be placed the nasal tubercle or horn of a saurian, like that of the Iguana (*Lign.* 208, *fig.* 2; *Geol. S. E.* pl. iii.), found with the remains of the Iguanodon, and probably belonging to that colossal reptile (*Wond.* p. 431; and *Petrif.* p. 298). It is four inches in length and 3.2 inch by 2.1 inch in diameter at the base, which is of an irregular elliptical form. Several smaller specimens have recently been discovered.

Examples of dermal scutes and spines, presenting modifications of form and structure distinct from those above described, have been brought to me from various localities of the Wealden; but, as in no instance a connexion with other parts of the skeleton could be traced, the particular reptiles to which they belonged cannot be ascertained.

We proceed to notice some of the principal genera of Fossil Reptiles, especially of those whose remains occur in the British strata; the arrangement of Professor Owen is adopted for the convenience of reference to the Brit. Assoc. Reports, 1839 and 1841, which should be consulted by the student who would acquire a knowledge of this department of Palæontology. The subject will be considered under the following heads; namely:—

I. *Enaliosaurians*, or Marine Reptiles; Ichthyosaurus and Plesiosaurus.
II. *Crocodilians*; Crocodile, Teleosaur, &c.
III. *Deinosaurians*; comprising the Iguanodon, Megalosaurus, Hylæosaurus, Pelorosaurus, &c.
IV. *Lacertians*; including the Mosasaurus, Rhyncosaurus, &c.

V. *Pterosaurians*; the Pterodactyles, or flying Reptiles.
VI. *Chelonians*; or Tortoises and Turtles.
VII. *Ophidians*; or Serpents.
VIII. *Batrachians*; or the Frog tribe; comprising the Labyrinthodonts.

I. ENALIOSAURIANS.—The extinct marine reptiles comprised in this order constitute two genera, which are characterized by essential modifications of osteological structure; they are named ICHTHYOSAURUS (*fish-lizard*), and PLESIOSAURUS (*akin to a lizard*). The general appearance of these beings is so well known, from the splendid collection of their fossil remains in the British Museum, and the numerous specimens in provincial and private collections, and by various works, both scientific and popular, in which their structure and physiological relations are fully elucidated, that they must be familiar to every reader.[590]

[590] *Bd.* vols. i. and ii. contain an admirable exposition of their habits and organization; and Brit. Assoc. Reports, 1839, 1841, elaborate osteological investigations of both genera. A folio volume on these extinct Reptiles, with splendid lithographs, by Thomas Hawkins, Esq., cannot fail to delight the reader by its graphic descriptions and beautiful illustrations. See also the masterly paper on the Ichthyosaur and the Plesiosaur, by the Rev. W. D. Conybeare, in the Geological Transactions, 1st series, vol. v. p. 559, *et seq.*

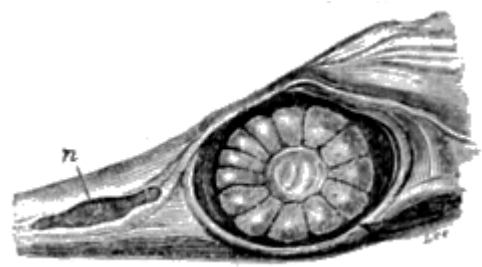
ICHTHYOSAURUS. PLESIOSAURUS.

The living ICHTHYOSAURUS must have borne a resemblance to a Grampus or Porpoise, with four

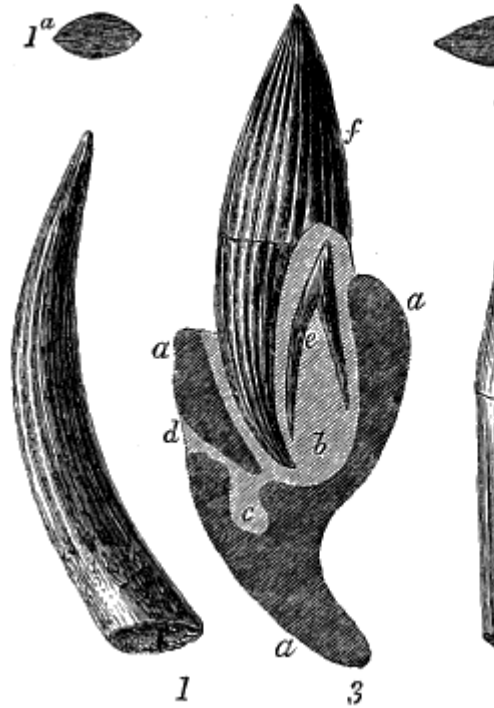
large flippers or paddles and a long tail, having a vertical caudal fin of moderate dimensions; the skin probably being naked and smooth, as in the Cetaceans. The PLESIOSAURUS presented a configuration still more extraordinary (*Wond.* p. 575). With a very small head, it possessed a neck of enormous length, a body of moderate size, with four paddles, resembling those of turtles, and a very short tail. They were both marine, air-breathing, cold-blooded, carnivorous, vertebrate animals; swarming in prodigious numbers during the secondary epochs, and particularly in the seas of the Liassic period (*Ly.* p. 277, figs. 310, 311). In both genera the construction of the skeleton presents many important variations from all known recent types; and should be carefully investigated by the student, who will find in the Reports of Professor Owen above referred to all the information that can be desired.[591]

[591] The Penny Cyclopædia, Art. Plesiosaurus, contains an able abstract of these Reports; and in the *Fossils of the British Museum*, the student will find a full account of the discovery of the Ichthyosaur and Plesiosaur, and of the deposits in which they are chiefly found, as well as detailed descriptions of the most characteristic structures of the different species.

It will suffice for our present purpose to point out a few important and obvious characters.



LIGN. 209. EYE OF ICHTHYOSAURUS. $^{1}/_{6}$ *nat. Lias. Lym*
Portion of the facial part of the skull of an Ichthyosaurus, showing th
and of the orbit with its circle of bony plates, forming the sclero
n. The left nasal aperture.



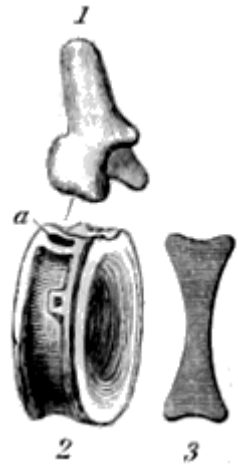
LIGN. 210. TEETH OF ICHTHYOSAURUS AND PLES
Lias. Somersetshire.

Fig. 1.— Tooth of Plesiosaurus.

1*a*. Transverse section of the lower part.
—
2.— Tooth of Ichthyosaurus.
2*a* Transverse section of the middle of the tooth.
—.
3.— Vertical section of part of lower jaw of Ichthyosaurus, with a dentition.
a, a, a. Section of the lower jaw, showing the deep furrow *b*,
c. The canal for the dental vessels.
d. Foramen for the passage of vessels to the outer integu
e. Germ of a successional tooth which has occasioned th the base of the mature tooth, *f*.

In the Ichthyosaurus, the nasal apertures or openings of the nostrils are not towards the snout, as in the Crocodile, but near the anterior angle of the orbit (see *Lign.* 209), approaching, in this respect, some of the recent lizards. The orbit is very large, and the sclerotic coat or capsule of the eye has in front an annular series of bony plates (*Bd.* pl. x. *figs.* 1, 3), which often occur in their natural position (*Lign.* 209). This structure is not possessed by fishes, but is analogous to that observable in the eyes of turtles, lizards, and many birds; as for example, in the owl and eagle: it confers on the eye additional power of adaptation and intensity of vision. The muzzle of the Ichthyosaurus is long and pointed; the lower jaw is formed of two branches, united anteriorly through nearly half their length; each branch is composed of six bones, as in the Crocodile and Lizards, but differently arranged than in those reptiles. The teeth are very numerous, amounting to nearly two hundred in some species, and are placed in a single row along the jaws, being implanted in a deep continuous groove (see *Bd.* pl. xi.). These teeth are of a pointed conical form, longitudinally striated, with an expanded base (*Lign.* 210). The new teeth

are developed at the inner side of the base of the old, and grow up and displace them (see *Lign.* 210). The microscopical structure of the teeth of the Ichthyosaurus is beautifully illustrated by Professor Owen (*Odontography*, p. 275, pl. lxiv.). The tooth consists of a pulp-cavity, surrounded by a body of dentine, which is invested at the base by a thick layer of cement; and at the crown by a coat of enamel, also covered by a pellicle of cement 3 the pulp-cavity, in fully-formed teeth, is more or less occupied by coarse bone. The chief peculiarity of this structure consists in the inflection of the cement into vertical folds at the base of the tooth, by which the marginal portion of the basal dentine is divided into a corresponding number of processes; producing, in a transverse section, the appearance represented in *Pl. VI. fig. 9*. This organization, as we have previously remarked, is similar to that observable in the teeth of the *Lepidosteus* (see p. 616), and of the extinct reptile, called *Labyrinthodon*, hereafter to be noticed.



LIGN. 211. VERTEBRA OF ICHTHYOSAURUS. $^{1}/_{3}$ *nat.*
Fig. 1.— Neural arch and spine.

2.— Body or centrum.
a. Socket for the reception of
— the corresponding process
of the neural arch.
3.— Vertical section of the centrum.



LIGN. 212. THE BONES COMPOSING THE PECTORAL ARCH OF ICHTHYOSAURUS. $^{1}/_{8}$ *nat.*

s, sternum.
cl, cl, clavicles.
sc, sc, scapulæ.
c, c, coracoids.



LIGN. 213. THE BON
C

s, sternum.
sc, sc, scapulæ or omo
c, c, coracoids.
g, g, the glenoid cav
humerus or arn

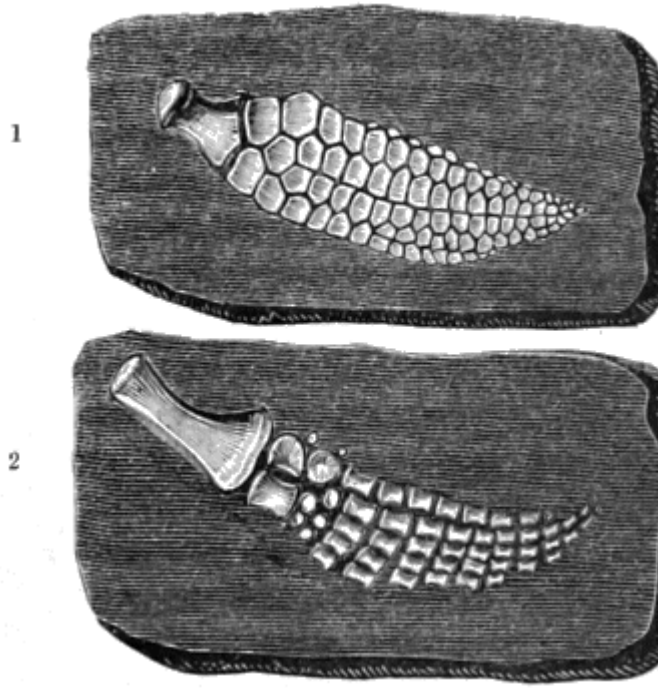
The vertebræ; (*Bd.* pl. xii.; and *Lign.* 211), of which there are upwards of one hundred and forty in the individuals of some species, are relatively very short in their antero-posterior diameter (*i. e.* from front to back); and deeply cupped on each articulating face, as in fishes. The annular part is not united to the body of the vertebra, as in mammals, nor connected by suture, as in Crocodiles, but terminates on each side in a compressed oval base, which fits into corresponding sockets placed on the boundary line of the spinal depression on the body (*Lign.* 210, 2*a*); thus completing the medullary canal (see *Bd.* pl. xii. *fig.* D, E.). Hence the collector may

easily recognise the body of an Ichthyosaurian vertebra, by the pits or depressions on the sides of the spinal interspace. The first and second vertebra; are anchylosed together, and have additional subvertebral, wedge-shaped bones, which render this part of the column a fixed point of support.[592] (*Bd.* pl. xii. figs. 3, 6.) The form and arrangement of the bones that enter into the composition of the pectoral and pelvic arches, and of the paddles, are exemplified in *Bd.* pl. xii.; and full osteological details are given in *Brit. Assoc. Rep.* 1839, p. 104. The characters of the several bones composing the pectoral arch of the Ichthyosaur will be readily understood from the accompanying illustration. The structure of the pectoral arch of the Plesiosaur is also shown in an accompanying Lignograph, for the sake of comparison. The bones of a fore-paddle of an Ichthyosaurus are represented (*Lign.* 214, *fig.* 1). In some species each paddle consists of nearly one hundred bones. These locomotive extremities are very analogous in their osteological construction to those of the Cetaceans, but they are connected with the trunk by means of the glenoid socket formed by the scapula and coracoid, which are firmly united to the sternum; whereas in the Cetaceans the pectoral fin is only attached to a simple scapula, which is merely suspended in the muscles. This structure, together with the presence of a clavicle in the Ichthyosaurus (see *Lign.* 212), which is wanting in the Cetaceans,, indicates, in the opinion of Professor Owen, that this marine fish-lizard was capable of some degree of locomotion on the land; and that it might have resorted to the shore to deposit its eggs, or, like the Crocodile, to sleep. From the frequent occurrence of a dislocation or abrupt bend of the vertebral series of the tail, at about one-third of its

length from the end, supposed to have been produced by the weight of a large fin, during the progress of decomposition, and from the terminal caudal vertebræ being laterally compressed, it is inferred that the Ichthyosaurus had a vertical fin at the extremity of the tail, which would thus be rendered a powerful instrument of progressive motion.[593] From the appearance of the *Coprolites*, which occur abundantly with the skeletons of these animals, it is obvious that the intestinal canal in the Ichthyosaurus was furnished with spiral valves, as in the Sharks; and the comminuted bones and scales in the coprolites prove that fishes constituted the principal food of these marine reptiles.

[592] This structure was first demonstrated by Sir Philip Egerton. See Geol. Trans. 2d series, vol. v. p. 187, pl. xiv.

[593] Geol. Trans. 2d ser. vol. v. p. 511, pl. xlii.



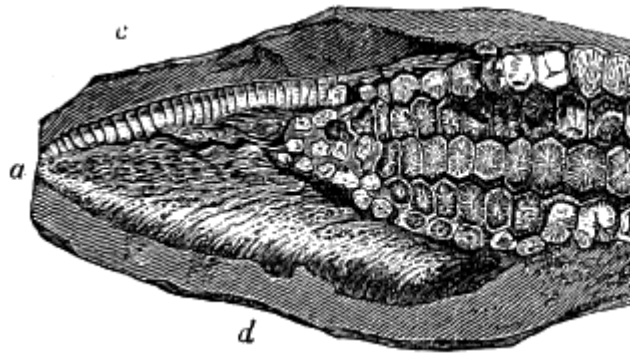
LIGN. 214. PADDLES OF ICHTHYOSAURUS AND PLESIOSAURUS, 1/8
Lias Shale. Lyme Regis.

Fig. 1.— Left fore-paddle of the Ichthyosaurus.
2.— Left fore-paddle of the Plesiosaurus.

The Ichthyosaurus has abdominal ribs (p. 656, note), as in the Crocodile, and it is therefore inferred that, if oviparous, it did not produce ova in such immense numbers as the Batrachians, &c. A specimen found by the late Mr. Channing Pearce renders it probable that the Ichthyosaurus may have been viviparous. A remarkably perfect adult Ichthyosaurus, examined by this gentleman, contained the bones of a fœtus (a few inches long) *in the cavity of the pelvis*. This specimen is in the collection of Mr. Pearce, at Bath. Remains or traces

of the dermal integument have been discovered in some examples from the Lias of Barrow-on-Soar, Lyme Regis, Ilminster, and the neighbourhood of Tewkesbury.[594]

[594] See Mr. Coles's interesting paper on the Skin of the Ichthyosaurus, in the Quart. Journ. Geol. Soc. vol. ix. p. 79.



LIGN. 215. HINDER PADDLE OF AN ICHTHYOSAURUS ($^1/_3$ *nat.*): with th
Lias. Barrow-on-Soar.
(*From Geol. Trans. 2d ser. vol. vi. pl. xx.*

INTEGUMENTS OF THE PADDLE.—The importance of carefully examining the surrounding stone before removing vegetable or animal remains from the matrix in which they are imbedded, and which has so often been insisted upon in the preceding pages, is strikingly exemplified in the highly interesting example of the hinder paddle of an Ichthyosaurus (*I. communis*) discovered by Sir Philip Egerton. *Lign.* 215 is reduced from the exquisite representation of the specimen accompanying the original memoir by Prof. Owen on this fossil, in the Geological Transactions. The specimen consists of the phalangeal bones of a posterior paddle, with the impression of the soft parts or integuments in their natural position; *a*, marks the termination or distal extremity of the fin,

consisting entirely of the softer integuments; these gradually widen and expand to receive the terminal rows of the phalangeal ossicles or bones, marked *b*. The upper border of this integumentary part of the paddle (*c*) is formed by a smooth, well-defined line, apparently a mere duplicature of integument. But the lower margin (*d*) exhibits the impressions of a series of rays, by which the fold of integument was supported; these rays bifurcate as they approach the margin of the fin, and were probably either cartilaginous, or composed of an albuminous horny tissue, like the marginal rays in the fins of Sharks. Dr. Buckland detected remains of the dermal integument of an Ichthyosaurus in a specimen from the Lias at Barrow-on-Soar (*Bd.* ii. p. 22, pl. x.); and in a fine skeleton with the four paddles (now in the British Museum), which I obtained from that locality, there were decided traces of the carbonized integuments around each paddle, but which were, unfortunately, chiselled away, in developing the bones, before I was aware of their true nature.

In Mr. Coles's paper, already referred to, the student has an instructive instance of the value of a careful examination of faint or obscure traces of organic matter accompanying these saurian remains, and how such an examination should be made. The Plate illustrative of the Memoir exhibits the minute, hooked, conical bodies, that form the dense felt-like mass which the black film, frequently accompanying these fossil bones, appears to consist of, when seen under the microscope. To what extent this substance entered into the constitution of the integuments, or of the exact relation of these "setiform scales" to the surface or the interior of the skin, our present knowledge does not enable us to judge.

PLESIOSAURUS.

PLESIOSAURUS. (*Bd.* pl. xvi.—xix.)—The animals of this genus present in their osteological structure a remarkable deviation from all known recent and fossil reptiles; uniting the characters of the head of a lizard, with the teeth of a crocodile, to a neck of inordinate length, with such modifications of the ribs, the pectoral and pelvic arches, and the paddles, as to justify the graphic simile of Professor Sedgwick, that the Plesiosaurus might be compared to a serpent threaded through the shell of a turtle.

The character which immediately strikes the observer, is the extraordinary length of the neck, and the relative smallness of the head. The neck, which in most animals is formed of but five vertebræ, and in the extremest recent example, the Swan, does not exceed twenty-four, is in the Plesiosaurus composed of from twenty to forty; and, in some species, is four times the length of the head, and equal to the entire length of the body and tail; while the length of the head (in *P. dolichodeirus*) is less than one-thirteenth of the entire skeleton. The skull resembles that of the crocodile in its general form, but is relatively smaller, and is more related to the lacertian type. The parietal bone is more triquetal than in the crocodiles; but the zygomatic bone is attached to its lower end. The breathing apertures are situated anterior to the orbits, on the highest part of the head. The lower jaw has the usual structure of the Saurians; but the dentary bone is greatly expanded anteriorly, and united in front (see *Bd.* pl. xix.). The teeth are implanted in separate sockets, as in the crocodile, and there are from thirty to forty on each side the jaws. They are conical, slender, long, pointed, slightly recurved, and longitudinally

grooved from the base upwards; having a long round fang. The pulp-cavity is long and single, surrounded by a body of firm dentine, covered on the crown with a layer of enamel, and at the base with cement (*Odont.* pl. lxxiv.). The dentition in the Plesiosauri differs from that of the Crocodiles, in the successional teeth emerging through distinct apertures on the inner side of the sockets of their predecessors, and not through the pulp-cavity. The vertebræ are relatively longer than in the Ichthyosaurus, and their articular faces are either flat, or slightly excavated towards the periphery, with a gentle convexity in the centre (*Foss. Til. For.* pl. ix. fig. 4).[595]

[595] For details, see Brit. Assoc. Rep. 1839, p. 50.

The caudal vertebræ have two distinct hæmapophyses, not united into a chevron-bone.

The cervical ribs, or hatchet-bones, are attached by two articular facets to the bodies of the vertebræ, but with a very narrow space between; scarcely large enough even for the passage of the sympathetic nerve; and apparently not sufficient for the vertebral artery.

The *pectoral arch* is remarkable for the pair of elongated and broad coracoid bones (*Bd.* pl. xvii. and *Lign.* 213); indeed the coracoids attain their maximum of development in the Plesiosaurus. The *ribs*, which are very numerous, and extend throughout a great portion of the vertebral column, are connected, anteriorly, in the abdominal region, by several slender bones, called *costal-arcs*, consisting of six or seven pieces to each pair of ribs; the Ichthyosaurus has a similar structure, but the arcs

are composed of but five pieces. As these connecting bones are so constructed as to admit of a certain degree of gliding motion upon each other, it is inferred that, by this mechanism, considerable expansion of the pulmonary cavities in these air-breathing marine reptiles was obtained (*Bd.* pl. xviii. fig. 3).

The paddles are composed of fewer and more slender bones than in the Ichthyosaurus, and must have been of a more elegant form, and possessed greater flexibility (*Lign.* 214, *fig.* 2). The wrist (*carpus*) consists of a double row of round ossicles, which are succeeded by five elongated metacarpal, and these by numerous, slender and slightly-curved phalangeal bones.

Sixteen species of Plesiosaurus and ten of Ichthyosaurus have been discovered in the British strata, and nearly forty are now known; their geological range is from the Lias to the Chalk, inclusive.[596] Their remains are found most abundantly in the Lias and Oolite. I have collected many Plesiosaurian vertebræ in the Wealden, and in the Green Sand of Farringdon. No traces of Ichthyosauri have been observed in the Wealden; but vertebræ, and jaws with teeth, occur in the lower Chalk and Galt of Kent and Cambridgeshire.[597] On the Continent the remains of Enaliosaurians have also been discovered in the same formations.

[596] See *Petrifactions*, for an account of the specimens in the British Museum.

[597] Brit. Assoc. Trans. 1845, Sect. p. 60. The Enaliosaurian bones and teeth found in the Cretaceous deposits of England have been fully described and illustrated by Prof. Owen, in

Dixon's *Fossils of Sussex*, &c., and in his Monograph on the Fossil Reptiles of the Cretaceous Formation, Palæontographical Society, 1851.

PLIOSAURUS.—-This name designates a gigantic extinct reptile, of which the upper and lower jaws, with teeth, considerable portions of the vertebral column, and many bones of the extremities have been discovered in the Kimmeridge clay of Oxfordshire, and are preserved in Dr. Buckland's museum. The teeth resemble those of the Plesiosaurus in their general aspect, being of a conical form, longitudinally grooved, and having a long fang; but they are readily distinguished by the subtrihedral form of the crown, produced by the smooth, flat, or slightly convex external surface; they approach in this respect the tooth of the Mosasaurus; from the latter, however, even fragments may be known by the presence of longitudinal ridges. The animal itself was an enormous marine reptile, allied to the Plesiosaurians, but more nearly related to the Crocodilians.[598]

[598] Brit. Assoc. Rep. 1841, p. 60. Odont. pl. lxviii.

II. CROCODILIANS.—The loricated, or mailed, Saurian reptiles, viz. the Alligators, Crocodiles, and Gavials, are well known as the largest living forms of cold-blooded oviparous quadrupeds.[599] No relics of any recent species have been observed in a fossil state; except that of the Gangetic Gavial, which has been found fossil in the Sub-Himalayas by Capt. Cantley and Dr. Falconer; but remains of Crocodilians of the existing generic type, having the spinal column composed of concavo-convex vertebra; (i. e. united to each other by a ball and socket-joint),

the convexity being behind, or towards the tail, have been found in the London Clay at Hackney and the Isle of Sheppey, and in the eocene deposits on the coast of Western Sussex and Hants.[600] But the Crocodiles of the Wealden, Purbeck, Oolite, and Lias differ materially in their osteological characters from the recent species, particularly in the structure of the vertebral column; which in one genus is composed of concavo-convex vertebra; placed in a reversed position to those of the existing species, the ball or convexity being anterior, or directed forwards. In the other genera, both the articular faces of the vertebræ are either flat, or concave.[601] (*Geol. S. E.* p. 296.)

[599] A detailed and philosophical examination of the osteology of the recent Crocodilia has lately been given to the scientific world by Prof. Owen, in his Monograph on the Reptilia of the London Clay, published by the Palæontographical Society of London, 1850. A condensed notice, by Prof. Owen, of the dental apparatus of the Crocodilians, is to be found in the *Cyclop. Anat.* Art. TEETH.

[600] See Brit. Assoc. Rep. 1844, Sect. p. 50; and 1847, Sect, p. 65.

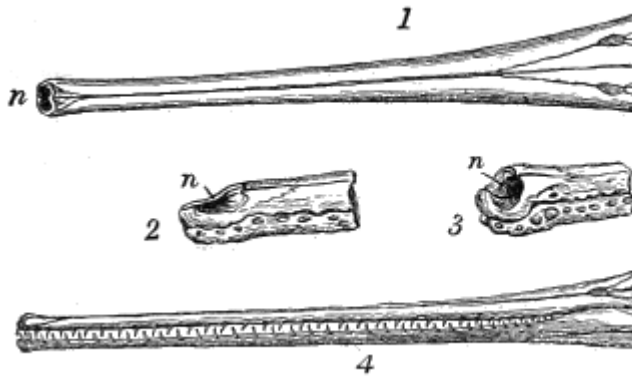
[601] Cuvier, Oss. Foss. tom. v. p. 153; on the fossil Crocodiles of Honfleur, which comprise both the types alluded to in the text.

Vertebræ of two species of Crocodilians or Alligators have been found in the cretaceous Green Sand of the United States: these are of the true procœlian[602] type, as in the existing species; but they present peculiar characters in the modification of the apophyses.[603]

[602] Procœlian, concave before:

amphicœlian, concave at both ends platycœlian, flat in front and concave behind.

[603] See Quart. Geol. Journ. vol. v. p. 380, pl. x.



LIGN. 216. SKULL AND JAWS OF TELEOSAUR
Lias. Whitby.

Fig. 1.— Upper view of the cranium of Teleosaurus.
c, occipital condyle.
t, *t*, temporal fossæ.
o, *o*, orbits.
n, nasal apertures.
2.— Muzzle or anterior extremity of the jaws of *Steneosaurus*.
3.— The same of Teleosaurus.
4.— Lateral view of the cranium and lower jaw of Teleosaurus.

With this exception, the Crocodilians with broad muzzles, as the Cayman and Alligator, have no representatives below the Tertiary formations; the *Crocodilia* of the Secondary deposits being all referable to the division having elongated beaks, like the recent Gavials (*Bd.* p. 250). The fossil Crocodiles of the latter type are arranged in two genera; namely, TELEOSAURUS[604] (*Lign.* 216, *fig.* 3), in which the nasal apertures terminate in two orifices,

(not blended into a single opening as in the recent species,) in front of the nose; and STENEOSAURUS (*Lign.* 216, *fig.* 2), in which the breathing canals end in two nearly semicircular vertical openings at the extremity of the muzzle. (See also *Bd.* pl. xxv.)

[604] The skeleton of a recent Gavial, and that of a Teleosaur, are represented on one plate, for comparison, in Prof. Owen's Monograph, *loc. cit.*

The British fossil species, most nearly related to the recent, occur in the Lower and Middle Eocene of the South-East of England. Two fine specimens of the skull of *Crocodilus toliapicus*, Cuvier and Owen (*C. Spenceri* of Dr. Buckland), have been found at Sheppey, as well as a skull of *C. champsoïdes* (Owen), and numerous vertebræ referable to each species. The eocene deposits of Hordwell Cliff have yielded the *Crocodilus Hastingsiæ*,[605] and the *Alligator Hantoniensis* (*Petrif.* p. 467; and *Charlesworth's Geol. Journ.* pl. i.); and the remains of a Gavial (*Gavialis Dixoni*, Owen, in Dixon's *Foss. Suss.*) have been found at Bracklesham.[606]

[605] This fossil Crocodile supplies a good illustration of the biconvex body of the first caudal vertebra already described as peculiar to these loricated reptiles, see page 656; and I have subjoined *Lign.* 217 in illustration of this structure.

[606] Most of these valuable fossils are in the British Museum. They are all described in detail and most elaborately illustrated in Prof. Owen's Monograph, already referred to.



LIGN. 217. FIRST CAUDAL VERTEBRA OF CROCODILUS H
1/3 *nat.*
Eocene. Hordwell Cliff.
s, spinous process, or neural spine.
z, anterior zygapophysis or oblique process.
z^1, posterior zygapophysis.
d, left diapophysis, or transverse process.
a, p, body or centrum, convex at both ends.

In the strata of Tilgate Forest, associated with innumerable remains of reptiles of various kinds, teeth of the Crocodilian type, belonging to two genera, are not uncommon.[607] The first kind (*Suchosaurus*[608] *cultridens* of Prof. Owen) is a tooth about an inch in length, of a slender acuminated form, compressed laterally, and gently recurved, with a sharp edge in front and behind; resembling, in its general figure, the tooth of a Megalosaurus, with the serrations on the edges worn off (*Pl. VI. fig. 7*). The sides of the crown are marked with a few longitudinal grooves. Some biconcave vertebræ found in the same quarries, and characterized by the compressed wedge-shaped form of the centre (*Foss. Til. For.* pl. ix. *fig.* 11), are supposed by Professor Owen to belong to the same reptile as the teeth above described; but it is hazardous to pronounce on

the identity of these detached teeth and bones, without more corroborative proof than has hitherto been obtained.

[607] Foss. South Downs, p. 50. *Foss. Tilg. For.* p. 64; pl. v. figs. 1-3, 7. *Cuv. Oss. Foss.* tom. v. p. 161, pl. x. See also Owen's later examination of these remains, *Report Brit. Assoc.* 1811, p. 67; and *Cyclop. Anat.* Art. TEETH.

[608] Brit. Assoc. Rep. 1841, p. 68. *Suchosaurus* is derived from *Suchus*, or *Suchis*, the name given by Strabo to the sacred crocodile of the Egyptians.

SWANAGE CROCODILE. (*Goniopholis crassidens.*) *Petrif.* p. 170, *Lign.* 38.—Under this name, the second species of Crocodilian teeth will be considered; the discovery of a considerable portion of a skeleton of a reptile with teeth of this form (*Wond.* p. 416), in a quarry near Swanage, having disclosed some of the most important osteological characters of the original. These teeth are distinguished from the former by their cylindrical base, and rounded, obtuse, conical crowns (*Petrif.* p. 171): they somewhat resemble in form those of the Crocodile, but the crown is strongly marked with numerous, well-defined, longitudinal grooves and ridges; and there is a sharp ridge on the middle of each side. A small specimen, broken off at the base, is represented *Pl. VI. fig. 5*; it shows the smooth cylindrical base of the tooth, which is covered with cement, and the finely striated enamelled crown; some of the teeth are more than two inches in length, and one inch in diameter at the base (*Foss. Til For.* pl. v. figs. 1, 2). I have found these teeth in numerous localities; they are always well preserved, with the ridges sharp, and

have a high polish (*Geol. I. Wight*, p. 357, *Lign.* 30); a series of successional teeth may often be detected in the pulp-cavity (see *Wond.* p. 414). The detached teeth, and fragments of dermal bones (*Lign.* 207), which, from their constant occurrence with this species, I had been led to consider as belonging to the same reptile, were the only relics that had come under my observation, until the discovery of the Swanage specimen above mentioned.[609] On the two corresponding slabs containing this fine fossil are imbedded many detached teeth; a portion of the left side of the lower jaw, with two teeth in place; ribs and numerous vertebræ, which are biconcave, and have an irregular medullary cavity in the centre of the body; chevron bones resembling those of the Crocodile; the bones of the pelvic arch, and some of those of the extremities. With these are the remains of the osseous dermal cuirass, consisting of numerous scutes (figured and described p. 657, *Lign.* 207), scattered at random among the other relics of the skeleton; some having the inner, and others the external surface exposed; several of these bones are perfect, and exceed six inches in length, and two and a half in breadth. Numerous scales of a small Ganoid fish (*Lepidotus minor*), common in the Purbeck strata, are also intermingled with these remains. This reptile is named *Goniopholis crassidens*, by Professor Owen.[610]

[609] Now in the British Museum: see *Petrif.* p. 170. A lithograph of one of the slabs was given in the third edition of the Wonders of Geology, 1839.

[610] *Gonio-pholis*:—*angle-scute*. Brit. Assoc. Rep. 1841, p. 72. Both the slabs of the Swanage specimen are admirably arranged in the same case in the British Museum, with

bones and scutes of this reptile from Tilgate Forest; there can be no doubt that the entire lower jaw of the Swanage reptile might have been obtained if the quarry-men had taken the precaution of examining the adjoining block of stone.

PŒCILOPLEURON.—The remains of an allied genus of Crocodile, the *Pœcilopleuron Bucklandi* (of Deslongchamps), occur in the Oolite, near Caen, Normandy. This reptile, like the Goniopholis, had biconcave vertebræ, with a large medullary cavity in the middle of the centrum. The body of the vertebræ is contracted in the middle, the neural arch anchylosed, with no trace of suture, and with a thin spinous process, which is remarkable for its backward inclination. Vertebræ of this character also occur in the Wealden strata of Tilgate Forest and the Isle of Wight.[611]

[611] Brit. Assoc. Rep. 1841, p. 84. *Foss. Til. For.* pl. ix. fig. 8, represents a caudal vertebra.

TELEOSAURUS. (*Bd.* pl. xxv.)—In the Oolite of England and the Continent, the remains of a genus of extinct reptiles, having, like the recent Gavial, long slender muzzles, have been discovered in several localities. These fossils consist of the osseous scutes of an imbricated dermal cuirass; of the cranium and jaws with teeth; of the vertebral column; and many other bones. The characters of the dermal scutes, and of the muzzle with its terminal nasal apertures, have already been described (p. 659, and p. 676). There are several species of *Teleosaurus*; a splendid specimen of *T. Chapmanni*, fifteen feet long, from the Lias-shale on the Yorkshire coast, is preserved in the Whitby Museum; and there are interesting examples

in the British Museum.[612] Teleosaurian remains have been found in the Oolite at Stonesfield, and at Deddington, Oxfordshire; and Mr. C. Moore, of Ilminster, whose museum is rich with perfect Ichthyosaurs and Fishes from the Upper Lias of the neighbourhood, has been highly successful in developing some charming specimens of small Teleosaurs from out of the same deposit. In the Oolite of Caen, in Normandy, very fine specimens of *T. Cadomensis* have been discovered; and from these the illustrious Cuvier first determined the character and affinities of the original.[613] The British Oolite contains also the relics of a reptile with biconcave vertebræ, belonging to the genus *Steneosaurus*: the cranium with the jaws and teeth have been found in Kimmeridge clay, at Shotover (*Bd.* pl. xxv.).[614]

[612] *Petrifactions*, p. 178.

[613] Oss. Foss. tom. v. p. 127.

[614] Report Brit. Assoc. 1841, p. 82.

From the Jura limestone at Monheim, in Franconia, the remains of a small Crocodilian reptile (Teleosaurus priscus), with a long slender muzzle, have been obtained. In a specimen[615] from the former locality, the skull, jaws with teeth, the entire vertebral column, and many parts of the skeleton are preserved: the entire length is but three feet.

[615] Now in the British Museum: see *Petrif.* p. 178, where a detailed description of this unique fossil is given. See also *Ossem. Foss.* tom. v. pl. vi.

STREPTOSPONDYLUS, *Lign.* 206, *figs.* 5, 7.—Baron Cuvier in his celebrated work, "*Recherches sur les Ossemens Fossiles*," has given an elaborate description

of the remains of two kinds of slender-nosed Crocodilians, from the Kimmeridge clay of Honfleur, and the Oxford clay of Havre.

The specimens consist of the jaws with teeth, vertebræ, and some bones of the extremities.[616] In one species, the vertebræ are biconcave; in the other, they are convexo-concave, and present a remarkable deviation from the recent Crocodilian type, namely, that they are placed in a reversed position,—the convex face of the vertebra being directed anteriorly, or towards the cranium, and the concavity posteriorly; the name of the genus, *Streptospondylus* (reversed-spine), denotes this peculiarity of structure. The bodies of three or four large convexo-concave cervical vertebræ, were discovered in the Tilgate strata many years since, and are described in my various works (*Geol. S. E.* p. 300); but no suspicion was then entertained of their belonging to this genus, although I had repeatedly compared them with the figures of the Honfleur crocodile,[617] the imperfect state of the processes obscuring their true characters. Professor Owen first detected the true character of these Wealden vertebræ, in a large cervical, six inches long (now in the British Museum), in which two oblique processes are preserved on the concave end of the bone, their flat, oblong, articular faces, are directed downwards and outwards,—a character which at once proves them to be the posterior pair, for the anterior oblique processes would be directed upwards and inwards.[618] Vertebræ of the same species occur in the Wealden of the Isle of Wight; and of another species in the Oolite at Chipping Norton, and in the Lias of Whitby.

[616] Oss. Foss. tom. v. p. 143, pl. viii. ix.

[617] Reduced figures of two of these

vertebræ are given in *Lign.* 206, *figs.* 5 and 7, p. 653.

[618] Brit. Assoc. Rep. 1841, p. 92. The position of the articulating surfaces of the oblique processes (*zygapophyses*) in more perfect specimens, subsequently discovered in various localities of the Wealden, established the existence not only of a saurian allied to the Streptospondylus, but also of other reptiles whose spinal column was wholly or in part made up of vertebræ which were convex in front and concave behind, as in the cervicals and anterior dorsals of certain mammalia. Some of these fossil vertebræ Dr. Melville has referred, with great probability, to the cervical region of the Iguanodon (see *Petrif.* p. 259); others cannot at present be satisfactorily assigned to any known genus of reptiles.

A concavo-convex caudal vertebra, with the relations of which I am unacquainted, was found in the same quarry in Tilgate Forest; a reduced outline of this unique fossil is given in *Lign.* 206, *fig.* 1. The centrum is of a sub-cylindrical form, and the articular face in front is concave, and that behind, convex; with a chevron-bone that is anchylosed to the body of the vertebra, as in some of the caudals of the Mosasaurus, and terminates in an inferior spine (*f.*); the pair of anterior oblique processes remains; the neural spinous process is destroyed.

CETIOSAURUS.—From a considerable number of vertebæ and bones of the extremities of some gigantic aquatic reptiles, discovered in the Oolite in various places in Oxfordshire, Northamptonshire, and Yorkshire, the present genus was established; the name being intended to indicate a distant general resemblance of these extinct Saurians to the

Cetaceans.[619] The vertebra; differ from those of the Iguanodon in having their articular faces of a sub-circular form, and the body relatively short; the anterior face is nearly flat, and the posterior concave, in the dorsal vertebra;; but in the caudal both faces are concave, and have a well-defined elevated margin, which gives the body a deeply excavated character, easily recognizable. Vertebræ of this kind were among my earliest discoveries in the strata of Tilgate Forest. (*Geol. S. E.* p. 282.) Some specimens are eight inches in the transverse diameter of the articular face, and but four and a half inches in the antero-posterior length of the body.[620] The original animals are supposed to have been of aquatic, and probably of marine habits, on the evidence of the sub-biconcave structure of the vertebræ and of the coarse cancellous tissue of the long bones, which are destitute of a medullary cavity. They must have rivalled the modern whales in bulk, for some specimens indicate a length of forty or fifty feet; they are supposed to have had web-feet, and a broad vertical tail.[621]

[619] Proc. Geol. Soc. vol. iii. p. 457.

[620] The osteological characters of these remains, and the physiological relations of the original animals, are described in *Brit. Assoc. Rep.* 1841, pp. 94-102.

[621] Brit. Assoc. Rep. 1841, p. 102.

POLYPTYCHODON.[622]—The remains of another gigantic marine Saurian have been discovered in the Green Sand at Hythe, in Kent; they consist chiefly of the bones of the pelvis and hinder extremities.[623] The femur must have been nearly four feet in length. The long bones have a cancellated structure, without

a medullary cavity 3 the outer surface is finely striated. Probably in a recent state the cells were filled with oil, as in the *Cetacea*. Neither the vertebræ nor the teeth of this reptile are known; but, provisionally, these remains have been referred to the same animal as that to which the large, conical, longitudinally ridged teeth belonged, which have been found in the Kentish Rag, at Maidstone, and in the Chalk of Sussex, and have been named *Polyptychodon continuus*.[624] Teeth of *P. interruptus* are not unfrequent in the Cretaceous series; and a portion of the lower jaw of this species, from the Chalk of Kent, is in Mr. Toulmin Smith's collection. [625]

[622] *Poly-ptych-odon*; many-wrinkle-tooth.

[623] *Geol. Proc.* vol. iii. p. 449. The bones from Hythe were presented by their discoverer, H. B. Makeson, Esq., to the British Museum. See *Petrifactions*, p. 200.

[624] Owen's Monograph, Cretac. Reptilia, Pal. Soc. p. 47.

[625] Ibid. p. 55. See also Dixon's Foss. Suss. p. 378. Teeth of the Polyptychodon are figured in *Odontography*, pl. lxxii.

CHAPTER XVII.

FOSSIL REPTILES; COMPRISING THE DEINOSAURIANS, PTERODACTYLES,

TURTLES, SERPENTS, AND BATRACHIANS.

III. DEINOSAURIANS.—The Order DEINOSAURIA (*fearfully-great lizards*) has been established for the reception of those extinct colossal reptiles, comprising the *Megalosaurus*, *Hylæosaurus*, *Iguanodon*, and *Pelorosaurus*, which, in their organization, present the transition from the Crocodilians to the Lacertians, and whose essential osteological characters Professor Owen has described as follow:—

"This group, which includes at least three well-established genera of Saurians, is characterized by a large sacrum, composed of five anchylosed vertebræ of unusual construction; by the height, breadth, and outward sculpture of the neural arch of the dorsal vertebræ; by the two-fold articulation of the ribs to the vertebra:, viz. at the anterior part of the spine by a head and tubercle, and along the rest of the trunk by a tubercle attached to the transverse process only; by broad, and sometimes complicated, coracoids, and long and slender clavicles; whereby Crocodilian characters of the vertebral column are combined with a Lacertian type of the pectoral arch. The dental organs also exhibit the same transitional or annectent characters, in a greater or lesser degree. The bones of the extremities are of large proportional size for Saurians; they are provided with large medullary cavities, and with well developed and unusual processes, and are terminated by metacarpal, metatarsal, and phalangeal bones, which, with the exception of the ungual phalanges, more or less resemble those of the heavy pachydermal Mammals, and attest, with the hollow long-bones, the terrestrial habits of the species.

"The combinations of such characters, some, as the sacral ones, altogether peculiar among Reptiles, others borrowed, as it were, from groups now distinct from each other, and all manifested by creatures far surpassing in size the largest of existing reptiles, will, it is presumed, be deemed sufficient ground for establishing a distinct tribe or sub-order of Saurian Reptiles, for which I would propose the name of Dinosauria.

"Of this tribe the principal and best established genera are the *Megalosaurus*, the *Hylæosaurus*, and the *Iguanodon;* the gigantic

Crocodile-lizards of the dry land; the peculiarities of the osteological structure of which distinguish them as clearly from the modern terrestrial and amphibious Sauria, as the opposite modifications for an aquatic life characterize the extinct *Enaliosauria*, or Marine Lizards."[626]

[626] Brit. Assoc. Rep. 1841, p. 103.

The elaborate investigation of the fossil remains of these stupendous beings, and the luminous exposition of their organization and physiological relations, embodied in the report to which the above extract is introductory, are among the most important contributions to Palæontology, and afford a striking example of the successful application of profound anatomical knowledge to the elucidation of the most marvellous epoch in the earth's physical history, the *Age of Reptiles*.

From the great size of the bones of these reptiles, their remains have excited the curiosity even of the common observer; and although an exaggerated idea has been generally entertained of the magnitude of the original animals, yet, even when reduced to their natural proportions by the rigorous formula of the anatomist, applied to the accumulated relics which years of laborious research have exhumed from their rocky sepulchres and deposited in our museums, their dimensions are sufficiently stupendous to satisfy the most enthusiastic lover of the marvellous.

Let the reader visit the British Museum,[627] and after examining the largest thigh-bone of the Iguanodon, repair to the zoological gallery, and inspect the recent Crocodilian reptiles, some twenty-five or thirty feet in length; and observe that the fossil *bone* equals, if not surpasses, in size, the entire *thigh* of the largest of existing reptiles; then let him imagine this bone clothed with proportionate

muscles and integuments, and reflect upon the enormous trunk which such limbs must have been destined to move and to sustain—and he will obtain a just notion of the appalling magnitude of the lizards which inhabited the country of the Iguanodon.

[627] See Fossils of the British Museum, p. 227.

The general characters of the extinct reptiles comprised in the order *Deinosauria*[628] must be known to the intelligent reader, from the various popular notices which have from time to time appeared; and their names have become as familiar as household words. I shall here restrict myself to a few general remarks on the form and structure of the teeth, and of some of the more important bones of the best known species of these great reptiles.[629]

[628] In the new edition of Pictet's *Paléontologie* (now in course of publication), two 4to. plates (xxiii. and xxiv.) are devoted to the illustration of the remains of these colossal reptiles.

[629] For further account of the Iguanodon, see *Petrif.* p. 224, &c.; of the Hylæosaurus, *ibid.* p. 314, &c.; of the Pelorosaurus, *ibid.* p. 330, &c.; of the Regnosaurus, *ibid.* p. 333, &c.; and of the Megalosaurus, *ibid.* p. 328, &c.



LIGN. 218. MEGALOSAURUS BUCKLANDI. $^{1}/_{4}$ *nat.*
Great Oolite. Stonesfield, Oxfordshire.
Portion of the left ramus of the lower jaw, containing several teeth in different stages of growth: inner aspect.
a, a. Crowns of successional teeth.
b, b. Transverse partitions of the tooth-sockets.

MEGALOSAURUS.



LIGN. 219.
TOOTH OF THE MEGALOSAURUS BUCKLANDI.
(*Nat. size.*)

Wealden. Tilgate Forest.

MEGALOSAURUS (*gigantic lizard*) BUCKLANDI. *Lign.* 218 and 219. *Bd.* pl. xxiii. *Wond.* p 421.—The oolitic flag-stone of Stonesfield, in Oxfordshire, has long been celebrated for the bones and teeth of a gigantic reptile, which Dr. Buckland first described by the name of *Megalosaurus*, in a highly interesting memoir (*Trans. Geol. Soc. sec. ser.* vol. i.), illustrated by figures of the teeth in a portion of the lower jaw, the sacrum, femur, and other bones. The remains of this reptile are also frequently discovered in the Wealden (see *Foss. Til. For.* p. 67, pl. ix. figs. 2, 6). The most important relic of this great carnivorous terrestrial lizard is a portion of the right ramus of the lower jaw, containing one perfect tooth, and the germs of several teeth (*Lign.* 218). The tooth of the Megalosaurus, (*Lign.* 219, and *Pl. VI. fig. 7*,) has a conical, laterally compressed crown, with the point recurved like a sabre, and the edges trenchant and finely serrated. The implantation of the teeth is very peculiar, and exhibits the dentition of the Crocodilians blended with that of the Lacertians. The jaw has an outer parapet, as in the true lizards (see *Lign.* 205), but the teeth are fixed in distinct sockets, formed by transverse partitions, that are attached to a mesial (*inner*) parapet, composed of a series of triangular osseous plates; the bases of the old teeth, and the germs of the new ones, being thus enclosed and concealed. The tooth is formed of a central body of dentine, the crown having a coating enamel; and the whole an external investment of cement, which forms a thicker layer around the fang; the pulp-cavity is occupied by coarse bone, in the adult tooth. The microscopical examination shows the dentine to consist of very fine calcigerous tubes, $^{1}/_{28000}$th of an

inch in diameter, without any admixture of medullary canals, radiating from the pulp-cavity at right angles with the external surface of the tooth, and sending; off numerous secondary branches; these ultimately dilate into, or inosculate with, a stratum of calcigerous cells that separates the dentine from the enamel.[630] A thin slice of a vertical section, viewed by transmitted light, is represented *Pl. VI. fig. 7 b*; showing the calcigerous tubes radiating from the centre, and terminating in the stratum of cells; this cellular structure is invested with a layer of enamel, and the latter with an external coat of cement, indicated by the dark outline.[631]

[630] Owen's *Odontography*, p. 271, which should be consulted for more minute details.

[631] To fully comprehend the minute structure of these and the other teeth figured in *Pl. VI.* Professor Owen's plates should be examined; the small scale necessarily adopted in the present work rendering it impossible to do justice to the subject.

Four specimens of the sacrum, composed of five anchylosed vertebral (*Foss. Til. For.* pl. xix. *fig.* 12), have been discovered; one of these is from Tilgate Forest. The femur of the Megalosaurus has two large rounded trochanters of nearly equal size, below the head of the bone; its shaft is sub-cylindrical, and slightly bowed.

This colossal carnivorous Saurian, whose length is estimated at thirty feet, appears to have been terrestrial, and an inhabitant of the same *terra incognita* as the Iguanodon; it probably preyed on the smaller reptiles, and the young of the Iguanodon, Crocodilians, &c.

HYLÆOSAURUS (*Wealden lizard*) OWENII. *Wond.* pl. iv. and p. 435; *Geol. S. E.* pl. v.—In the summer of 1832, I obtained the interesting specimen which first demonstrated the existence of the remains of another extraordinary modification of Saurian organization in the Wealden. The circumstances which led to this discovery afford an instructive lesson to the young collector.

Upon visiting a quarry in Tilgate Forest, which had yielded many organic remains, I perceived in some fragments of a large mass of stone, which had recently been broken up and thrown on the road-side, traces of numerous pieces of bone. I therefore collected all the recognisable portions of the block, and had them conveyed to my residence. The first step was to cement together those pieces that would admit of juxtaposition, and these were at length united into a block of stone five feet long, three wide, and about one foot thick. This was firmly fixed in a stout frame, to prevent the separation of the united portions during the process of chiselling. Guided by the indications which the sections visible on the edge afforded, a thin iron wedge was carefully driven in, about half an inch above the uppermost layer of bones, and a large slab was flaked off; the three dermal spines (*Wond.* pl. iv. 5) in the middle of the specimen were thus exposed, and shivered to pieces; some fragments adhered to the mass broken off, others to the block, and many were detached; every piece, however small, was collected, and those adhering to the slab were chiselled out; and the whole were then carefully replaced and cemented to the bones that remained imbedded in the large block. After an interval of some days, to allow of the firm cohesion of the cemented parts, the task was resumed, and the stone chiselled away, until some portion of the large bones of the pectoral arch (*Wond.* pl. iv. 7) were observed. The specimen was at length brought to the state in which it now appears (in the British Museum[632]); but during the progress of its development, which occupied many weeks, it was repeatedly necessary to suspend the work, and unite displaced fragments of bone, and resume the task after their consolidation. The plate in the *Geol. S. E.* conveys a good idea of the original.

[632] See *Fossils, Brit. Mus.* p. 139, &c.

The specimen consists of a part of the spinal column, composed of seven dorsal and three or four

cervical vertebræ, almost in their natural juxtaposition, with obscure indications of a part of the base of the skull; eleven ribs; the bones of the pectoral arch (two *coracoids* and two *scapulæ*); with numerous dermal bones and spines. A second specimen of this reptile was found near Bolney, in Sussex; and like the former, it was, unfortunately, almost wholly destroyed by the labourers; but I obtained many bones, some of which are perfect, and indicate an animal of considerable magnitude: a *scapula*, nineteen inches long, an arm-bone or *humerus*, numerous ribs, bones of the phalanges, &c. A fine series of twenty-six caudal vertebra, having a total length of nearly six feet, with chevron bones and dermal spines, was discovered in 1837, in Tilgate Forest.[633] A few detached bones are the only other relics of this reptile that have come under my observation.[634] The osteological characters presented by these remains afford another example of tire blending of the Crocodilian with the Lacertian type of structure; for we have in the pectoral arch the scapula or omoplate of a crocodile associated with the coracoid of a lizard. Another remarkable feature in these fossils is the presence of the large angular bones or spines (described p. 660, figured *Lign.* 208), which, there is reason to infer, constituted a serrated crest along the middle of the back: and the numerous small oval dermal bones, which appear to have been arranged in longitudinal series along each side of the dorsal fringe. (*Geol. S. E.* p. 323.)

[633] See *Fossils, Brit. Mus.* p. 323.

[634] See "Memoir on the Remains of the Iguanodon, Hylæosaurus, and other Saurian Reptiles," by the Author, in *Philosophical Transactions* for 1841, Part II.

The vertebræ, ribs, and other parts of the skeleton found in these specimens also present modifications of structure of great interest.[635] No specimens of teeth have been found associated with the remains of the Hylæosaurus, in such manner as to afford unequivocal proof of their belonging to that animal. But in the same quarries, teeth, decidedly of the Lacertian structure, are occasionally found, and may with some probability be referred to that reptile. These teeth (see *Pl. VI. fig. 6a*.) are about $1^1/_4$ inch in length, and commence at the base with a cylindrical shank, which gradually enlarges into a crown of an obtuse lanceolate form, convex in front, hollowed behind, and terminating in a rounded obtusely angular apex, the margins of which are generally more or less worn.[636] The crown is solid, but the fang encloses a small pulp-cavity; the surface is enamelled, and covered with very fine longitudinal striæ; the base in every specimen appears broken transversely, as if it had been anchylosed to the jaw, or to the base of a socket. The fang never presents an appearance of lateral adhesion, as if belonging to a Pleurodont lizard. Sections of these teeth expose a simple, central, medullary canal, the upper part of which is generally filled with the ossified remains of the pulp; and this is surrounded by a body of firm dentine, with extremely minute calcigerous tubes radiating from the centre to the periphery of the tooth, which is invested with a relatively thick coat of enamel, in which no structure is apparent. *Pl. VI. fig. 6b* represents a small portion of a vertical slice, highly magnified and viewed by transmitted light. The reference of these dental organs to the Hylæosaurus must not, however, be considered as conclusive, until confirmed by the discovery of the teeth attached to the jaw, in connexion with other

parts of the skeleton. The locomotive organs of the Hylæosaurus are but imperfectly known; a perfect humerus, one phalangeal bone, and fragments of the fibula (the small bone of the leg) are the only bones hitherto observed. The length of this reptile, which was probably terrestrial and herbivorous, may be estimated at from twenty to thirty feet.

[635] See Report, Brit. Assoc. 1841, pp. 111-120. Phil. Trans. 1841, pp. 141-144, pl. x.

[636] Rep. Brit. Assoc. 1841, p. 118. Geol. S. E. England, pl. ii. figs. 2, 4. Phil. Trans. 1841, p. 144, pl. vi. figs. 9, 10, 11.

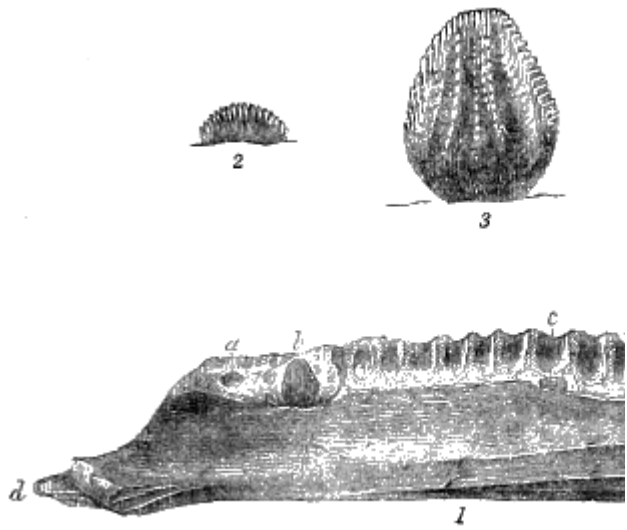
IGUANODON. *Ligns.* 219 to 226; *Wond.* pl. ii. iii., and pp. 422, &c.—Soon after my first discovery of the remains of vertebrated animals in the strata of Tilgate Forest, some teeth of a very remarkable character particularly engaged my attention, from their dissimilarity to any that had previously come under my notice.[637] Attention having been directed to these interesting fossils, examples were soon discovered of teeth in various conditions, from the sharp, unused tooth of the young reptile, to the obtuse, worn-out crown of the adult. From the resemblance of the perfect teeth to those of the Iguana (*Lign.* 205, p. 649), a land lizard of the West Indies, I proposed the name of *Iguanodon* (signifying an animal with teeth like those of the Iguana) for the extinct reptile to which they belonged. The numerous bones and teeth subsequently exhumed from the strata of Tilgate Forest and other localities in the Wealden of Sussex and of the Isle of Wight, and the considerable portion of the skeleton of an individual discovered by Mr. Bensted in the Kentish Rag, have supplied the data upon which our present knowledge of the characters of the original is based.

[637] These are described in *Foss. South D.* 1822, p. 54, under the head "*Teeth and bones of unknown animals*." This was the earliest published notice of the fossils of the Wealden; it contains also a description of a tooth of the Megalosaurus (p. 55, No. 42).

In Wond, pp. 422-435, a brief account will be found of the character of the teeth, horn, femur, vertebræ, &c., and of the Maidstone specimen[638] (*Pl. III.*).

[638] In a Monograph on the Reptiles of the Cretaceous Deposits of England, published by the Palæontographical Society, Professor Owen has lately figured anew and described in detail this most valuable fossil skeleton; to which description are appended the Professor's latest views on the structure of the teeth of this reptile.

The "Geology of the South-east of England" contains accurate figures of the long bones of the leg (*Geol. S. E.* pl. ii), femur, clavicles (*Geol. S. E.* pl. iv.), tympanic bone (*Geol. S. E.* pl. ii.), horn and ungual bone (*Geol. S. E.* pl. iii.). In the "Fossils of Tilgate Forest," there are fifteen quarto plates devoted to the illustration of the bones and teeth of the Iguanodon and other Wealden reptiles. The osteological structure is fully detailed in *Rep. Brit. Assoc.* 1841, pp. 120-144. A general notice of the principal bones of the Iguanodon, with plates, will be found in *Phil. Trans.* 1841, pp. 131-151; and in *Petrif.* chap. iii. the author has given a detailed account of the most important specimens, both in the British Museum and in his own collection, together with a résumé of the palæontology and geology of the Wealden district.



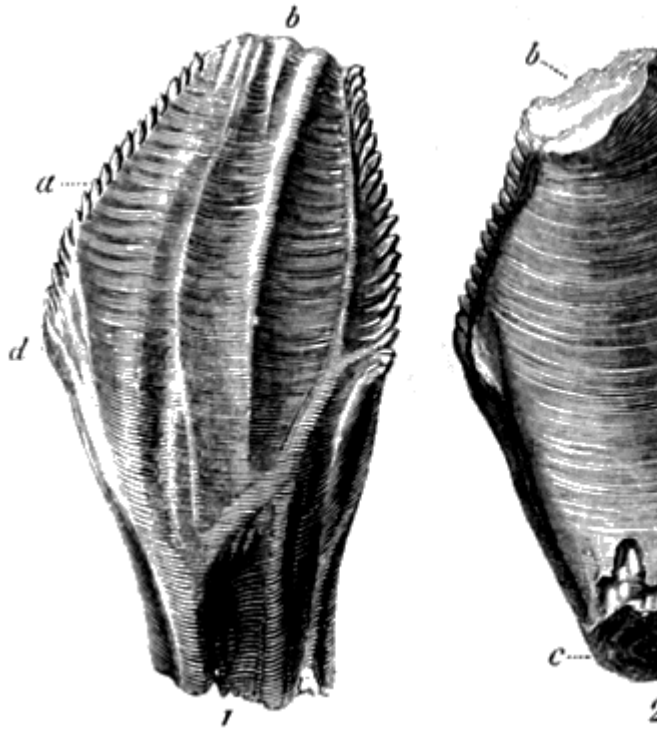
LIGN. 220. IGUANODON MANTELLI. [1]/
Wealden. Tilgate Forest.

The right ramus of the Dower Jaw; [639] discovered in 1848, by

Fig. 1.— The inner aspect, showing three teeth, and the sockets of eigh
a. Germ of a tooth.
b. Perfect crown of a successional tooth.
c. Remains of a successional tooth, the upper part having beer
d. The symphysial extremity of the jaw.
e. The opercular furrow.
f. The coronoid process.

2.— 3, and 4, the teeth *a*, *b*, and *c*, in *fig.* 1, represented on a large

[639] For the outer aspect, and a restoration of the whole jaw, *Petrif.* pp. 247 and 249.



LIGN. 221. LOWER TOOTH OF THE IGUANODON: *nat. siz*
Tilgate Forest.
The apex slightly worn.

Fig. 1. Inner aspect, showing the longitudinal ridges, and denticulated
— the tooth.

2. View of the outer surface of the tooth.
— *a.* The denticulated margin.
b. The apex of the crown, worn by use; b. *fig.* 2, shows the oblic
produced by mastication.
c. A transverse fracture of the fang, showing a section of the me
the ossified remains of the pulp.
d. Marks the inferior limit of the denticulated margin; if a line v
from d, across the tooth, the under figure would represent a toc
denticulations, and deprived of its peculiar dental characters; ir
somewhat resembles an incisor of a Rhinoceros (see *Ligns.* 222,



LIGN. 222. UPPER TOOTH OF THE IGUANODON: *nat. size*.
Wealden. Brook Bay, Isle of Wight.
The crown is worn down to an oblique smooth surface, and the fang is absorbed.

JAW AND TEETH OF THE IGUANODON. *Ligns.* 219-223.—Although the form and structure of the cranium are unknown, yet the half of a lower jaw, discovered in Sussex by Capt. L. Brickenden,[640] and a fragment of an upper jaw, found some years since,[641] enable us to form a tolerably perfect idea of the structure and functions of the dental organs of the Iguanodon. The unused tooth of this reptile is characterized by the prismatic form of the crown, the presence of from two to four longitudinal ridges on its enamelled face, the denticulated margins (*Lign.* 221, *a*), and finely serrated edge of the summit, as seen in *Lign.* 220, *fig.* 3. The shank or fang of the tooth (*Ligns.* 221, 223, *fig.* 2) is sub-cylindrical,

slightly curved, and tapers to a point. The inner surface of the crown in the lower teeth, and the outer surface in the upper, are covered with a thick layer of enamel, but the opposite face of the crown and the sides have but a thin coating of this substance. The teeth of the upper jaw (*Lign.* 222) are curved in the opposite direction to those of the lower, and have the convexity external, and the concavity internal. Thus the upper and lower molars were related to each other nearly as in the Ruminants; the outer aspect below corresponding to the inner above (see *Petrif. Lign.* 56, p. 254). The specimens met with have almost always the apex of the crown more or less worn down by use[642] (see *Lign.* 223), and presenting an oblique, triangular, smooth surface, as in the fine large specimen figured in *Lign.* 221, which was found imbedded in the trunk of a Clathraria, as if it had snapped off while the animal was in the act of gnawing the tough stem. The denticulated margins are well developed; in *fig.* 1, they appear as simple serrations; but viewed laterally, they are seen to be formed by a series of denticulated plates (*Lign.* 223, *fig.* 6). The crown of a tooth of a young animal, worn at the summit, and presenting but three longitudinal ridges, is represented *Pl. VI. fig. 4a*. The microscropical structure consists of a simple pulp-cavity in the centre of a body of dentine permeated by calcigerous tubes, but with this peculiar modification, that the dentine is traversed by vascular canals, radiating at definite intervals from the pulp-cavity nearly to the periphery of the tooth, and running parallel with the calcigerous tubes; thus constituting a softer and coarser dentine than in the other reptiles, and resembling that which characterizes the teeth of some of the herbivorous mammals.[643] The crown of the tooth is covered

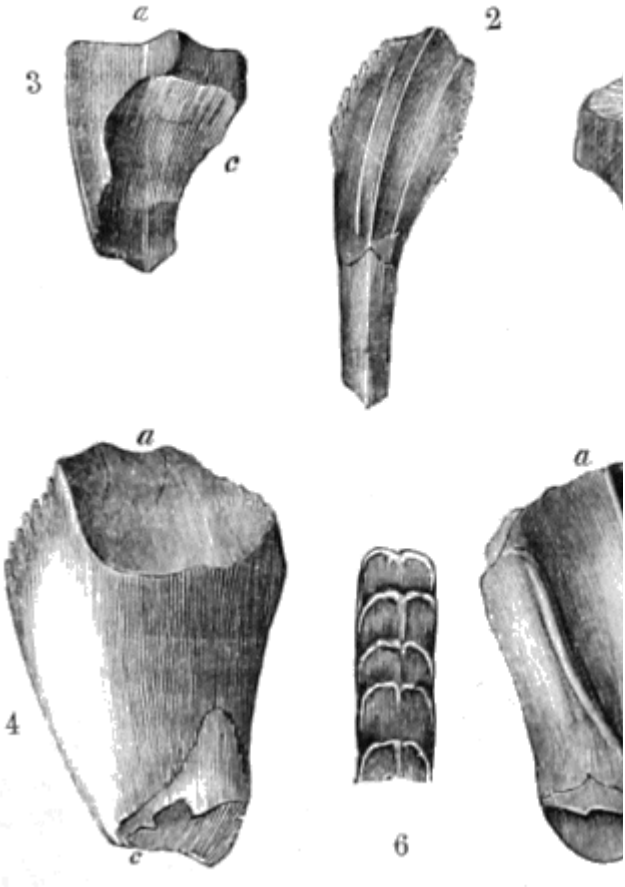
with a layer of enamel, which is thickest on the external surface: and the fang is invested with cement. The structure here described is shown in *Pl. VI.; fig. 4b*, a vertical, and *fig. 4c*, a transverse section of a tooth, seen by transmitted light, with a high magnifying power. The calcigerous tubes are $^{1}/_{25000}$ an inch in diameter. Sections of the teeth of the Iguanodon are beautiful objects under the microscope, for the medullary canals are generally of a deep yellowish brown colour.

[640] Figured and described in the *Phil. Trans.* 1848, p. 188, pl. xvi. xvii.

[641] Both specimens are fully described in *Petrif.* pp. 242, *et seq.*

[642] Plates iv. and xvii. in the "Fossils of Tilgate Forest," contain representations of upwards of thirty specimens of teeth in various states of development and detrition.

[643] Tomes on the Microscopic Structure of the Tooth of the Iguanodon, *Petrif.* pp. 239, 240. See also Owen's *Odontography*, p. 249, and pl. lxxi.; and *Cycl. Anat.* Art. TEETH.



LIGN. 223. TEETH OF IGUANODON. *Wealden. Tilga*

Fig. 1. Outer aspect of an upper tooth (in a reversed position), worn f
— absorbed; fig. 3, inner aspect of the same tooth.
a, a. Flat grinding surface, produced by mastication when all t
of the crown is worn away.
c. Cavity produced by the pressure of a new tooth.

2. Lower tooth of a young animal, slightly worn: inner aspect.
—

4. Outer Surface of a lower tooth of an adult; and fig. 5, inner su
— *a, a.* The hard cutting edge of the oblique surface worn by mas
c. Indentation produced by the pressure of a successional tooth

6. Edge view of the serration on fig. 5; magnified.

The dentine is less vascular, and therefore hardest, on that side of the crown which has the thicker coat of enamel; hence the tooth wears away faster on one side than on the other, and an oblique grinding surface, with a sharp edge of enamel, is maintained until the crown is worn away. The internal structure of the teeth of the Iguanodon is thus in perfect accordance with their external configuration, and must have been admirably adapted, in every stage, for the laceration and comminution of the tough vegetable substances which, there is every reason to conclude, constituted the food of this colossal oviparous quadruped.

VERTEBRA OF THE IGUANODON,[644] *Lign.* 206, p. 653; *Lign.* 224.—The remains of the vertebral column of the Iguanodon, consisting generally of broken and water-worn dorsal and caudal vertebræ, deprived of their processes and reduced to the state of the specimens represented *Lign.* 206, *figs.* 6 and 8, are so abundant in some of the Wealden strata, that a short account of their characters may be useful. A reference to *Lign.* 206, and its description, will render the following remarks intelligible to the general reader. The vertebræ of the Iguanodon are distinguishable from those of other reptiles which occur in the same strata by the following peculiarities, which the figure of a perfect specimen of a caudal vertebra (*Lign. 206*, *fig.* 3) will serve to illustrate. The body, or centrum, is either flat or somewhat depressed on both articular faces; its sides are nearly flat, or somewhat convex, vertically (as in *fig* 3), and slightly concave lengthwise, or from front to back: in some examples, the body is more

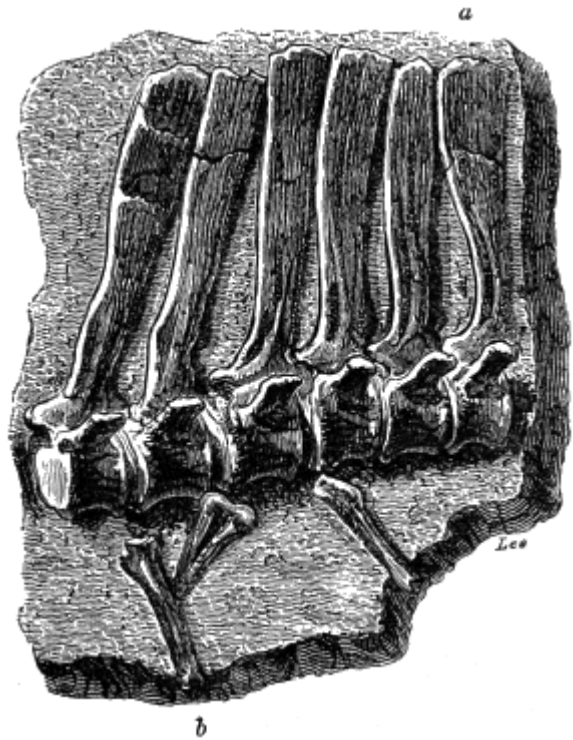
contracted towards the inferior surface, as in *fig.* 6; and in the vertebræ, near the middle of the tail, the sides are compressed, so as to give an angular contour and somewhat vertical elongation to the face, as in *fig.* 4; but in the dorsal vertebræ, the articular faces are nearly circular, but somewhat higher than wide. In the caudal vertebræ, the inferior angles of the body are truncated (*w*, *figs.* 3, 4), and present an oblique, smooth face, to articulate with the chevron bone (*fig.* 3, *f*). The annular part is united to the body by suture (*fig.* 3, *o*), and anchylosed in the dorsal vertebræ; and in these bones the neural arch is very high, and greatly expanded, and its bases extend transversely inwards, and join each other below the spinal canal, forming a ring, or bony channel, to contain the spinal chord. [645] "The transverse processes are straight, and very long in the vertebræ from the middle of the trunk, indicating a considerable expanse of the abdominal cavity, adapted for the lodgment of the capacious viscera of a herbivorous quadruped." (*Owen.*) The spinous processes (*Lign.* 206, *fig.* 3, *d*) are large and of great height in the anterior caudal vertebræ, *Lign.* 224; and here the chevrons, or hæmapophyses (*Lign.* 224, *b*, and *Lign.* 206, *fig.* 2, and *fig.* 3, *f*), are also of considerable length; the bases of the latter are always united (*Lign.* 206, *fig.* 2, *g*), and often blended, so as to form but one face for articulation with the truncated inferior angles of the body of the vertebra:, leaving a vertically elongated channel for the passage of the large blood-vessels of the tail. The external surface of the vertebræ of the Iguanodon is more or less marked with fine longitudinal striæ; those of the Megalosaurus have a smoother and more polished surface.[646]

[644] A detailed account of the elements of

the spinal column of the Iguanodon, and remarks on various fossil vertebræ, the relations of which with the Iguanodon have been considered doubtful, will be found in *Petrif.* pp. 256-279.

[645] See also lithographs of dorsal and caudal vertebræ from the Kentish Rag; Owen's *Monog. Cret. Rept.* (Pal. Soc.) 1851.

[646] See Rep. Brit Assoc. 1841, pp. 125-133, where an elaborate investigation of the vertebra: of the Iguanodon is given by Professor Owen.

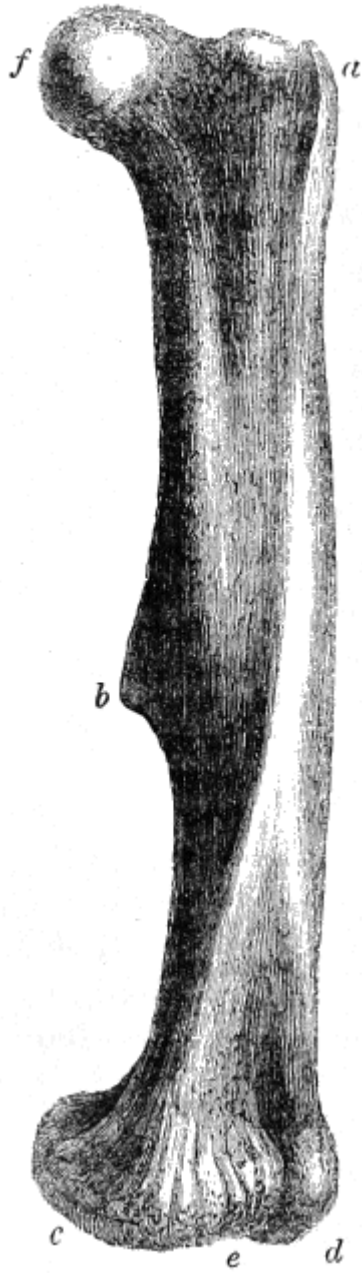


LIGN. 224. SIX CAUDAL VERTEBRA OF THE IGUANODON. $^{1}/_{14}$ *nat. size*. *Wealden. Tilgate Forest.*

a, a. Spinous processes (*neurapophyses*), from 13 to $15^{1}/_{2}$ inches in height.
b, b. Three displaced chevron bones (*hæmapophyses*), imbedded in the stone near their original position at the junction of the bodies of the vertebræ.
c. Anterior articular face of a vertebra.

BONES OF THE EXTREMITIES. *Ligns.* 225 and 226.—The thigh-bone (*femur*), both bones of the leg (*tibia* and *fibula*), and many of the metatarsal and phalangeal bones have been discovered; the osteology of the hinder extremity is, therefore, almost perfect. The thigh-bone (*Lign.* 225; and *Petrif.* p. 292,) is of a very remarkable character, having a closer resemblance to the femur of a huge mammalian, than to that of a reptile.[647] Several perfect specimens have been discovered, as well as the associated bones of the leg (*Petrif.* p. 293, *Lign.* 62); but the first fragment that came under my notice, was the middle portion of the shaft of a femur of enormous size, and of an irregular quadrangular form; and so shapeless and unintelligible it then appeared, that several years elapsed before its real nature was determined. (*Foss. Tilg. For.* pl. xviii.)

[647] See Cuvier's *Ossem. Foss.* vol. ii. p. 36.


f
a
b
c
e
d

LIGN. 225. LEFT FEMUR OF THE IGUANODON.
$^{1}/_{10}$ *nat. size.*
Anterior aspect.
Wealden. Brook Bay, Isle of Wight.
a. Outer trochanter.
b. Median trochanter.
c. Inner condyle.
d. Outer condyle.
e. Anterior infra-condyloid fissure.
f. Head of the femur.

An entire thigh-bone of an adult Iguanodon, from the Weald clay in the west of Sussex, measured three feet eight inches in length.[648] end thirty-five inches in circumference at the condyles; and I have a femur of a very young animal, that is but five inches long. The form of the thigh-bone is so peculiar, that fragments may easily be recognised. The head of the femur (*Lign.* 225, *f*,) is hemispherical, and projects inwards; there is no appearance of a *ligamentum teres*; a flattened process or trochanter (*Lign.* 225, *a*,) forms the external boundary of the neck of the bone, from which it is separated by a deep and narrow vertical fissure; the shaft is of a sub-quadrangular shape, and a slightly elevated ridge, produced by the union of two broad, flat, longitudinal surfaces, extends down the middle of the anterior face, and, diverging towards the inner condyle, gradually disappears. The bone terminates below in two large condyles, separated in front and behind by a deep, narrow cleft, or groove (*Lign.* 225, *e*). Near the middle of the inner edge of the shaft, there is a compressed ridge, with an angular projection, or trochanter. Thus the upper part of the femur maybe known by the presence of the flattened, or laterally compressed trochanter; and if that process be wanting, a fractured surface indicating its position may be detected; the middle of the shaft is characterized by

its broad angular faces, and the inner submedian trochanter: the condyloid or inferior extremity of the bone may be distinguished by the deep groove between the condyles, both in front and behind.

[648] The average length of the adult femur is estimated at about four feet five inches.

The arm-bone (*humerus*) of the Iguanodon has been discovered in the Wealden of the Isle of Wight by Mr. Fowlstone; it is figured and described in *Petrif.* p. 286. The humerus is also present in the Maidstone specimen[649] of Iguanodon, before referred to at page 692: in pl. ii. of *Wond.* this bone is termed the *radius*. The humerus of this reptile is much smaller than the femur; in the Maidstone specimen the former is about 20 inches, and the latter about 33 inches in length.

[649] The two bones marked "6" in pl. ii. *Wond.* and in *Lign.* 65, *Petrif.* (one of which is figured in outline in *Lign.* 226, *fig.* 4,) regarded by Prof. Owen as the *radius* and *ulna* (the two bones of the fore-arm): the author's reasons for regarding these bones as *metacarpals* are given in full at p. 289, *Petrif.*

As separate bones of the feet of the Iguanodon, for example, *metacarpals*, *metatarsals*, *phalangeals*, and *unguals*, often occur in the strata of the Wealden, figures of several specimens, on a reduced scale, are introduced in *Lign.* 226, and may enable the student to identify those he may meet with in his researches. [650] The ungual phalanges, or claw-bones, which were invested with the nail, are sometimes found of an enormous size; from a quarry near Horsham, Mr. Holmes obtained specimens more than five inches

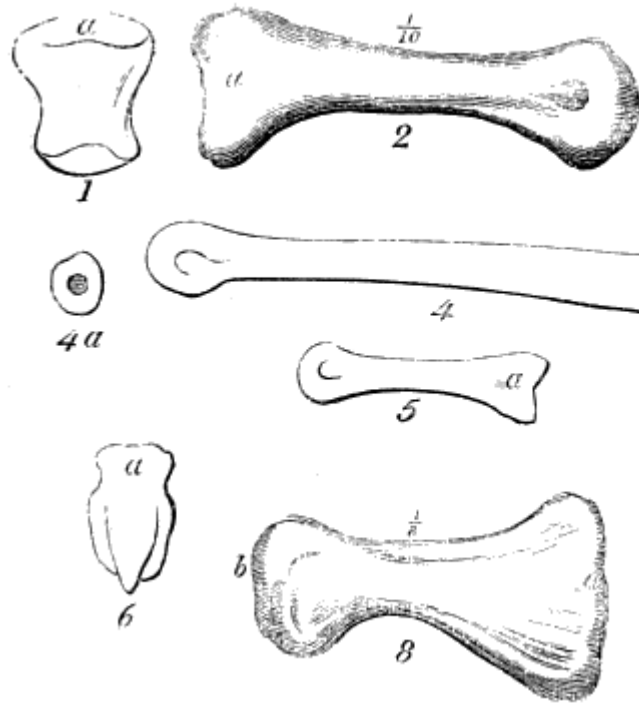
long, and three inches wide at the articular extremity.

[650] See Rep. Brit. Assoc. 1841, pp. 137-142.

LENGTH OF THE IGUANODON.—The length of the united head and trunk, according to my estimate in *Geol. S. E.* p. 316, is seventeen feet and a half; by Professor Owen's estimate it is reduced to fifteen feet;[651] a difference of no importance in such merely approximative calculations, particularly when the form of the cranium is unknown.[652]

[651] Ibid. p. 144.

[652] The more recently discovered specimen of lower-jaw, already referred to, page 693, indicates a length of between three and four feet for the entire jaw, *Petrif.* p. 249.



LIGN. 226. BONES OF THE FEET AND CLAWS OF THE I
Wealden. Tilgate Forest.
(See *Wond.* pl. in.)

Fig. 1.— Metatarsal: original 6 inches long: upper surface.
2.— Metacarpal bone.
3.— Under surface of fig. 1.
4.— A phalangeal bone of the fore-foot: the original 14 inches lor
4*a*.— A transverse section of the same, showing the medullary cavi
5.— One of the second row of phalangeal bones of the fore-foot.
6.— View from above of one of the claw-bones of the hind-foot; 1
7.— Profile of claw-bone of fore-foot:[653] $^1/_6$ *nat.*
8.— Metatarsal, or bone of the hind-foot: $^1/_8$ *nat.*
a. Denotes the proximal articulation, or that nearest the trun
b. The distal, or extremity most distant from the trunk.

[653] This bone is conjecturally referred by Prof. Owen to the Megalosaurus.

The estimated extent of the tail has been subject to variation. My early estimate of its length gave rise to the idea of this reptile having attained seventy feet in length. Professor Owen, however, considered that the abbreviated character of the anterior caudal vertebræ indicated a far less extent of tail, which the Professor estimated at thirteen feet; this opinion, from the evidence then before us, seemed well founded, but from evidence since afforded by a series of eleven caudal vertebra, belonging to the middle region of the tail, that have been lately discovered, (*Petrif.* p. 312,) it is not at all improbable, that, instead of all the caudal vertebræ being abbreviated, these elements of the tail were elongated as in the corresponding part of the skeleton of the Iguana, and that the largest Iguanodons may have attained a length of from sixty to seventy feet.

The author's physiological inferences as to the structure and economy of the Iguanodon, deduced from the study of the osseous remains of this singular creature, especially the lately discovered remains of the jaw-bones, are given in full at pp. 307-313 *Petrif.* or *Foss. Brit. Mus.*: and at pp. 335-338, *ibid.* may be found some general remarks on the physical geography and the nature of the fauna and flora of the country inhabited by these stupendous reptiles, whose remains are so characteristic of the Wealden rocks.

JAW OF THE REGNOSAURUS. (*Petrif.* p. 333.)—A portion of the right ramus, or side, of the lower jaw of this reptile was discovered in a block of sandstone from Tilgate Forest. It consists of a fragment, six inches long, of the dentary bones, with a small portion of the opercular; and it contains the fangs of fifteen teeth, which are closely and evenly set in a

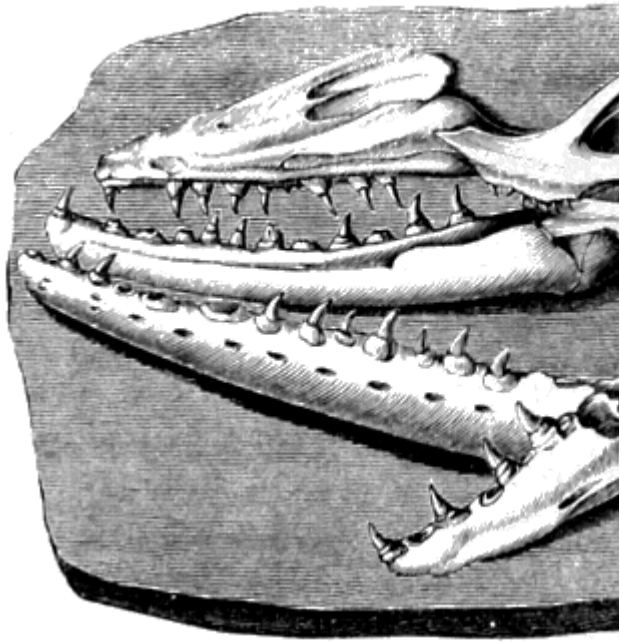
regular series, and imbedded laterally in grooves, or sockets, in the dentary bone; there are three or four sockets of successional teeth on the inner side of the bases of the old teeth. (*Phil. Trans.* 1841, pl. v. figs. 1, 2.) Unfortunately, all the crowns of the teeth are wanting. The outer parapet of the dentary piece is entire, and its upper margin is finely crenated. All the fangs of the teeth are exposed, but there are traces of a thin inner wall, indicating the probability that, as in the Megalosaurus, the teeth were supported medially by an osseous plate, and were implanted in distinct sockets.[654] In my memoir on this fossil jaw in the *Phil. Trans.* (1841, p. 131), I referred it to the genus Iguanodon; but subsequent observations have led me to conclude that it is generically distinct; and in my Memoir on the Jaw of the Iguanodon, in *Phil. Trans.* 1848 (p. 183), I have proposed for the animal to which it belonged the distinct generic appellation, REGNOSAURUS, with the specific name *Northamptoni*.

[654] The collector will perceive the importance that attaches to the discovery of even a fragment of the jaw of an unknown reptile, containing teeth in their natural position.

LACERTIAN REPTILES.

IV. LACERTIAN REPTILES.—The recent Lacertians, or true Lizards, are smaller and less highly organized reptiles than the Saurians of the Crocodilian order; and their dermal covering consists of a finer and more delicate squamous integument. They are also characterized by important modification in their osteological structure. The spinal column is almost always composed of concavo-convex vertebræ, with the convexity behind; the ribs are slender and

rounded, having a single convex tubercle of attachment. The fossil species are, for the most part, of gigantic dimensions, and deviate in a striking manner from any that now exist. Vertebræ of the recent lacertian type are very rare in the secondary strata; I believe a few in my cabinet, obtained from the sandstone of Tilgate Forest, and which belonged to a very small unknown reptile, are the most ancient examples at present known.



LIGN. 227. MOSASAURUS HOFFMAN
(*The original is feet by $2^{1}/_{2}$ feet.*)
Remains of the jaws of the great fossil reptile

MOSASAURUS. *Bd.* pl. xx.; *Wond.* p. 311; *Petrif.* p. 193.—Of the fossil lizard of Maestricht, named *Mosasaurus* (lizard of the Meuse) from the river adjacent to the quarries of St. Peter's Mountain, in

which its remains have been discovered, I have given a detailed account at pages 193-196 of *Petrif.* A specimen, with the jaws, and bones of the palate armed with teeth, now in the museum at Paris, has long been celebrated, and is still the most precious relic of this extinct reptile hitherto discovered; a reduced representation is given in *Lign.* 227; and *Pict. Atlas*, pl. lxx. This is the *Mosasaurus Hoffmanni*.[655] The specimen is four and a half feet long, and two and a half feet wide; it consists of both sides of the lower jaw, with the right ramus of the upper jaw in its natural position, and the left, which is displaced, lying across the articular extremity of the left branch of the lower jaw: of the pterygoid bones, which are armed with teeth; of the left tympanic bone (*os quadratum*), which is but little removed from its natural situation, and connects the lower jaw with the cranium; one of the metacarpal or metatarsal bones, and some fragments.[656]

[655] Several fine portions of the jaws, and many vertebræ of this animal, are in the British Museum: see *Foss. Brit. Mus.* p. 139. In a splendid work, *Histoire Naturelle de la Montagne de St. Pierre*, by the late Faujas St. Fond (1 vol. folio, with numerous plates), there are admirable figures of the remains of the Mosasaurus.

[656] In the British Museum there is a cast of this specimen, in a case near the bones of the Iguanodon.



LIGN. 228. MOSASAUROID TEETH.[657]
$^1/_2$ *nat. size.*

Figs1*a*, 2*a*. Transverse sections of the crowns of the teeth, figs. 1 and 2 respectively.

[657] Reduced from figures accompanying Dr. Gibbes's Memoir "On the Mosasaurus and three allied new genera," (with plates,) in the *Smithsonian Contributions*, vol. ii. 1849. This interesting paper comprises much information regarding the Mosasaurians of the Cretaceous deposits of N. America; but we cannot fully coincide with the author in his palæontological determinations.

The teeth are large, and supported on expanded conical osseous eminences, which are anchylosed to the alveolar ridge of the jaw (*acrodont*). The crown of the tooth is conical and recurved, with the outer face nearly flat, and this space is bordered on each side

by a longitudinal ridge; giving the tooth somewhat of a pyramidal figure. (See *Ligns.* 228-230.) Professor Owen states that the crown consists of a body of simple and firm dentine, with fine and close-set calcigerous tubes, enclosing a simple pulp-cavity; irregular processes of the latter extend as medullary canals into the conical base of the tooth, but not, as in the Iguanodon, into the substance of the coronal dentine; the dentine is invested with a moderately thick coat of enamel.[658]

[658] See Odontography, p. 258, and pl. lxxii.; the student should also consult Cyclop. Anat. Phys. *Art.* TEETH.

The vertebræ of the Mosasaur, as is usual in the existing lizards and crocodiles, are concave in front and convex behind, and the neural arch is united to the centrum by suture. The entire vertebral column of *M. Hoffmanni* appears to have consisted of 131 vertebræ, of which 97 belonged to the tail.[659] This Mosasaur was about twenty-five feet long.

[659] See Cuvier, *Oss. Foss.* vol. v. pp. 326-334.



LIGN. 229. TOOTH OF MOSASAURUS: *magn. twice.*
Either a pterygoid tooth of M. Hoffmanni, or a jaw-tooth of

M. gracilis.
Chalk. Gravesend.
(In Mr. Wetherell's Collection.)

This extinct lacertian reptile forms an intermediate link between the Saurians without pterygoid teeth (Monitors) and those with them (Iguanas). Its crocodilian affinities are but partial.

The Mosasaurus appears to have had webbed feet, adapted or crawling on land as well as for swimming,[660] and a long and vertically expanded tail, serving as a powerful oar, and enabling the animal to stem the roughest waters.

[660] See Prof. Owen's observations on the bones that have been regarded as referable to the extremities of this creature, and especially on the phalangeal and other bones of the Mosasaur of the New Jersey greensand; *Monog. Cret. Rept.* 1851, pp. 36-40.

Prof. Goldfuss has described the remains of another and smaller species of Mosasaurus (*M. Maximiliani*), from Upper Missouri, U.S.; and Prof. Owen, in Dixon's "Fossils of Sussex," has established a third and still smaller species (*M. gracilis*),[661] to which he refers the four or five mosasaurian vertebræ found in the Chalk of Sussex. Two of these (caudal) are figured in *Geol. S. E.* p. 146, and *Petrif. Lign.* 44; and these and others are lithographed in plate viii. of Prof. Owen's *Monog. Cret. Reptilia*, 1851.

[661] See also *Monograph on the Reptiles of the Chalk*, 1851, p. 31, and plate ix.

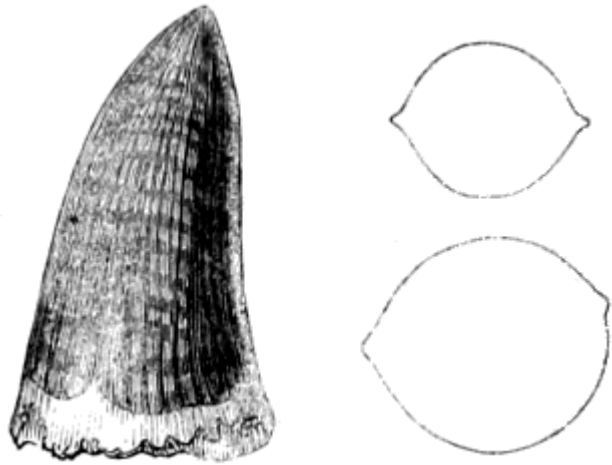
The remains of Mosasaurus occur also in the cretaceous sands of New Jersey, U. S. (See Dr. Morton's *Synopsis of the Organic Remains of the United States*, 1834; and the Quart. Journ. of the Geological Society, vol. v. 1849.)

LEIODON ANCEPS.[662]—Under this name Professor Owen has described a splendid fossil, consisting of a portion of the lower jaw of an acrodont reptile, with teeth, obtained by Edward Charlesworth, Esq. from the Chalk north of the Thames. This specimen was submitted to my inspection, many years since, by Mr. Charlesworth, and I then pointed out the analogy of this acrodont jaw to that of the Mosasaurus.

[662] Ibid. p. 42, pl. ix. A.

Prof. Owen in 1840 (*Odontog.* p. 261), and in 1841 (*Rep. Brit. Assoc.* p. 144), described and figured some teeth from the same specimen, which were lent by Mr. Charlesworth. These teeth the Hunterian Professor regarded as characteristic of a new genus of Mosasauroid reptile, to which he gave the name *Leiodon* (in allusion to the smoothness of the teeth). In 1845 (*Rep. Brit. Assoc.* p. 60) Mr. Charlesworth noticed, and in 1846 (*London Geol. Journal*, p. 23, plates iv. and vi.) figured and described, the above mentioned portion of jaw with teeth, under the name *Mosasaurus stenodon*; and in 1851 Prof. Owen figured and described this specimen under the name of *Leiodon anceps*, which was originally proposed for the animal, as known from its teeth, in 1840.

The portion of bone on which the teeth, five in number are implanted is seven inches in length, and is, in Professor Owen s opinion, the dentary piece of the lower jaw, and not a portion of a pterygoid bone. Mr. Charlesworth has had a section made of four of the teeth, and finds that the pulp-cavities are more or less occupied with solid cones of silex, which must have permeated the osseous parietes of the teeth.



LIGN. 230. MOSASAUROID TOOTH.
Resembling the back-teeth in the lower jaw of Mosasaurus Hoffmani
Chalk. Gravesend.
(In the Collection of Mr. Wetherell.)

The teeth of Leiodon have a simple pulp-cavity, surrounded by fine dentine, with an external layer of smooth enamel. The apex of the crown is sharp-pointed; the body of the crown is slightly recurved; its base is expanded into a thick circular fang, which is anchylosed to a short conical process of the alveolar border of the jaw: the teeth differ from those of the Mosasaurus in having the outer side as convex as the inner side, the transverse section being an ellipse with pointed ends, which latter correspond with the lateral trenchant edges of the crown of the tooth: the teeth are more closely set than in the Mosasaur and Geosaur. (*Owen.*)

GEOSAURUS SŒMMERINGII. *Petrif.* p. 175.—In the British Museum are the remains of a reptile from the "white Jura" (upper oolite) of Monheim, in Franconia, which Cuvier describes as being more

nearly related to the Lizards than Crocodiles. The length of this reptile is estimated at about ten feet. The eyes had a circle of osseous plates in the *sclerotica*, like those of the Ichthyosaurus; the teeth resemble those of the Mosasaurus in being sub-compressed and recurved, but they are at once distinguished by their anterior and posterior finely serrated sharp edges; the crown is invested with an external coat of enamel.[663]

[663] Oss. Foss. tom. v. p. 343.

RAPHIOSAURUS SUBULIDENS.—A portion of a lower jaw, containing twenty-two closely set, subulate teeth, anchylosed by their bases to a shallow alveolar groove and an outer alveolar parapet of bone, as in the Iguana, thus corresponding with the pleurodont Lizards, is described under this name by Professor Owen, (*Geol. Trans.* 2d ser. vol. vi. pl. xxxix.); and *Monog. Cret. Rept.* (Pal. Soc.) 1851, p. 19, pl. x. figs. 5, 6. It is from the Lower Chalk, near Cambridge, and is in the collection of James Carter, Esq. of that place. Remains of Raphiosaurus have been found also in the Chalk at Northfleet, Kent.

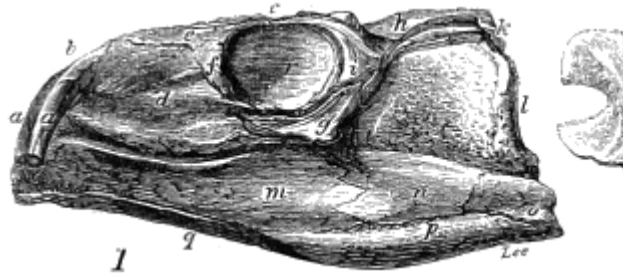
DOLICHOSAURUS LONGICOLLIS.—In the Chalk of Kent was found, some years since, a considerable portion of the skeleton of a lacertian reptile, consisting of the posterior half of the spinal column, with remains of the pelvic and thigh bones; it was figured in the *Geol. Trans.* 2d ser. vol. vi. pl. xxxix.; and is now in the collection of Sir P. G. Egerton. From the researches of the late Mr. Dixon, it appears that a mutilated reptilian head and anterior portion of a spinal column, with fore-arm and scapular bones, now in the collection of Mr. Smith, of Tunbridge Wells, belong to the same skeleton as the

vertebral remains above mentioned. Both specimens were obtained at the same time from the well-known chalk-pit at Burham, Kent. Professor Owen has lately described these interesting remains in detail (*Monog. Cret. Rept.* 1851, pp. 22, &c.), and finds no intrinsic contradiction to exist to the historical evidence adduced as to the probability of the two moieties having belonged to the same individual. In the two specimens there exist sixty-three concavo-convex (*procœlian*) vertebræ, of which fifty-seven form the series between the skull and the pelvis, giving the trunk a length of about eighteen inches. This unique reptile was elongate and snake-like in its form, with the abdomen deep and narrow, like that of the water-snakes: its limbs were short; its tail, from the character of the few caudal vertebræ remaining, must have been relatively long and powerful. This long and slender lacertian was therefore probably to a considerable degree aquatic in its habits, swimming with an undulatory eel-like movement.

The Dolichosaurus (*long-lizard*) presents somewhat of the ophidian character in the number and size of its cervical vertebræ, in the size and shape of its ribs, and in the slender proportions of its trunk and head; but, with these partial exceptions, its affinities are truly lacertian. (Owen.)

RHYNCHOSAURUS ARTICEPS. *Lign.* 231.—In a quarry of Upper New Red Sandstone at Grinsell, near Shrewsbury, Dr. O. Ward discovered a skull ($3^1/_2$ inches long), vertebræ, ribs, bones of the pectoral and pelvic arches, portions of two femora with medullary cavities, and fragments of other bones of a very remarkable lacertian reptile (*Lign.* 231). The lower jaw is preserved with the skull in its natural position. The cranium in its general aspect resembles

that of a turtle, rather than of a lizard; for the intermaxillary bones are double, as in Chelonians, and symmetrical, and are not united by a median process; they are very long, and curve downwards, giving the fore part of the skull the profile of a parrot. See *Lign.* 231.



LIGN. 231. RHYNCHOSAURUS ARTICEPS. *New Red Sandstone;* 1
Fig. 1.—Lateral view of the cranium and lower jaw: 1/

CRANIUM. LOWER JAW.

a, Intermaxillary bones.
a. Intermaxillary bones.
b. Nasal.
c. Frontal.
d. Maxillary.
e. Anterior frontal.
f. Lachrymal.
g. Malar.
h. Posterior frontal.
i. Orbital division of posterior frontal.
k. Temporal.
l. Tympanic.
m. Dentary.
n. Coronoid.
o. Articular.
p. Angular.
q. Opercular or splenial.
r. The orbit.

Fig. 2.—The upper aspect of a dorsal vertebra: *nat. size*.

There are no teeth apparent in either jaw: the margin of the upper maxillary has feeble dentations, but in the lower jaw even these indications are wanting, and it is probable that this reptile had its jaws encased by a bony or horny sheath, as in birds and turtles.[664] (Owen.)

[664] Rep. Brit. Assoc. 1841, p. 150. See also Camb. Phil. Trans, vol. vii. p. 357, tab. 5, 6.

THECODONTOSAURUS AND PALÆOSAURUS. *Ly*. p. 306, figs. 348, 349.—Numerous bones and teeth of reptiles occur in the Magnesian Conglomerate, near Bristol, and have been described by Dr. Riley and Mr. Stutchbury in an interesting memoir to which reference should be made for details (*Geol. Trans.* 2d ser. vol. v. p. 349, pl. xxix. xxx.). The bones denote an approach to the lizards; the teeth are implanted in sockets; these reptiles, therefore, belonged to the group termed thecodont, and the name *Thecodontosaurus*, given to these extinct Saurians by Dr. Riley, has reference to this character. The teeth are pointed, compressed laterally, slightly convex on each side, with a trenchant, finely serrated edge in front and behind; the fang is sub-cylindrical. Other teeth from the same deposit, possessing the same general characters, but distinguished by peculiarities of form, have been referred to another genus, named *Palæosaurus*. The vertebræ found associated with the teeth and jaws are biconcave, and are remarkably characterized by the great depth of the spinal canal in the middle of the centrum or body of the vertebræ, so that the spinal chord must have

presented a moniliform or bead-like appearance. These reptiles, in their *thecodont* type of dentition, biconcave vertebræ, double-headed ribs, and proportionate size of the bones of the extremities, are nearly allied to the *Teleosaurus*, (see *ante*, p. 679); but they combine a lacertian form of tooth, and a lacertian structure of the pectoral, and probably of the pelvic arches, with these crocodilian characters; they have also distinctive modifications: such, for example, as the moniliform spinal chord.[665]

[665] Owen; Rep. Brit. Assoc. 1841, p. 155, &c.

DICYNODON. *Ligns.* 232, 233, 234.—This singular fossil reptile was discovered, by Mr. Bain, in South Africa. It is distinguished, by some remarkable peculiarities of structure, from other animals of the Saurian order; of which it represents a new tribe, or sub-order. The cranium is narrow; the nostrils are divided, as in Lizards, and not confluent, as in Chelonia; the skull, in other respects, much resembles in general appearance that of a Turtle; the orbits are large; the jaws are edentulous, as in the Turtles, with the exception of a pair of long tusks, [666] implanted in sockets in the upper maxillary bone, like those of the Walrus; these tusks are of a finer texture than that of the Crocodile's teeth, and almost as dense as in the Hyæna. These creatures present in the most striking manner that blending of the peculiarities of several existing orders, which is continually presented to the palæontologist; for with a type essentially lacertian are combined crocodilian and chelonian modifications. Although no vestiges of these reptiles have been discovered in England or in Europe, yet the occurrence of an allied form, the *Rhynchosaurus* (*Lign.* 231), in our New Red

Sandstone, and the probability that the South African reptiliferous deposits may, from their position, belong to the Triassic Epoch, induce me to give a somewhat extended notice of these extraordinary fossils: and I am led to do so on another account, namely, because the memoir,[667] of which the following is a brief abstract, is so excellent an example of the manner in which such investigations should be conducted, so as to arrive at any satisfactory conclusions as to the characters and relations of the lost types of beings, whose fragmentary and petrified relics are the only vestiges that remain.

[666] Hence the generic name, *Dicynodon*: from δις (twice), and κυνὸδονς (canine tooth).

[667] Prof. Owen's Memoir on the Dicynodon, Geol. Trans. 2d ser. vol. vii. pp. 59, *et seq.*; and plates iii. to vi.

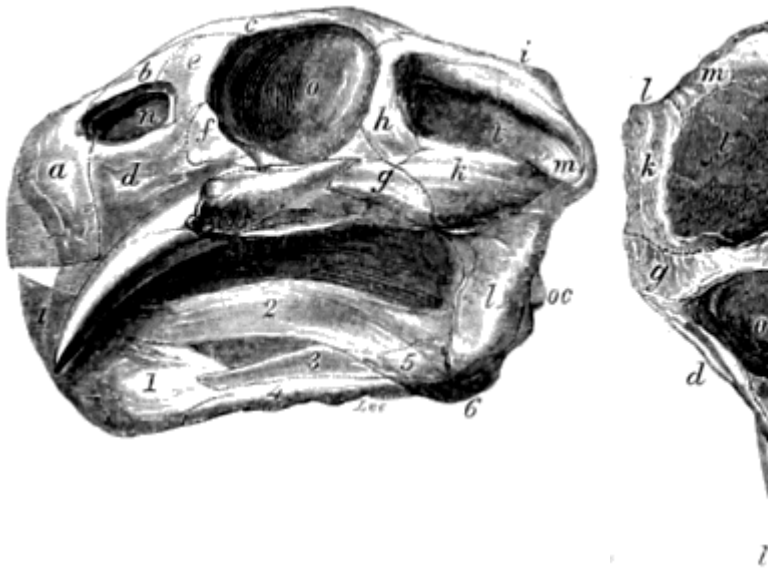
The fossils under consideration were exhumed some years since by Mr. Andrew Geddes Bain, from the intensely hard argillo-calcareous nodules of the sandstone strata which range over an immense tract of country beyond the mountains north of Capetown, [668] The extensive series of these and other fossils from South Africa, collected by the indefatigable labour of Mr. Bain, have lately been deposited in the British Museum; but the specimens described and figured in Prof. Owen's Memoir, above alluded to, are nearly all that have as yet been successfully worked out from the exceedingly hard matrix in which the bones are imbedded. These consist of crania and jaws, referable to four species.[669]

[668] For a notice of the geological structure of this region, see Mr. Bain's paper in Geol. Trans. 2d ser. vol. vii. pp. 53, &c.; and

the abstract of a later Memoir by Mr. Bain, in the Literary Gazette, Dec. 18, 1852 (No. 1874).

[669] Namely, Dicynodon lacerticeps (*lizard-head*), D. testudiceps (*turtle-bead*), and D. strigiceps (*owl-head*), the trivial names of which have reference to the general form of the head; and D. Bainii, the largest, but unfortunately as yet the least known species, which takes the name of the intelligent and energetic discoverer and collector of the whole.

LIGN. 232.



LIGN. 232 and LIGN. 233. DICYNODON LACERTICE
South Africa.
(*See Geol. Trans. 2d ser. vol. vii. pl. iii.*)
The letters of reference correspond in the two fi

LIGN. 232. Side view of the Cranium and Lower Jaw
LIGN. 233. Upper aspect of the Cranium: $^{1}/_{3}$ *n*

Cranium and Upper Jaw. Lower Jaw.

a, a. Intermaxillary bone.
b, b. Nasal.
c, c. Frontal.
d, d. Maxillary.
e, e. Prefrontal.
f, f. Lachrymal.
g, g. Malar.
h, h. Post-frontal.
i, i. Parietal.
k, k. Temporal.
l, l. Tympanic.
m, m. Mastoid.
n, n. Nasal apertures.
o, o. Orbits.
oc, oc. Basi-occipital.
t, t. Temporal fossæ.
t′, t′. Canine teeth in the upper jaw.

1. Dentary bone.
2. Coronoid.
3. Opercular.
4. Angular.
5. Articular.
6. Surangular.

The most striking character in these crania is the presence of a pair of long, sharp-pointed, gently curved tusks, implanted in the superior maxillary bones, and which descend, one on each side of the

fore-part of the lower jaw, as seen in *Ligns.* 232 and 233, *t*, *t′*. This is a dental character which, with this exception, is peculiar to the mammalia (the Walrus, Musk-deer, and Machairodus), and is rare even in that class.

Examination of the skull.—One of the crania showed the median undivided process of a single *intermaxillary* bone, ascending and separating *two distinct anterior nasal apertures*; in another, the boundaries of a very much contracted cranial cavity were evident: these characters combined to prove that the skulls were referable to air-breathing oviparous and cold-blooded animals, or Reptiles; but neither to Crocodilians nor Chelonians, and for the following reasons:—

1stly. The originals were not mammalians; for no mammalian has the *intermaxillary bone single* (as in *Lign.* 233, *a*), or the *external bony nasal aperture double*; and neither mammalian nor bird has the cavity for the brain so relatively small as in this fossil.

2dly. They were not Crocodiles; for in all crocodiles the intermaxillary bone is divided by a suture, and the anterior nasal aperture is single and on the median line, as in mammalia.

3dly. They were not Chelonians; for all turtles have the nasal opening single and placed in the middle of the fore-part of the skull, in the very situation which, in the Dicynodon, is occupied by the convex imperforate median plate of the broad intermaxillary bone.

4thly. They could not be Fishes, as those animals have no well-defined external respiratory nasal

apertures.

5thly. They were neither Batrachians (frogs) nor Ophidians (serpents); for, although the reptiles of these two orders have a single intermaxillary and double nostrils, like the fossils, the latter are at once separated from them by the presence of a strong and complete zygomatic arch (*Ligns.* 232 and 233, *g*, *d*), continued from the tympanic bone to the large immovably articulated superior maxillary.

Lastly, the characters last named, and the presence of vertical tympanic pedicles (*Lign.* 232, *l*), suspended by their upper part to the junction of the zygomatic and mastoid bones, prove the affinity to the lacertians or true lizards.

These bidental crania have certain characters in common with that of the Rhynchosaur, which is also, as we have before seen, of the true lacertian group, but the Dicynodonts are more nearly allied to the Crocodiles and the Chelonians than the Rhynchosaurus appears to be.

Referring to the original Memoir for anatomical details, I must limit this notice to a few additional general remarks. Both the jaws are edentulous, with the exception of the pair of tusks, as in Chelonians; there are no traces of teeth, or of their sockets, in the lower jaw, which is short and very deep, and anchylosed at the symphysis, as in turtles; the alveolar border forms a smooth trenchant edge, which shuts within the corresponding part of the upper jaw: it is probable that both jaws were covered by horn, as in the chelonians. The tusks are implanted in wide and deep conical alveoli in the suborbital part of the maxillary bone, and project about two inches beyond the sockets (*Lign.* 232);

they are long and pointed, and are directed downwards and forwards, with a slight backward curve, and slightly converge towards their extreme points (*Lign.* 233). These teeth consist of a simple body of unvascular dentine, with a very thin external coat of enamel. The tooth-ivory is more dense than in any known reptile, and approaches in its intimate texture that of the canines of the carnivorous mammals. The base of the tooth has a conical cavity (*Lign.* 234), indicating a persistent matrix or dental pulp, the rest of the tooth without the socket being solid. There are no traces whatever of the germs of successional teeth. It is therefore inferred, that, like the tusks and scalpriform incisors of mammalia, the canine or maxillary teeth of the Dicynodon were capable of constant growth and renovation; thus offering an approach to the typical dentition of mammalia, unknown in any other reptiles.

As the points of the teeth in the only known perfect specimen are unworn, it is inferred that these tusks were not employed either as instruments for obtaining food, as in the Dugong, or for locomotion, as in the Walrus, but were simply offensive and defensive weapons.[670]

[670] See Prof. Owen's detailed account of these curious dental organs in the Memoir already referred to, and in the *Art.* TEETH, in the Cyclopædia of Anatomy and Physiology.



LIGN. 234.
DICYNODON TESTUDICEPS. (Owen.)
(Geol. Trans. 2d ser. vol. vii. pl. v. figs. 3 & 4.)
Fig. 1. Longitudinal section of the fang of the tooth implanted in its socket: $^1/_3$ *nat. size.*
1*a*. Transverse section of the tooth.

A few sub-biconcave vertebræ and other undetermined bones were associated with these remains; and many similar crania, both with and without the tusks, and other cranial remains with jaws armed with numerous teeth, as well as indications of smaller reptiles, form part of Mr. Bain's collections now in the National Museum, awaiting the skilful manipulation of the experienced workman to clear away their hard investing matrix, and the scientific examination of the palæontologist to elucidate their zoological characters.

TELERPETON ELGINENSE (MANTELL). *Ligns.* 235 and 236.—This is the oldest Reptile yet known.[671] Its remains consist of the impression[672] of a skeleton of a small, four-footed, vertebrate animal, on a block of the Old Red or Devonian Sandstone

from Spynie, near Elgin, North Britain. It was obtained by Mr. Patrick Duff, in 1851; and a detailed description of this unique fossil, with an illustrative plate, will be found in the Quarterly Journal of the Geological Society, vol. viii. pp. 100, *et seq.*; together with a notice by Captain Brickenden of the geology of the district where the specimen was found, and a paper on some fossil foot-prints,[673] discovered by this geologist in the same rock.

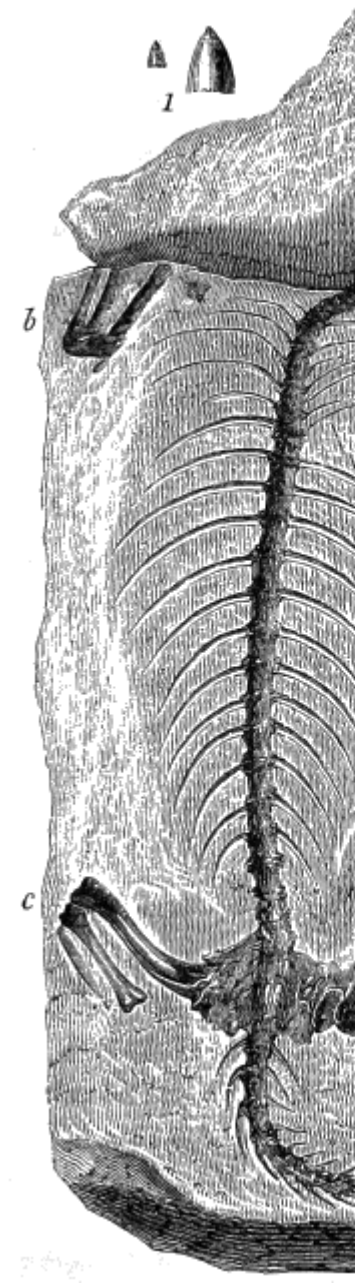
[671] The word TELERPETON simply denotes the remote antiquity of this Devonian reptile of Scotland, τήλε (far off), ἑρπετον (reptile); the trivial name, *Elginense*, records the locality from whence it was obtained.

[672] A model of this most delicate and valuable impression has been deposited in the palæontological gallery of the British Museum.

[673] A general notice of the fossil foot-prints, or *Ichnolites*, that have been referred to Reptiles will be given at a subsequent page of this chapter.

By reference to *Lign.* 235, it will be seen that the cranium is almost wholly lost; a few conical teeth, mostly of a very small size, were observed in connexion with the vestige of the jaws. The spinal column is represented by the impressions of about thirty-six vertebræ, eleven or twelve of which belong to its caudal portion. The vertebræ present some faint evidence of their possessing a biconcave form; the length of one of the dorsal vertebræ is $^{1}/_{9}$th of an inch. There are twenty-one pairs of long slender ribs. The pectoral arch and anterior extremities have nearly disappeared in the fracture of the stone. The pelvis and sacrum are very obscure; the latter is formed probably of two anchylosed vertebra;. The

thigh-bones are somewhat curved; the tibia is gently bowed, and expanded at each extremity. There are no remains of the feet.


1
b
c

LIGN. 235. TELERPETON ELGINENS

Impression of the skeleton (*nat. size*); showing the outline of the verteb
caudal series of vertebræ, the left humerus, radius, and ulna, impr
indications of part of t

a. The remains of the cranium.

b, b. Imprints of portions of the anterior extremities.

c, c. Well-defined impressions of the thigh-bones and leg-bones, with a

1. One of the teeth: *nat. size* and *mag.*

The structure of this reptilian skeleton, as far as the specimen can serve to show, indicates a peculiar type of organization, in which, as in numerous other extinct forms, in this, as in other Classes, osteological characters are associated which in existing oviparous quadrupeds are restricted to distinct orders and genera.



LIGN. 236.
TELERPETON ELGINENSE (MANTELL).
Outline of the restored form of the original reptile: $^1/_2$ *nat.*

The *lacertian* affinities of the Telerpeton are well marked in the relative size and form of the bones of its extremities, the situation of its pelvis, and probably in the articulation and the length of its ribs; but the contracted, biconcave centrum, and the short neural spine of the vertebræ, as well as the horizontality of the articulating surfaces of the zygapophyses, and the general uniformity of character throughout the spinal column, are to be regarded as *batrachian* modifications. Probably the original was a peculiar type, which, in the present

state of our knowledge, it would be rash to ascribe to either order. The length of the original animal could not have exceeded six or seven inches. *Lign.* 236 represents in outline the probable form of this small, but most interesting reptile.

V. PTEROSAURIANS, OR FLYING REPTILES.—PTERODACTYLUS (*wing-fingered reptile*). *Lign.* 237. *Petrif.* p. 187; *Wond.* p. 577; *Bd.* pl. xxi. xxii.—The extinct reptiles denominated Pterodactyles, constituting a few genera of an order of Saurians organized for aërial life,[674] are unquestionably the most marvellous even of the wonderful beings which the relics of the Age of Reptiles have enabled the palæontologist to reconstruct. With a long-snouted head and long neck, much resembling that of a bird, bat-like wings, and a small trunk and tail, with lacertian affinities in its skull, teeth, and skeleton, and with a bird-like structure of sternum and scapular arch, these creatures present an anomaly of structure as unlike their fossil contemporaries, as is the duck-billed Ornithorhynchus, of Australia, to existing animals. The cranium, or brain-case, is small; the jaws are either long, and armed with numerous sharp-pointed teeth, or toothless, like those of a bird. The teeth of the Pterodactyle are all laniary; they are simple, of a conical form, recurved, with but little difference in their form and size, and implanted in distinct sockets, with wide intervals between each. In some species there are twenty-eight or thirty in the lower, and twenty-two in the upper jaw.

[674] The only known recent reptile at all analogous is the little *Draco volans* of the East Indian Islands; but even this can scarcely be regarded as a flying animal, its lateral

> membranous expansions, which are rather parachutes than wings, and formed by elongated ribs, not by the fingers, presenting but a rudimentary condition of wings compared with those of the Bat and the Pterodactyle.

The orbit is very large; the sclerotica consists of an annular row of bony plates, but less in number than in the Ichthyosaurus; the external orifice of the nostrils is near the orbits; remains of the *os hyoides* (bone of the tongue) have been observed.



LIGN. 237. PTERODACTYLUS CRASSIROSTRIS:

Oolite. Solenhofen.

The cervical vertebræ are large and strong, and capable of great flexibility forwards and backwards, probably to allow the head to fall back to the centre of gravity during flight. There are frequently traces of ossified condition of the tendons of the muscles of the neck. This is well seen in *P. macronyx* and *P. crassirostris* (*Lign.* 237), and is a peculiarity dependent on the additional support required by the long neck of the animal.

The dorsal vertebræ are from seventeen to twenty in number. The sacrum is formed by the coalescence of two vertebræ only, as in existing reptiles, and not of many, as in birds and certain extinct saurians. The tail is generally short, an unusual character with saurians; but a species with a long tail occurs at Solenhofen.

There are five toes or digits on each foot; the outer finger of the fore-arm is immensely elongated, for the support of a membranous expansion (the impression of this wing-membrane is preserved on the stone in some examples); and the other digits, of fore and hind feet, terminated in long curved claws. The size and form of the extremities show that the *Pterodactylus* was capable of perching on trees, of hanging against perpendicular surfaces, and of standing firmly on the ground, when, with its wings folded, it might crawl on all-fours, and walk or hop like a bird. A reference to the graphic description of the characters and probable habits of these beings, by Dr. Buckland, *Bd.* i. p. 221, and the beautiful illustrations accompanying it (*Bd.* ii. pl. xxi. xxii.), will equally instruct and gratify the reader.

The most perfect examples of the *Pterodactyles*

have been discovered in the lithographic stone of Monheim, Pappenheim, and Solenhofen, where their bones are associated with the remains of *Dragon-flies* (see p. 551) and other insects. In England, bones of these reptiles have been obtained from the Lias of Lyme Regis, from the Oolitic slate of Stonesfield, from the Wealden strata of Tilgate Forest, and the Chalk of Kent.[675] One of the most interesting British specimens consists of a considerable part of the skeleton of a species about the size of a Raven, discovered by the late Mary Anning, in the Lias of Lyme Regis, and now deposited in the British Museum.[676] It consists of the principal bones of the extremities, and of several vertebra:, and is figured and described by Dr. Buckland, *Geol. Trans.* 2d ser. vol. iii. pl. xxvii. This specimen is distinguished by a greater length of the claws (whence the name of the species, *P. macronyx*, *long-claw*,) than in any previously known.

[675] For a detailed description of the Pterosaurian remains from the English Chalk, with numerous beautiful illustrations, see Prof. Owen s *Monograph*, published by the Palæontographical Society, 1851. Other important memoirs on Pterodactyles and their structure, not mentioned in the text, are, by Von Meyer, in *Nova Acta Acad. Nat. Curios.* vol. xv. part ii. and *Palæontographica*, part i. 1846; Goldfuss, *Nova Acta*, vol. xv. part i., and *Reptilien der Vorwelt*, 1831; Prof. Owen *Quart. Journ. Geol. Soc.* vol. iii. and Mr. Bowerbank, *ibid.* vol. iv.

[676] See *Petrif.* p. 189.

The remains of the Pterodactyles of the Chalk, for the most part, indicate a large size for the original animals. It has been estimated that some of these

gigantic flying reptiles possessed an extent of wing surpassing that of the great albatross. The *Pterodactylus Cuvieri* had probably an expanse of wing not less than eighteen feet from tip to tip; another Chalk species, *P. compressirostris*, fifteen feet; whilst the *P. macronyx*, of the Lias, measured about four feet seven inches from the extremity of one wing to that of the other.[677]

[677] Bowerbank, *Rep. Brit. Assoc.* 1851, and Owen, *Monograph*, p. 104.

CHELONIANS.

VI. CHELONIAN REPTILES.—Those singular reptiles, commonly known by the name of Tortoises and Turtles, and designated by naturalists CHELONIA (from *Chelone*, the Greek term for a Tortoise), are distinguished from all other animals by the osseous cuirass in which their bodies are enclosed, the head and neck, extremities, and tail, alone being excluded. This remarkable bony case is produced by the extraordinary development of the bones of the thorax and back; and consists of an under (*sternal*) and an upper (*dorsal*) portion. The breast-plate, or *plastron*, which is the true sternum, is composed of nine pieces of bone, eight of which are in pairs, and the ninth, or odd plate, is situated between the four anterior plates. The variation in the form of these plates is considerable, and affords important distinctive characters. In the young state of land and fresh-water tortoises, there are vacancies between the pieces, which are filled up in the adult, the whole being ultimately united into one bony plate; but in the marine turtles (and also in the *Trionyces*, or soft tortoises), these pieces do not completely unite, and interspaces always remain. The bones of which the dorsal buckler, *carapace*, or upper shield is composed

consist of eight of the ten pairs of ribs, united by a longitudinal series of angular plates, which are attached to the annular part of the vertebra throughout the whole, or a great part of their length, according to the age and species of the individual. [678] Numerous modifications exist in the form of the buckler, in its flatness or convexity, in the degree of extension of the ribs, and their angular plates, and in the characters of the scutes or horny integument with which the carapace is covered; and with corresponding variations in the head, and in the locomotive extremities, in the numerous species and genera of the Chelonian reptiles, according to their adaptation to a terrestrial, fluviatile, or marine existence.

> [678] In the Monograph on Eocene Reptiles, 1849, Prof. Owen has given a succinct account of the carapace and plastron of the *Chelone*, and a brief notice of the composition and homologies of these bony encasements in the Tortoise, with references to more particular and comprehensive memoirs by himself and others.

The animals of this order are arranged in four principal groups, viz. the marine, or Turtles (*Chelones*); the fluviatile, or river-Tortoises (*Trionyces*); the marsh-Tortoises (*Emydes*); and the terrestrial or land-Tortoises (*Testudines*). The marine Chelonians generally feed upon vegetables; the *Emys* and *Trionyx* approach more nearly to the terrestrial than to the marine species; they are carnivorous, feeding on frogs, fishes, fresh-water mollusca, and other small animals. The *Trionyces* differ from their congeners in being destitute of a horny external integument, having no scutes on the buckler or any other part of the body but the osseous carapace is

invested with a strong tough skin, which equally covers the dorsum and sternum, to which it firmly adheres; the dermal surface of the bones in these Tortoises is always rugose, and either granulated, or covered with punctations and depressions. The buckler of the Trionyces is of a depressed form, with a soft flattened margin. The Testudinidæ, or land-Tortoises, are too well known to render any description requisite for our present purpose.

In the marine species, eight pairs of ribs and thirteen plates of the longitudinal series form the buckler; the ribs or costal plates are united to each other through a great part of their extent; but towards their distal or outer extremities each rib contracts, and terminates in a point, which is supported on a marginal series of bony plates; the intervals between the ribs are filled up in the living animal by a cartilaginous membrane which never becomes ossified. This character, therefore, affords an important aid in the discrimination of the fossil remains of this family.[679]

[679] The reader will recognise this peculiarity in the gilded skeleton of the carapace of Turtles, frequently exhibited in the soup-shops of the metropolis.

In the terrestrial and the marsh Tortoises, the ossification is complete in the adult state; but in the fluviatile Trionyces, which are without a horny integument, there is no border, or marginal series of bony plates, and the extremities of the ribs are therefore always distinct, and generally have an obtuse extremity. The skeletons of the three groups present corresponding modifications, and an accurate knowledge of the osteology of the recent animals is necessary to enable the palæontologist to arrive at

secure conclusions as to the characters and relations of the fossil species.[680] We can only advert to one remarkable osteological character,—the construction of the shoulder, which differs from that of all other animals, in being situated within the cavity of the thorax, instead of without. In consequence of this modification, a process of the shoulder-blade (*scapula* or *omoplate*), termed the *acromion*, is largely developed, and the shoulder-bone is tri-mucronate, or three-pronged, consisting of a short, thick head, containing a concavity (which, with that on the coracoid-bone, forms a socket for the arm-bone), and of two diverging branches. This form is so peculiar, that the collector can be at no loss to recognise the shoulder-bone of a *Chelonian*, should it come under his notice with other fossil relics (see *Foss. Til. For.* pl. xix. *fig.* 11). The shoulder-blade and its associated coracoid-bone undergo certain modifications in the three groups of Turtles, by which the anatomist may pretty certainly determine the terrestrial, fluviatile, or marine character of the animals to which they belonged. The successful application of a perfect knowledge of this department of osteology, is admirably exemplified in the works to which reference has been made; and even but a slight acquaintance with its principles will often enable us to obtain some general information as to the nature and relations of fossil Chelonians.

[680] The student should consult Cuvier's *Ossemens Fossiles*, tom. v. part iime. chap. ii.: and Prof. Owen's *Monographs*, published by the Palæontographical Society, 1849, 1851, 1853. The Penny Cyclopædia, *Art.* TORTOISES, contains an excellent summary of the osteology of these reptiles, also an abstract of Professor Owen's Report on the Fossil *Chelonia*.

The student will remember that all the Chelonians are edentulous, *i. e.* toothless; their bony jaws being covered by horny sheaths, as in birds; these mandibles are therefore the only dental organs that can occur in a fossil state.

TURTLES AND TORTOISES.

FOSSIL TURTLES AND TORTOISES.[681]—Some of the earliest indications of the presence of Reptiles on our planet are afforded by the foot-prints of Chelonian animals on the surfaces of the layers of sandstone of the Old Red formation at Elgin, and of the New Red in Dumfriesshire, at Storeton, near Liverpool, and at some places in Germany (see *Bd.* i. p. 259, and p. 265, note). But no osseous remains of the animals of this family have hitherto been found in strata antecedent to the Oolite. The Solenhofen quarries (Kelheim) have yielded the bones and carapaces of several Emydian tortoises, and some remains of Chelonians have been found at Stonesfield, and in the Portland Sandstone.[682] In the Jura limestone at Soleure, two large species of Emydians have been discovered. The Wealden and Purbeck formations abound in Chelonian remains of both fluviatile and marine genera. From the Isle of Purbeck numerous fine examples have been obtained;[683] my own researches in the strata of Tilgate Forest (*Foss. Til. For.* p. 60) have also brought to light several species, and in particular an interesting Chelonian related to the soft-skinned, fresh-water tortoises, *Trionyces* (*Geol. S. E.* p. 255). In the Cretaceous formation of England the remains of these reptiles are not frequent. The Greensand of Cambridgeshire (*Rep. Brit. Assoc.* 1841, p. 172,) has yielded a marine species, and that of Kent a fine

Emydian form (Owen, *Monog.* 1851); and in the White Chalk a few examples have been obtained, to which we shall hereafter more particularly allude. On the Continent fine examples have been found in the slate of Glaris (see *Bd.* pl. xxv′.); and in the upper Cretaceous strata of the Netherlands, at Maestricht, and at Melsbroeck, near Brussels, many beautiful specimens of fresh-water tortoises (*Emydes*), and marine turtles (*Chelones*), have from time to time been obtained; these are figured and described by Baron Cuvier (*Oss. Foss.* tom. v. pp. 236, 239). In the Eocene strata of England, several species of Chelonians have been collected; of these eleven belong to the marine genus *Chelone*; eight to the fresh-water *Trionyx*; and eight to the marsh-tortoises, *Emys* and *Platemys*. The Isle of Sheppey and Hordwell have yielded the majority of these relics; the turtles are smaller than the recent analogues, which now inhabit intertropical latitudes.[684] The Eocene strata of France contain several fresh-water tortoises, some of which are referable to the Emydes, and others to the Trionyces. From the gypsum beds, near Paris, the remains of one or two species of Trionyx have been obtained (*Oss. Foss.* tom. v. p. 222), of another at Aix, in Provence, and of three or four species in other localities. A fine specimen of fresh-water tortoise from Œningen, near Constance, is described and figured by Professor Bell in Geol. Trans. 2d ser. vol. iii. The fossil remains of *Testudinidæ*, or land-tortoises, are exceedingly rare. No well-determined remains are known in the British strata; the impressions of scutes found in the Stonesfield slate, and the foot-prints above described, being the only indications of the existence of these reptiles. The presence of land-tortoises in the strata of France appears to be equally problematical, for the relics

obtained from Montmartre and Aix (*Oss. Foss.* p. 245) afford no certain data as to the character of the original.

[681] See *Rep. Brit. Assoc.* 1841, pp. 168, et seq.

[682] See *Rep. Brit. Assoc.* 1841. pp. 160 and 169.

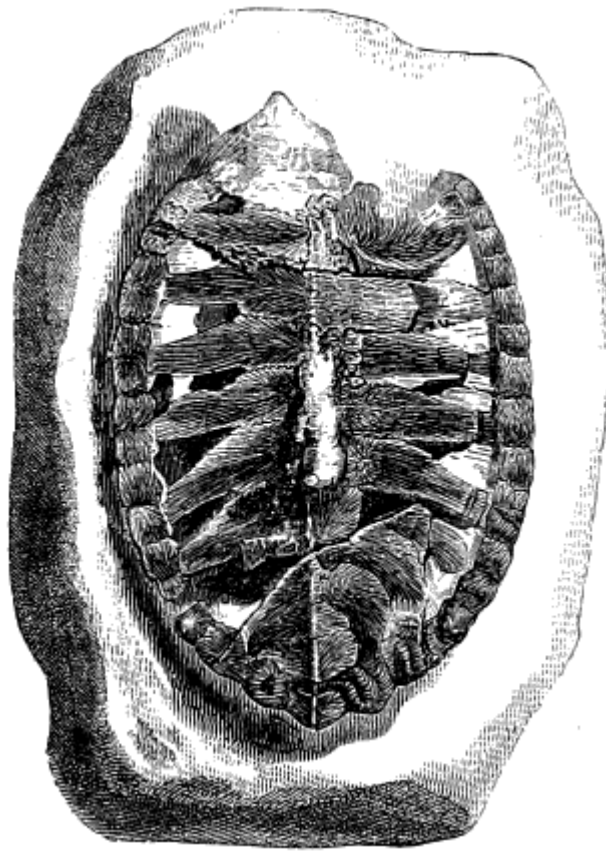
[683] Some of the most beautiful of these almost perfect specimens have lately been figured and described by Prof. Owen in his Monograph on the Fossil Chelonian Reptiles of the Wealden and the Purbeck; Palæontographical Society, 1853.

[684] Rep. Brit. Assoc. 1841, p. 177, and Monograph on Fossil Reptiles, Pal. Soc. 1849, in which the anatomical details are given with the characteristic accuracy and minuteness of the author.

The Tertiary formations of India, however, have furnished decided examples of fossil terrestrial tortoises; and among the innumerable relics of the beings of an earlier world, which the indefatigable labours of Dr. Falconer and Captain Cautley have brought to light, and which those accomplished naturalists have so skilfully developed, are the remains of land tortoises of prodigious magnitude (*Colossochelys atlas*); one specimen indicating a length of twelve or fourteen feet, with a breadth and height of corresponding proportions! These remains are associated with the bones gigantic extinct mammalia, allied to the *Palæotheria* and other pachyderms of the eocene deposits of the Paris basin; and with those of Emydian and Crocodilian reptiles. [685]

[685] *Petrif.* pp. 11 and 468.

FOSSIL MARINE TURTLES.—In illustration of this subject, I select a specimen discovered in the lower Chalk, at Burham, Kent, which is remarkable for its beautiful state of preservation, and its peculiar osteological characters.



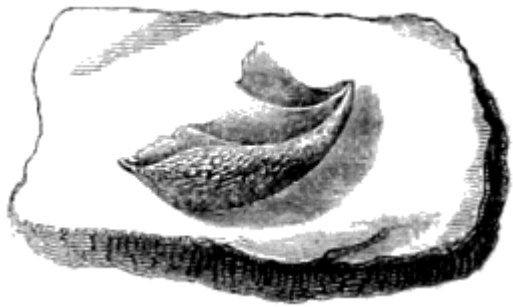
LIGN. 238. CHELONE BENSTEDI: *nat. size*.
Chalk. Kent.
The dorsal shield or carapace of this specimen admits of being remove
and four sternal plates, a coracoid-bone, and several vertebræ are the
exposed.

CHELONE BENSTEDI. *Lign.* 238.—To Mr. Bensted, of Maidstone, whose discoveries have rendered his quarry of Kentish Bag classic ground to the British palæontologist, I am indebted for this splendid fossil turtle. The quarry whence it was obtained is situated at Burham, a short distance from the banks of the Medway, between Chatham and Maidstone, and presents a good section of the lower Chalk. This locality is rich in fossil remains, rivalling in this respect the quarries near Lewes, Worthing, and Arundel, in Sussex. Two other fossil Turtles have been obtained from this quarry, and now enrich the cabinets of Sir P. Egerton and Mr. Bowerbank. Other relics of Chelonians found in this place are four marginal plates of the carapace, and fragments of ribs,[686] some marginal plates of a much larger individual, mandibles, and other fragments, which are noticed in Prof. Owen's Monograph, 1851. The specimen, of which *Lign.* 238 is a reduced figure, consists of the dorsal buckler or carapace almost entire; it is of a depressed elliptical form, with a longitudinal median ridge; it is six inches in length, and three and a half inches in breadth across the middle. It is composed of eight ribs, or costal plates, on each side the dorsal ridge, which is formed of ten neural plates; and there is a border of marginal plates. These plates are united to each other by finely indented sutures, and bear the imprints of the horny scutes, or tortoise-shell, with which they were originally invested. The expanded ribs are united throughout the proximal half of their length, and gradually taper to their marginal extremities, which are supported by the plates of the osseous border.[687] This description applies to the specimen as seen in *Lign.* 238; but Mr. Bensted so skilfully cleared away the chalk as to admit of the removal of a great

part of the dorsal shield, by which means some of the vertebræ, four sternal (*hyosternal* and *hyposternal*) plates, and one of the coracoid bones are displayed. This brief description will suffice to convey a general idea of the characters of this fossil, which differs from any known recent turtle, and possesses some anomalous features, that appear to indicate some slight Emydian affinities.

[686] See *Geol. Proceed*, vol. iii. p. 299.

[687] See also *Phil. Trans.* 1841, p. 153, pl. xi. and xii.; and *Palæontograph. Monograph*, 1851, p. 4, plates i. ii. and iii.

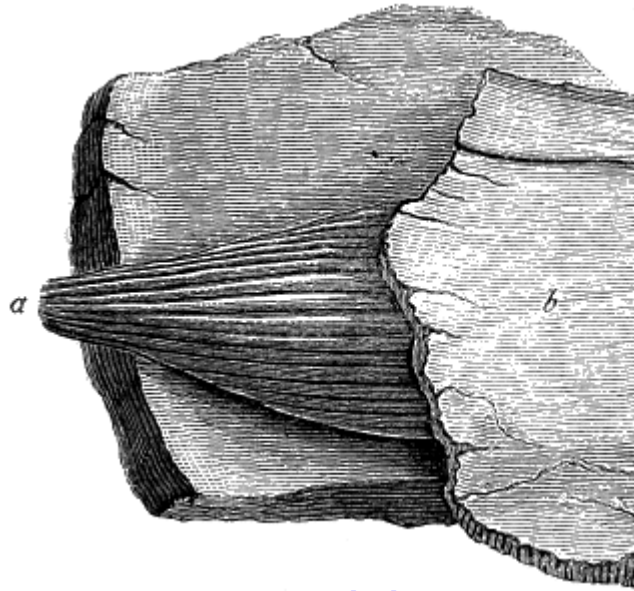


LIGN. 239.
BEAK OR MANDIBLE OF A TURTLE: *nat. size*.
Chalk. Lewes.

Among the numerous fossils obtained from the Chalk of Sussex, the only trace of a Chelonian reptile that has come under my observation is the bony mandible or beak of a Turtle, *Lign.* 239. Its surface displays a fibrous cancellated structure, denoting the attachment of the horny sheath with which, in a recent state, it was covered. More or less perfect specimens of such mandibles also occur in the Chalk of Kent and elsewhere, but no bones of the skull have yet been met with in that deposit. In the Greensand

of Cambridgeshire, however, the cranium of a small turtle has been found. It is figured and described by Prof. Owen as *Chelone pulchriceps* (*Monograph*, 1851).

CHELONE BELLII. *Lign.* 240, *Petrif.* 155.—In the strata of Tilgate Forest, fragments of the carapace, of the plastron or sternum, and of the marginal plates, with some of the bones of the extremities, of a large marine turtle have been discovered; several specimens are figured in *Foss. Til. For.* pl. vi. and vii. Some examples must have belonged to an individual at least three feet in length. Unfortunately, the specimens hitherto obtained are very imperfect, and do not exhibit essential distinctive characters, with the exception of the ribs, which are united to within a short distance of their distal or marginal extremities; hence the costal interspaces are reduced to much smaller dimensions than in any recent or fossil Turtles with which I have had the means of comparing them. The fragment of a rib, imbedded in Tilgate grit, figured *Lign.* 240, well exhibits this character.



LIGN. 240. CHELONE BELLII[688] (G. A. M.). *Wealden. T*
Portion of a costal plate, and the extremities of a rib
(*Foss. Tilg. For.* pl. vi. *fig.* 2.)

a. The striated pointed extremity of rib.

b. The distal portion of the costal plate.

[688] The remains of this reptile were noticed in the "Fossils of the South Downs, or Illustrations of Geology of Sussex," 4to. 1822, p. 47, and subsequently figured in the "Illustrations of the Geology of Sussex, with figures and descriptions of the Fossils of Tilgate Forest," 4to. 1827, p. 60, pl. vi. and vii.; and this extinct *Chelone* was regarded as a species, characterized by the great development of the rib-plates, and named after Professor Bell, the eminent zoologist, in the first Edition of the "Medals." But in the *Monograph*, *Weald. Rept.* 1853, this determination has lately been overlooked; and the specimen figured *Tilg. Foss.* pl. vi. *fig.* 2, is referred to the newly named *Ch. costata*, characterized by its broad

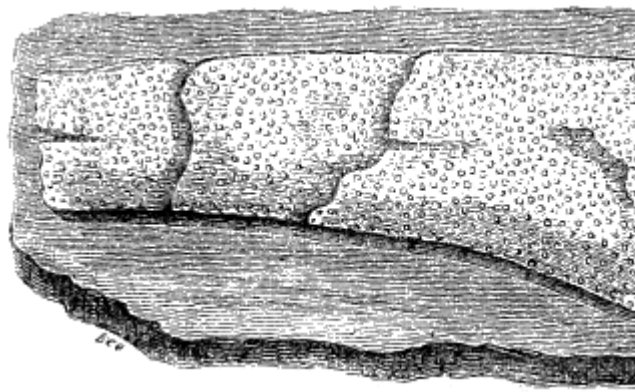
and prominent ribs. A third name even (*Ch. Mantelli*) has been bestowed on this interesting fossil, by a German palæontologist.

FOSSIL FRESH-WATER TORTOISES.—The remains of fresh-water Tortoises, referable to the *Emydidæ*, occur in the Purbeck and Wealden strata (Owen's *Monograph*, 1853, and *Rep. Brit. Assoc.* 1841); the resemblance of some of these to the Jurassic species from Soleure was noticed by Cuvier (*Oss. Foss.* vol. v.). Among the Chelonian remains of the Wealden, some of the most remarkable are the costal plates and other bones of a Tortoise, which in its essential characters is closely allied to the Trionyces,[689] but differs from the recent forms, in having possessed a dermal horny integument, formed of scutes of tortoise-shell. The chelonians of the genus Trionyx (so named from their having three claws) have the extremities of the ribs free, and not articulated to a border of marginal plates, and there are intervals between their costal plates even in the adult state. The external surface of the bones of the buckler is covered with granulations, or with little pits, for the attachment of the soft skin, the only integument with which these animals are invested; and, being destitute of horny scutes, their bones exhibit no furrows, as in the other genera. But the fossil rib-plates (see *Lign.* 241) have a shagreen-like or punctated surface, like the recent Trionyces, and at the same time bear the imprints of horny scutes; and, instead of being nearly of an equal width throughout their entire length, as in the existing species, have one extremity much wider than the other, as in the land-tortoises. From the slight degree of convexity of the ribs, it is evident that the carapace was much flattened, as in the Trionyx.[690] Except in having a

defensive dermal integument, and agreeing in this respect with many of the Crocodilian reptiles, with which its bones are associated, the original must have closely resembled the existing predaceous fresh-water soft Turtles; and, doubtless, like those reptiles, inhabited the muddy beds of lakes and rivers, preying upon the eggs and young of the larger reptiles, and on the uniones and other fluviatile mollusca, whose shells are very commonly found imbedded with its remains.

[689] The relations of these peculiar remains to *Trionyx* were pointed out in *Foss. S. D.* 1822, p. 47.

[690] See *Petrif.* p. 157, &c.



LIGN. 241. TRETOSTERNON BAKEWELLI; [691] 1/3 *na*
Wealden. Tilgate Forest.
(*Foss. Tilg. For.* pl. vi. *fig.* 1.)
One of the costal plates.

[691] This Tortoise, with the sanction of Baron Cuvier, was described under the name *Trionyx*, in *Foss. Tilg. For.* 1827, p. 60, and its distinctive characters were pointed out. In *Geol. S. E.* 1833, p. 255, the specific name *Bakewelli* was proposed in honour of the late

ROBERT BAKEWELL, Esq., whose excellent works have so greatly promoted the advancement of geology; a privilege to which, as the original discoverer of the species, and of its zoological relations, I was fairly entitled. But this name does not appear in the list of British Chelonians, either in *Rep. Brit. Assoc.* 1841, or in Mr. Morris's *Cat. Brit. Org. Rem.* 1843. With a melancholy pleasure I now restore the name of my lamented friend, as a just, but very inadequate tribute of respect to his memory.



LIGN. 242. PALÆOPHIS TOLIAPICUS: $^{2}/_{3}$ *nat. size.*
London Clay. Isle of Sheppey.
Six concavo-convex vertebræ of the trunk.

FOSSIL SERPENTS.

VII. OPHIDIANS, OR SERPENTS. *Lign.* 242.—The remains of the vertebral columns of extinct Serpents were discovered many years since in the London clay of the Isle of Sheppey, and specimens were obtained by the celebrated HUNTER, and preserved in his museum. These specimens, together with others in the collections of Messrs. Saull, Bowerbank, Dixon, Combe, and S. Wood, have been figured and described, and their relations to existing types elaborately worked out, by Professor Owen.[692] The *Palæophis typhæus*, from the Bracklesham clay, had a

length of about twenty feet, and, from the compressed character of its caudal vertebræ, was probably a sea-serpent. A somewhat smaller species also occurs at Bracklesham. The Sheppey specimens are referred to another species of this extinct genus, namely, the *P. toliapicus* (*Lign.* 242); it was from ten to twelve feet in length. The remains of two species of land-serpents, respectively about four and three feet long, have been found at Hordwell Cliff. These belong to the extinct genus *Paleryx*, thus named in reference to the near affinities of the Hordwell vertebræ to those of the recent *Eryx*, one of the Boa and Python group of serpents.[693]

[692] Geol. Trans. 2d ser. vol. vi. p. 209, &c. pl. xxii.; Rep. Brit. Assoc. 1841, p. 180; "Dixon's Geology and Fossils of Sussex," pp. 211-217, pl. xii. *fig.* 14; and especially Palæontographical Monograph, 1850, p. 51, *et seq.*; and plates xii. to xvi.

[693] See Monograph on Eocene Reptiles, 1850, from which these notices of the Eocene Ophidians are abridged.

The vertebræ of Serpents are distinguished by a transversely oblong anterior concavity, forming a deep cup, and a corresponding posterior convexity or hall; by the interlocking of the projecting posterior oblique processes with the anterior pair; and by the oblong tubercle on each side of the anterior part of the body of the vertebra, for moveable articulation with the head of the ribs; a spinal column thus constructed combines in the highest degree perfect flexibility with great strength.

In addition to the ophidian relics above referred to, fossil vertebræ of a small serpent (*Palæophis?*) have been found in the Eocene sand below the Bed

Crag, at Kyson in Suffolk;[694] a locality that has yielded other organic remains of great interest (see chap. xix.; and *Wond.* p. 258). The only fossils of this order of reptiles known to Baron Cuvier appear to have been some vertebræ from the bone-breccia of Cette (*Oss. Foss.* tom. iv. p. 177).

[694] Rep. Brit. Assoc. 1841, p. 181; and Monograph, 1850, p. 66.

Fossil eggs of snakes are occasionally met with in a comparatively recent limestone, of fresh-water origin, in Germany, near Offenbach, associated with shells of land and fresh-water molluscs. Like the turtles' eggs on the shores of Ascension Island, these ova were probably laid in the moist mud, and became encrusted and preserved by a deposit of tufa.[695]

[695] Quart. Journ. Geol. Soc. vol. vi. part 2, p. 42.

BATRACHIANS.

VIII. BATRACHIANS.—The reptiles termed BATRACHIANS (from the Greek name for Frog) are characterized by the metamorphoses which they undergo in the progress of their development from the young to the adult state; the Frog, Toad, and Newt are familiar examples of this order. Their organs of aërial respiration consist of a pair of lungs; but in their young state they are provided with gills, supported, as in fishes, by cartilaginous arches. These organs disappear, in most species, when the animals arrive at maturity; but in a few genera, as the Siren and Proteus, they are persistent. The skeletons of these reptiles present corresponding modifications. The skull is, for the most part, much depressed, and the cerebral cavity small; it is united to the vertebral

column by two distinct condyles, situated on the sides of the occipital or cranio-spinal aperture.[696] The vertebral column, in some genera (as, for example, in the common frog), is very short, and is reduced to eight or ten bones, the caudal vertebræ being fused into a long cylindrical style; but in the higher organised Batrachians the spine is composed of concavo-convex vertebræ, as in the Crocodile: in the lower type, as the Siren, Proteus, and Axolotl, the vertebræ are biconcave, as in numerous species of fossil Saurians. The ribs are merely rudimentary, being very short and few; a condition which has relation to the mode of reproduction in these animals, the eggs being accumulated and shed at once.[697] Some of the Batrachians are edentulous, but others have numerous small, conical, uniform, closely-arranged teeth, placed either in a single row, or aggregated like the rasp-teeth in fishes.[698]

[696] Saurians, like birds, have a single occipital condyle.

[697] See Dr. Roget's *Bridgewater Essay*, p. 395.

[698] The variations in the dental system of these animals are given in *Odontography*, chap. ii. p. 187.

FOSSIL BATRACHIANS.

BATRACHOLITES; or fossil remains of Batrachians. —The skeletons, vestiges of the soft parts, and imprints of the feet of several genera of Batrachians occur in a fossil state in tertiary deposits, all of which, like the existing races, appear to belong to fresh-water or terrestrial species. In the pliocene or newer tertiary strata, on the banks of the Rhine, at Œningen, and in the *papierkohle* of the Eifel, several

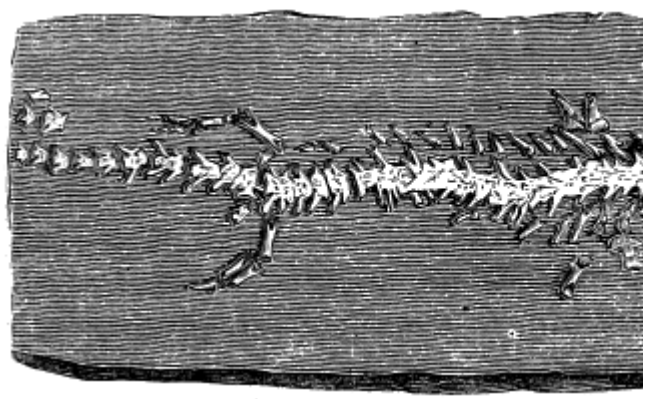
species of Frog, Toad, and Newt, have been discovered. Fossil frogs of a small species, very similar to the recent, occur in numbers in a dark shale, overlaid by basalt, in the vicinity of Bombay. [699]

[699] Quart. Geol. Journ. vol. iii. p. 221.

A celebrated fossil of this class is the gigantic Salamander (*Cryptobranchus*), three feet in length (*Lign.* 243), found at Œningen (see *Wond.* pp. 263, 580), which a German physician of some note (*Scheuchzer*) supposed to be a fossil man![700] and he described it in an essay, entitled "*Homo diluvii testis et Theoscopos*," as being the moiety, or nearly so, of a human skeleton, with the bones and flesh incorporated in the stone.[701] A fine example of this fossil Salamander is preserved in the British Museum (*Petrif.* p. 186).

[700] Phil. Trans, for 1726, vol. xxxiv.

[701] Ample description and figures of this highly interesting fossil are given by Cuvier, *Oss. Foss.* tom. v. part ii. p. 431, pl. xxv. xxvi.



LIGN. 243. CRYPTOBRANCHUS SCHEUCHZERI: $^{1}/_{11}$
Tertiary. Œningen.

LABYRINTHODON.

LABYRINTHODON. *Ly.* p. 290-293; *Wond.* p. 550. By far the most interesting evidence of the existence of Batrachian reptiles in the earlier ages of our planet has been afforded by Professor Jäger's discovery of the skull, teeth, and other remains of gigantic extinct animals, allied to the Salamander, in the Upper New Red Sandstone (*Keuper*) of Wirtemberg.[702]

> [702] Über die Fossile Reptilien welche in Würtemberg aufgefunden worden sind, von Dr. Geo. Friedr. Jäger. 4to. Stuttgart, 1828. See also Hermann von Meyer's Notice of the Saurians of the Muschelkalk, Banter Sandstein, and Keuper, *Quart. Geol. Journ.* vol. iv. pt. ii. p. 40.

These remains were referred by this eminent physician and naturalist to saurian genera, although the double condyle of the occipital bone indicated Batrachian affinities. It was reserved, however, for our distinguished countryman, Professor Owen, to correct the error into which the German *savant* had fallen,—remove the obscurity in which the subject was involved,—determine the natural relations of the original,—and develope a modification of dental organization of the most unexpected and interesting character.

Dr. Lloyd, of Leamington, having discovered some fossil teeth and bones in the light-coloured sandstone of the New Red, at Warwick and Leamington, submitted them to Professor Owen, who, struck with their general resemblance to the teeth of the gigantic *Salamandroïdes* of Wirtemberg, instituted a microscopic examination of the British and German specimens. The result proved that the teeth from both localities possessed a remarkable and

complicated structure, produced by the convergence of numerous inflected folds of the external layer of cement towards the pulp-cavity; to which, as we have already seen (p. 666), a very slight approach was made in the tooth of the Ichthyosaurus, and a still closer approximation by the teeth of certain fishes (*Lepidosteus*, p. 616). From the intricate meanderings or labyrinthine inflections observable in the sections of these teeth, Professor Owen has given the name of *Labyrinthodon* to these extinct Batrachian reptiles, and has determined five British species; one of which (*L. Jægeri*) he conceives to be identical with a species described by my friend, Dr. Jäger.

The remains of the skeletons of these reptiles, hitherto found in Warwickshire, consist of portions of the cranium, and of the upper and lower jaws, with teeth, vertebræ, a sternum, and some of the bones of the pelvis and the extremities. From a specimen (of *L. scutulatus*) consisting of an aggregated group of bones, imbedded in sandstone, comprising four vertebræ, portions of ribs, a humerus, a thigh-bone, and two leg-bones, with several small osseous scutes, it appears that one species, at least, resembled the Crocodiles in its dermal structure. But Professor Owen remarks, that this modification of the dermal system does not affect the claims of the Labyrinthodonts to be considered as Batrachians, although all the known living species of this order are covered with a soft, lubricous, naked integument; for the skin is the seat of the most variable characters in all animals; and the double occipital condyle, the simple lower jaw, the palatal vomerine bones, and the teeth of these fossil reptiles must be deemed decisive of their

essentially Batrachian nature.

From the specimens of the cranium the important fact has been ascertained, that the Labyrinthodonts had subterminal nostrils leading to a wide and shallow nasal cavity, which is separated by a broad and almost continuous palatal flooring from the cavity of the mouth; indicating, by its horizontal position, that the posterior apertures were placed far behind the external nostrils; whereas in the recent air-breathing Batrachians the nasal canal is short and vertical, and the inner apertures pierce the anterior part of the palate. The nasal cavities in the Frog are vertical; for this reptile swallows air. The Labyrinthodonts must, therefore, have breathed air like the Crocodiles, and were probably provided with well-developed ribs, and not mere rudimentary styles, as in most living Batrachians.

TOOTH OF THE LABYRINTHODON. *Pl. VI. fig. 3.*—The tooth of the Labyrinthodon is of a conical figure, very slightly recurved, and marked externally with shallow, fine, longitudinal strife. *Pl. VI. fig. 3a*, represents ($^1/_2$ *nat. size*) a specimen presented to me by Dr. Jäger. The tooth is implanted, by a single fang, in an alveolar groove to which it is anchylosed. It consists of a simple central pulp-cavity, surrounded by a body of dentine, which has an external thin coat of cement; and a vertical duplication or fold of this cement penetrates the substance of the tooth at each of the striæ, which are arranged at intervals of about one line around the entire circumference of the tooth. The inflected folds of cement extend inwards towards the centre, in a straight direction for about half a line, then become undulated, and finally terminate in a dilatation or loop, close to the pulp-cavity, from which it is separated by a thin layer of

dentine. Within these inflections of the cement, the dentine, or tooth-bone, is similarly disposed; a layer of dentine lining the folds of cement, and having corresponding interspaces, which are filled up by the processes from the pulp-cavity. It is this blending of the cement and dentine in labyrinthine folds, that gives the peculiar character observable in transverse sections of the teeth. *Pl. VI. fig. 3a*, represents a transverse section of half the diameter of the tooth; the vacancy in the middle of the line at the bottom is a section of half the pulp-cavity. *Fig. 3b* is a vertical section of a fragment near the summit of the tooth; and *fig. 3c*, a highly-magnified view of one of the anfractuosities, showing a fold of cement, surrounding a fold of dentine, and in the centre of the latter the termination of a process of the pulp. The section of the tooth of the Ichthyosaurus, *Pl. VI. fig. 9*, shows the most simple modification of this structure; the apparent complication of that of the Labyrinthodon arises from the inflections of the three elements of dental organization being more numerous and diversified. But the beautiful plates and the graphic description of the original discoverer must be seen and perused to obtain an adequate idea of the exquisite structure of the fossil teeth; for the distribution of the extremely minute calcigerous tubes of the dentine is as diversified as that of the constituent substances. And even after viewing these *chefs-d'œuvres* of structural delineations, should the reader have an opportunity of examining a transverse section of a tooth under the microscope, he will feel how feebly any engraving can represent the characters of the original.[703]

[703] Professor Owen's Memoir on the Labyrinthodonts, in *Geol. Trans.* 2d ser. vol. vi. pp. 503-543, with five admirable lithographs

by that excellent artist, Mr. Scharf, and the description of the structure of the teeth, *Odontography*, p. 195, pl. lxiii. lxiv. should be consulted. See also *Cyclop. Anat.* Art. TEETH.

ARCHEGOSAURUS.

ARCHEGOSAURUS. *Lign.* 244, *Ly.* p. 336, *figs.* 384, [704] 385.—The occurrence of reptilian remains in deposits of higher antiquity than the Triassic was first established in 1844, by the discovery of the skull and other portions of the skeleton of an air-breathing reptile, the *Apateon pedestris*, related to the Salamanders, and about three feet in length, in the coal of Münster-Appel in Rhenish Bavaria. In 1847 Professor Von Dechen obtained, in nodules of argillaceous ironstone, from the coal-field of Lebach, in the district of Saarbrück, three species of the same type of reptiles; these have been described by Goldfuss, under the name of *Archegosaurus*.[705] One of them was well known to collectors, but had previously been regarded as a fish (the *Pygopterus lucius* of M. Agassiz).

[704] The original of this figure of *Archegosaurus minor* is now in the British Museum.

[705] See a notice of the researches of Goldfuss, Von Dechen, and Von Meyer in the geological and zoological history of this interesting group of batrachoid reptiles, *Quart. Journ. Geol. Soc.* vol. iv. part ii. (Miscell.) p. 513, *et seq.*

The skull and portions of the trunk of this species (*A. Dechenii*), see *Lign.* 244, indicate an animal three and a half feet in length. Seventeen dorsal vertebræ, imprints of the ribs, and remains of the extremities, have been collected. The jaws to beyond the orbit

have small fine conical teeth, longitudinally striated. The eye was furnished with an osseous ring. The skin, of which a considerable part was detached, was covered by long, narrow, wedge-shaped, horny scales, arranged in rows (*Lign.* 244). The cranial bones are characterized by reticulating grooves and pittings, similar in character to the reticulate markings on the cranial bones of the Labyrinthodon, but of a more delicate sculpturing. The original reptiles were quadruped; the fore and hind feet had distinct toes; but the limbs were feeble, and only capable of swimming, or, when on land, of a slow creeping movement.

The Archegosaurus is closely allied to the Labyrinthodonts;[706] and, in the words of Professor Owen,[707] it is "essentially Batrachian, and most nearly allied to the perennibranchiate, or lowest or most fish-like of that Order of Reptiles."

[706] We may remark that in the opinion of Dr. Goldfuss and Von Meyer (*loc. cit.*) the Labyrinthodon and the Archegosaurus are saurian forms connecting the Crocodiles and the Lizards, and representing in the ancient fauna an arrested or "permanent larva-condition of the loricated reptiles, as the sirens do among the recent batrachians." Professor Owen's estimation of the affinities of these genera is stated above, and in the *note* at p. 55, Geol. Journ. vol. iv. part ii.

[707] Quart. Geol. Journ. vol. ix. p. 69.

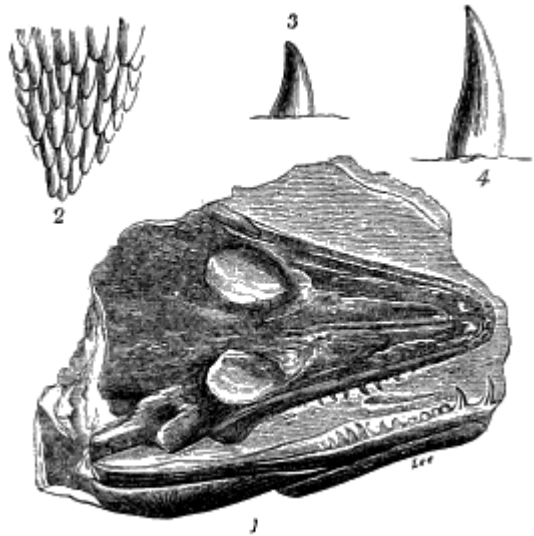
PARABATRACHUS COLEI.—Under this appellation Professor Owen has lately described (*Quart. Geol. Journ.* vol. ix. p. 67, pl. ii. *fig.* 1,) a batrachoid fossil, consisting of cranial and maxillary bones with teeth, probably from the shale of the Glasgow coal-field, at

Carluke, Lanarkshire. The slab of coal-shale in which the specimen is imbedded contains also a large scale of the *Holoptychius* (see p. 618).

DENDRERPETON ACADIANUM.

DENDRERPETON ACADIANUM.[708] (*Quart. Journ. Geol. Soc.* 1853, pp. 58-67, plates ii. and iii.)—The remains of a reptile and a land-shell, resembling a *Pupa*, were discovered in 1852, by Sir C. Lyell and Mr. J. W. Dawson, in the interior of an erect stamp of a fossil tree (*Sigillaria*), in the coal-measures at the South Joggins cliffs, Nova Scotia. These remains were fully described by Professor Jeffries Wyman, of Harvard University, U. S., and Professor Owen in the Appendix to the Memoir by Sir C. Lyell and Mr. Dawson, in the Journal of the Geological Society, vol. ix. Some of the bones were recognised as having a near resemblance to those of the recent *Menobranchus* and *Menopoma* (Perennibranchiate Batrachians, inhabiting North American fresh-waters); the sculptured cranial bones are analogous to those of the *Labyrinthodon* and *Archegosaurus*; and the teeth have a Labyrinthodontoid structure: numerous, small, concentrically striated scutes, of an irregular oval shape, accompany the bones and teeth.

[708] The *Tree-reptile of Acadia* (Acadia being the ancient Indian name for Nova Scotia).



LIGN. 244. ARCHEGOSAURUS DECHENII. $^1/_2$ *nat. size. Coal Formation. Saarbrück.*

Fig. 1.— The cranium and part of the lower jaw.
2.— A portion of the skin, or dermal scutes, magnified.
3 and 4.—Magnified figures of two teeth.

The conclusions arrived at by the eminent comparative anatomists to whose examination the remains in question were submitted, show that the character of the fossils are those of Perennibranchiate Batrachians; that, with regard to the long bones, it is not improbable that the corresponding bones in the *Archegosaurus* (p. 745) and *Labyrinthodon* (p. 741) would present similar correspondences with those of the existing perennibranchiates; and that, although the *Dendrerpeton* cannot be referred to any known form of the two genera just mentioned, yet there exists strong evidence of its close affinity with these extinct Batrachians.

The *Dendrerpeton Acadianum* was probably between two and three feet in length. A series of minute biconcave vertebræ were found with the other remains in the erect tree, these, however, from their relatively small size, and from other characteristics, are regarded by Professor Wyman as having probably belonged to some other associated reptile.

The Labyrinthodont reptiles have been regarded as characteristic of the Permian and Triassic epochs, their remains being found in Germany and England in rocks of that age. The commencement of the existence of this family of sauroid-batrachians, however, is of greater antiquity, since their relics also occur in the formations of the Carboniferous epoch. The *Archegosaurus* (p. 745), a batrachian but slightly removed from the true Labyrinthodont type, has left its well-characterized remains in the Coal of Germany; the *Parabatrachus*, in that of Scotland; and the allied *Dendrerpeton*, in the Nova Scotian coal-field. This last-mentioned great carboniferous formation has, however, afforded fossil evidence of the existence of the true Labyrinthodonts in the Coal-period, for some cranial bones, imbedded in a mass of Pictou coal, lately sent to England by Mr. J. W. Dawson, and the subject of a Paper by Professor Owen, read before the Geological Society, were demonstrated by that distinguished palæontologist to have close affinity with the corresponding parts of the skull of the Triassic genera *Capitosaurus* and *Metopias*.

ICHNOLITES.

ICHNOLITES (*Foot-prints on stone*). *Lign.* 245.—The sandstones and mud-stones of many localities retain

the track-prints of animals that have passed along on the surface of the beds when in a soft state. These foot-prints, or *ichnolites*, either occur as impressions on the surface originally marked lay the animal in the act of progression, or as the reverse of such impressions, being casts *in relief* on the under side of the layer covering the surface originally impressed. Such indications of footsteps and trails have been noticed especially in the forest marble, a member of the Lower Oolite series, where Crustacea and Mollusks have left their markings, and in the New Red Sandstone, where the indications of reptilian quadrupeds and of bird-like bipeds[709] have been here and there preserved in great distinctness. Tracks referable to Crustaceans have been found by Mr. W. E. Logan, on the very ancient and rippled surfaces of the Potsdam Sandstone of North America (see p. 543, *note*); and very lately Mr. J. W. Salter has communicated to the Geological Society the discovery of markings, referred by him to the little entomostracous Hymenocaris (see p. 526), on the Lower Lingula Flags of North Wales,—deposits of as great an age, if not older. The most ancient reptilian ichnolites are those discovered by Capt. L. Brickenden[710] in the Old Red, at Cummingston, near Elgin, which have some resemblance to the track of a club-footed Chelonian (*Ly. fig.* 521); and those of the Devonian sandstone of Sharp Mountain, Pennsylvania, discovered by Mr. I. Lea,[711] which exhibit distinct toes, and are probably allied to the Cheirotherian ichnolites, about to be mentioned, as are also other ancient fossil foot-tracks in the Carboniferous deposits[712] of Pennsylvania, which are figured and described in *Ly.* pp. 337-340.

[709] See ORNITHOIDICHNITES, in chap, xviii.

[710] Quart. Geol. Journ. vol. viii. p. 97, pl. iii.

[711] Across the ridges of the ripples on this slab is a narrow groove, passing along between the two rows of foot-prints; this might have been made by the body or the tail of the animal. *Rep. Brit. Assoc.* 1849, Sect. pp. 56 and 134; and *Trans. Americ. Phil. Soc.* new series, vol. x. part ii. plates xxxi. and xxxii.

[712] With regard to the distribution of reptilian life during the carboniferous and succeeding epochs, see above, page 748.

The sandstones of the New Red or Triassic series frequently retain the track-prints of animals, and numerous notices of such occurrences have been published.[713] In addition to the account of these invaluable evidences of the existence of bygone creatures that is here given, the attention of students is especially directed to Dr. Buckland's most interesting description and illustrations of such as were known when his Treatise was published (*Bd.* i. p. 259, &c.; and ii. p. 36, pl. xxvi. &c.).

[713] The following are the principal notices of ichnolites by English authors which are not referred to in the text:—Cunningham, Yates, and Egerton on Cheirotherian traces in Cheshire, *Geol. Proc.* vol. iii. pp. 12-15; Dr. Black on foot-prints at Runcorn, *Quart. Geol. Journ.* vol. ii. p. 65, pl. ii.; Mr. Cunningham. *Liverpool Lit. and Phil. Proc.* 1848, p. 129, plates iii.-v.; Mr. Hawkshaw on the New Red with foot-prints at Lymm, *Rep. Brit. Assoc.* 1842, Sect. p. 56; Mr. Rawlinson on the same, *Quart. Geol. Journ.* vol. ix. p. 37; Prof. Harkness on the track-bearing beds of Dumfriesshire, *Rep. Brit. Assoc.* 1850, Sect. p. 83; *Quart. Geol. Journ.* vol. vi. pp. 389 and 393; and *Annals Nat.*

Hist. 1850, vol. vi. p. 203; Sir W. Jardine, *Annals Nat. Hist. loc. cit.* Foreign authorities may be found by reference to Pictet's *Traité de Paléontologie*, a new and enlarged edition, vol. i. 1853, p. 567, *et seq.*

The imprints of the feet of some large quadrupeds, having the fore-paws much smaller than the hinder, have been found in Saxony (see *Wond.* p. 555, *Bd.* p. xxvi.); and also in strata of the same age in Warwickshire and Cheshire. The quarries at Storeton Hill, near Liverpool, are celebrated for the abundance and variety of these imprints.[714] Some of the strata of sandstone in this locality are divided by thin beds of clay; a lithological structure which admits of the ready separation of the stone in the direction of the sedimentary planes.

[714] The Museums at Warwick, Warrington, and Liverpool are rich in impressed slabs from the Triassic districts. Numerous fine specimens may be also seen in the Museum of the Geological Society, Somerset House, the Museum of Practical Geology, in Jermyn Street, and in the British Museum (see *Petrif.* pp. 14 and 63).

RAIN-PRINTS ON STONE.

Imprints are found on the face of each successive stratum; and on some of the layers, not only the tracks of animals that have walked over the clay when soft are distinctly observable, but the surface is often traversed with casts of the cracks caused by the desiccation of one layer of clay previously to the deposition of the succeeding layer of sand or mud; and it often presents a blistered or warty appearance, being covered with either little hemispherical eminences or depressions, which an accurate

investigation of the phenomenon has proved to have been produced by showers of rain (*Ly.* figs. 526-528). On the slabs of sandstone, the forms of the sun-cracks, rain-drops, and foot-prints appear in relief, being casts moulded in the soft clayey mud upon which the original impressions were made; while on the clay or shale, corresponding depressions are apparent.[715]

[715] The impressions of rain-drops on stone were first noticed, and their origin explained, by Mr. Cunningham. *Geol. Proc.* vol. iii. p. 99. See also an interesting Paper by Sir C. Lyell, *Quart. Geol. Journ.* vol. vii. p. 240.

The foot-prints on these strata are of several kinds; some appear to have been produced by small reptiles and crustaceans; but the principal imprints are identical with those which have been observed in Saxony, and are referable to some large quadruped, in which the fore-feet were of a much smaller size than the hind-feet (*Lign.* 245). From a supposed resemblance of the imprints to those of a human hand, Professor Kaup proposed the name of *Cheirotherium*, to designate the unknown animal which had left these "footsteps on the sands of Time." But since Professor Owen's discovery, that the bones and teeth of reptiles found in similar strata in Warwickshire belong to gigantic Batrachians, and since the fore and hind-feet of the frog-tribe are often as dissimilar in size as the impressions of the *Cheirotherium*, it has been suggested, with much probability, that the foot-prints in question may be those of Labyrinthodonts; but until the form of the feet of these extinct Batrachians can be ascertained, this inference must be regarded as conjectural (*Ly. fig.* 331).

CHEIROTHERIUM.



LIGN. 245. CHEIROTHERIUM KAUPII. $^{1}/_{8}$ *nat. siz*
Casts of the foot-marks of a gigantic extinct Batrachian, probably a La
also of the cracks of the opposed surface.
Trias. Hessburg, near Hildburghausen, Saxony.
Fig. 1.— Casts of the imprints of a hind and a fore-foot of the same ani
2.— Similar tracks of another individual on the same stone.

Allusion has already been made to foot-prints, supposed to be those of tortoises (see p. 729), on slabs of Triassic sandstone in Scotland. Of these there are five species at Corncockle Muir, in Dumfriesshire: they are termed *Chelichnus* by Sir W. Jardine, who has lately described them in his *Ichnology of Annandale*, a splendid folio work, illustrated with full-sized lithographs, coloured after nature. They are accompanied with three other forms of footstep (*Herpetichnus*, *Batrachnis*, and *Actibatis*), one of which Sir W. Jardine regards as indicative of an animal probably of a saurian form.

At Grinsill quarry, from which the remains of the *Rhynchosaurus* (p. 712) were obtained, some small foot-prints have been observed, which, with some probability, have been referred to that animal (*Rep. Brit. Assoc.* 1841, p. 146).

A beautifully distinct series of foot-prints, with the mark of a trailing tail, on a rippled slab from the New Red of Shrewley Common, Warwickshire, are figured and described by Strickland and Murchison (*Geol. Trans.* 2d ser. vol. v. pl. xvviii.). This ichnolite has been provisionally assigned by Professor Owen to *Labyrinthodon leptognathus*.[716] Similar impressions occur in company with other Cheirotherian imprints at Storeton Hill and at Grinshill.

[716] Geol. Trans. 2d ser. vol. vi. p. 525. The probable relations of *Cheirotherium Hercules* to *Labyrinthodon Jægeri*, and of *Ch. Kaupii* to *L. pachygnathus*, are pointed out by the same high authority, *ibid.* pp. 537, 538.

ON COLLECTING FOSSIL REPTILES.

ON COLLECTING THE FOSSIL REMAINS OF REPTILES.—The length to which this article has extended, compels me to omit a retrospect of the geological distribution of fossil reptiles; and I must refer the reader to the brief review of the Age of Reptiles in *Wond.* p. 568, *et seq.*, and *Petrif.* p. 147, &c., and close this chapter with some directions for collecting reptilian remains, and a list of a few British localities.[717]

[717] An able Summary on British Fossil Reptiles is appended to Prof. Owen's Report, *Rep. Brit. Assoc.* 1841, p. 191.

The fossil *Teeth of Reptiles* are commonly found in

as perfect a state of preservation as those of fishes; and require but the usual care for their preservation. But the collector should assiduously search for vestiges of the jaw and cranium; and it is desirable to place in the same drawer any undetermined bones found associated with the teeth; as they may ultimately afford some clue to the nature of the original animal. The microscopical examination of the teeth is to be conducted in the manner previously directed (p. 639); but for valuable specimens the lapidary should be employed, and transverse sections made from near the apex, the middle, and base of the tooth; if due care be taken, several slices may be obtained from one specimen. I have ten slices from one tooth of the Labyrinthodon. The bones imbedded in limestone generally partake of the chemical character of the rock, and are often permeated with calcareous spar; mere fragments, when polished, frequently display the internal structure.

The suggestions for repairing fossil bones (p. 46) render further instructions on that head unnecessary; and the description of the development of the specimen of Hylæosaurus (p. 689) affords a practical lesson to the young collector.

When a vertebra is found in an imperfect state, it should be closely examined on the spot, and, if it present proofs of recent fracture, the detached processes should be sought for; even if the body of a vertebra be imbedded in stone, and the processes appear to have been broken off before it was enveloped in the rock, the corresponding parts will often be found in the same mass of stone. There is in the British Museum a very fine Saurian vertebra imbedded in a large slab of Tilgate stone, in which the spinous process is seen lying in the same block,

several inches distant from the centrum or body; when observed in the quarry the latter only was exposed, and I was about to detach it from the slab, for the convenience of carriage, when I perceived indications of the spinous process. The vertebra was therefore allowed to remain, and the stone chiselled away, so as to expose the spine; and the specimen then displayed its present interesting character.

It may frequently happen that a fragment of a large bone,—as, for example, the thigh-bone of the Iguanodon,—may be obtained from a quarry; and after an interval of some weeks the corresponding portions be discovered. This was remarkably exemplified in the first specimen which revealed to me the peculiar characters of the femur of the Iguanodon. The lower part, or condyloid extremity, of a gigantic bone, firmly impacted in a block of Tilgate-grit, was found in a quarry near Cuckfield; it was evidently but a fragment of the fossil, for the fracture was recent; I therefore requested the quarry-men to make diligent search for the corresponding portion, but without success. Several months afterwards, upon a fresh explosion in the quarry, the head of a large bone was found loose among the fallen mass; but there were no indications that it belonged to the specimen previously found; and it was regarded as another relic of some one of the colossal animals whose bones were distributed in the Wealden deposits. Teeth, fragments of bones, and other fossils were from time to time obtained from the same quarry; and among these a huge quadrangular fragment of bone, similar to the enormous mass that had so long been in my possession, and had defied all attempts to ascertain its character.[718] It was some time before it occurred to me, that the three portions of unknown colossal

bone might belong to the same specimen; but eventually they were found to correspond, and upon cementing them together, the femur of the Iguanodon was, for the first time, developed.

[718] The fragment alluded to is figured, *Foss. Til. For.* pl. xviii.

The figures in *Lign.* 206 will assist the collector in recognising the different vertebral processes, even when occurring as detached fragments. When specimens are evidently rolled or water-worn, there is, of course, no probability that the corresponding portions will be met with. Every fragment of a bone the nature of which is not obvious should be carefully preserved; for sooner or later its characters may be ascertained. It is scarcely necessary again to remind the collector, that search should be made for indications of the soft parts around the bones; the specimen of the paddle of the Ichthyosaurus (*Lign.* 215, p. 669), with its integument, must have impressed this fact too strongly on the mind to be soon forgotten. If the impression of the extremities of a bone, of which a fragment only remains, be observed, the block of stone should be preserved, as a cast may be taken, and the entire form of the original be ascertained.

BRITISH LOCALITIES OF FOSSIL REPTILES.

Aust Cliff, near Bristol. *Lias.* Plesiosaurus.

Barrow-on-Soar. *Lias.* Ichthyosaurus, Plesiosaurus.

Bath. *Lias.* Plesiosaurus.

Battle, Sussex. *Wealden.* Iguanodon, Cetiosaurus, Goniopholis, Chelonians.

Binstead, Isle of Wight. *Upper Eocene.* Fresh-water Tortoises. Bognor. Lower Eocene. Chelone.

Bolney, Sussex. *Wealden.* Hylæosaurus, Iguanodon, Chelonia, Goniopholis.

Bracklesham Bay. *Middle Eocene.* Crocodiles, Serpents, Chelonians. Brighton. Chalk. Vertebra of Mosasaurus or Leiodon.

Bristol. *Lias.* Ichthyosaurus.

Brook-Point, Isle of Wight. *Wealden.* Iguanodon, Cetiosaurus, &c.

Burham, near Maidstone. *Chalk.* Chelone, Dolichosaurus, Pterodactylus.

Bur wash, Sussex. *Wealden*; quarries in the neighbourhood. Goniopholis, Turtles.

Cambridge. *Lower Chalk.* Raphiosaurus, Polyptychodon. Charmouth. Lias. Ichthyosaurus.

Charmouth. *Lias.* Ichthyosaurus.

Cheltenham. *Lias.* Ichthyosaurus.

Chipping Norton. *Oolite.* Streptospondylus.

Clayton. *Chalk.* Coniosaurus.

Corncockle Muir, Dumfries. *New Red.* Imprints of feet of Reptiles.

Coton-End, Warwickshire. *New Red.* Labyrinthodon, &c.

Cubbington, Warwickshire. *New Red.* Labyrinthodon.

Cuckfield. *Wealden*; quarries in the vicinity. Iguanodon, Pelorosaurus, Hylæosaurus, Trionyx, &c.

Culver Cliff, Isle of Wight. *Wealden.* Streptospondylus.

Dover. *Chalk.* Ichthyosaurus, Plesiosaurus.

Garsington, Oxfordshire. *Oolite.* Cetiosaurus.

Glastonbury. *Lias.* Ichthyosaurus.

Grinsill, Warwickshire. *New Red.* Rhynchosaurus.

Guy's Cliff, Warwick. *New Red.* Labyrinthodon.

Harwich. *London Clay.* Chelonia.

Hastings. *Wealden.* Iguanodon, Pelorosaurus, Goniopholis, Turtles.

Heddington, Oxfordshire. *Kimmeridge Clay.* Pliosaurus.

Hordwell. *Middle Eocene.* Crocodiles, Chelonians, Serpents.

Horsham, Sussex. *Wealden*; quarries in the vicinity. Hylæosaurus, Iguanodon, Goniopholis, Turtles, &c.

Ilminster. *Upper Lias.* Ichthyosaurus, Teleosaurus.

Kyson, Suffolk. *Eocene.* Serpent, Lizard.

Leamington. *New Red.* Labyrinthodon.

Lewes. *Chalk.* Vertebra; of Mosasaurus or Leiodon.

Lyme Regis. *Lias.* Pterodactyles, Ichthyosauri, and Plesiosauri in abundance.

Maidstone. *Lower Green Sand*; quarries near the town; particularly Mr. Bensted's "*Iguanodon quarry*." Iguanodon, Plesiosaurus, Polyptychodon, Fresh-water Tortoise.

Malton. *Oolite.* Megalosaurus.

Market Rasen. *Kimmeridge Clay.* Pliosaurus.

Norfolk? *Chalk.* Leiodon: very rare.

Portland, Isle of. *Oolite.* Turtles.

Purbeck, Isle of. *Purbeck.* Goniopholis, Chelonians. *Kim. Clay.* Pliosaurus.

Redland, near Bristol. *Magnesian Conglomerate.* Palæosaurus, Thecodontosaurus.

Saltwick. *Lias.* Teleosaurus.

Sheppey, Isle of. *London Clay.* Turtles, Serpents, Crocodiles.

Shotover, near Oxford. *Kimmeridge Clay.* Pliosaurus, Teleosaurus.

Southerham. *Chalk.* Mosasaurus, Plesiosaurus.

Stonesfield. *Oolite.* Megalosaurus, Teleosaurus, Pterodactyles.

Stourton, Cheshire. *New Red.* Foot-prints of reptiles (Cheirotherium), &c.

Street, Somersetshire. *Lias.* Ichthyosauri and Plesiosauri.

Swanage, Isle of Purbeck. Goniopholis, Chelonians.

Tilgate Forest. *Wealden*; quarries in various localities. Iguanodon, Megalosaurus, Hylæosaurus, Suchosaurus, Turtles, and Tortoises.

Watchett, Somersetshire. *Lias.* Plesiosauri, Ichthyosauri.

Warwick, Guy's Cliff, near. *New Red.* Labyrinthodon.

Westbrook, Wilts. *Kimmeridge Clay.* Ichthyosaurus.

Weston, near Bath. *Lias.* Plesiosaurus.

Whitby, Yorkshire. *Lias.* Ichthyosauri, Plesiosauri, Teleosaurus.

Wight, Isle of; along the southern shore, near Brook-Point. *Wealden.* Iguanodon, Cetiosaurus, &c., washed up on the sea-shore.

CHAPTER XVIII.

ORNITHOLITES; OR FOSSIL BIRDS.

Excepting in strata of comparatively modern origin, the remains of Birds are of extreme rarity in a fossil state. In the caverns that contain the skeletons of carnivorous animals, and which in many cases were once their dens, the bones of several species of existing genera of Birds have been discovered, in England, on the Continent, in America, and in Australia; and recently there have been obtained from alluvial deposits in New Zealand the skeletons of Birds, some of enormous magnitude, and under conditions which leave some doubt whether, like the *Dodo*, the species may not have been extirpated by man during the last few centuries; or even if some

stray individuals of the race may not, according to the belief of the aborigines, be still, in existence in the interior of the country.

From the gypsum quarries at Montmartre, near Paris, Baron Cuvier obtained several species of Ornitholites; and Prof. Owen has described the relics of three or four species from the London Clay: these fossil birds of the eocene tertiary deposits are the most ancient relics of this class known to the geologist, with the exception of the foot-prints on the *New Red* sandstone of North America, that have been referred to animals of this class.

The rarity of the remains of Birds may probably in some measure be attributable, as Sir C. Lyell has suggested, to the peculiar organization of these animals; for their power of flight necessarily renders them less liable to be engulphed and imbedded in the deltas of rivers or in the bed of the ocean, than quadrupeds; and the lightness of their structure, occasioned by their tubular bones and feathery dermal integument, generally prevents the sinking of the bodies of such as die on, or fall into, the water; so that their carcases are devoured or decomposed.

In illustration of this subject, I purpose, in the *first* place, to explain such peculiarities in the osteology of the animals of this class, as may assist the collector in the identification of their fossil remains; *secondly*, to take a cursory survey of the geological distribution of fossil Birds, and examine a few of the most interesting examples; and *lastly*, consider the striking phenomena presented by the foot-prints of supposed Birds on the strata of those ancient deposits which are comprised in the *Trias* or New Red formation.

OSTEOLOGY OF BIRDS.

I. OSTEOLOGICAL CHARACTERS.—The skull in adult birds presents this remarkable feature, that it is composed of but one bone without any trace of suture: the osseous tissue is very compact; the bone is white, and very smooth externally. The lower jaw is formed, as in reptiles, of several bones, namely, articular, angular, supra-angular, and dental; it is united to the skull by the intervention of a bone (*os quadratum*), as in certain reptiles. Both jaws are destitute of teeth, and are protected by dense horny sheaths, which form powerful dentary organs. The vertebral column of the neck is exceedingly flexible, and is composed of a greater number of bones than in any other living animals; for the cervical vertebæ, which in the mammalia amount to seven, in birds vary from ten to twenty-four, as in the Swan. To admit of this extreme mobility of the neck without injury to the enclosed spinal cord, the annular part, or neural arch, of each cervical vertebra is enlarged at the extremities that form a junction with the corresponding bones; thus presenting a modification of vertebral development directly the reverse of that possessed by the extinct saurian of the Magnesian conglomerate (see p. 714). The dorsal and sacra vertebral, on the contrary, are firmly interlocked, and often anchylosed together, and constitute a strong, inflexible pillar to afford a fixed point of support to the powerful locomotive organs of flight. There are no *lumbar*, or rib-less vertebræ. The sacrum often consists of eighteen, twenty, or more vertebræ, anchylosed into a solid bone. In the young Ostrich the vertebræ may be found separate and distinct; and the neural arch is shifted to the union of two vertebræ, as in the *Megalosaurus*. The sacral spinal

cord is almost as large as the brain; to supply the large muscles. The foramina for the passage of the nerves are double, one for the sensitive, and the other for the motive root, which pass out separately and unite in. a ganglion externally. The ribs are formed so as to combine strength with lightness in the construction of the walls of the chest, for each rib has a *recurrent apophysis*, or process, that extends backwards, and glides over the contiguous bone; this is a very peculiar and obvious character.[719] The ribs are united in front to the sternum by bony processes, analogous to the *costal-arcs* of the Plesiosaurus. The pectoral arch is distinguished by the prominent longitudinal keel or crest of the sternum; a structure designed to give attachment to the powerful pectoral muscles which move the wings, and which presents characteristic modifications in the different orders; and by the peculiar bone, termed the *furcula*, or merry-thought, which connects the clavicles. The clavicles are strongest and most open in birds of strongest flight. The coracoids (in birds) relate to respiration, and serve to admit of contraction and expansion of the sternum and abdomen. The bones of the anterior extremities are modified to adapt these instruments for the purposes of flight, and those of the fore-arm (*radius* and *ulna*) are very long, and firmly united together; the ulna has a row of slight eminences for the attachment of the quills of the secondary feathers. The wrist, or *carpus*, is composed of but two bones, articulated to the radius and ulna, and which admit only of a *lateral* movement, by which the wings are folded close to the body. The bones of the hinder extremities consist of the thigh or *femur*;[720] the leg-bones, *tibia*[721] and *fibula*, the latter very small and anchylosed to the former; and of a single

shank-bone, which supplies the place of the tarsal and metatarsal bones of other animals. This bone is articulated at its upper extremity to the tibia, and terminates at the lower end in distinct processes, which correspond in number with the toes; each process having a groove for the pulley-like tendon that moves the corresponding toe. This construction is peculiar to birds; for although in some quadrupeds, as the horse for example, the metatarsus consists of but one piece, the tarsus is composed of several bones.

[719] In very old crocodiles an analogous apophysis, which is generally cartilaginous, is sometimes found, ossified (*Owen*).

[720] The acetabulum, or socket for the head of the thigh-bone, is always perforated. The femur has a surface for the articulation of the fibula; and by this character the femur of all birds may be distinguished. There is always a *patella*.

[721] The lower end of the tibia is very like that of the femur.

The toes of birds present deviations equally recognisable; for the number of the articulations (or *phalangeal* pieces of bone) in each toe is different. Thus the thumb, or short toe, has *two* bones; the first toe on the inner side *three*; the the middle toe *four*; and the outer toe *five*. In general, three toes are directed forwards, and one backwards. In some species, the thumb or opposable toe is altogether wanting; in others, as in the swallow, it is directed forwards; in climbing birds, both the outer and the back toe are situated behind. The position of the hind toe, therefore, affords an important indication of the habits of the bird (see *Wond.* p. 146, *Lign.* 23),

and from a fragment of the lower extremity of the shank or tarso-metatarsal bone, with any trace of this articulation, we may determine whether the individual to which it belonged was a climber, wader, &c. In the toes of Crocodiles alone, the number of joints is the same as in birds; but in these reptiles, each toe is supported by a distinct metatarsal bone. The osteological peculiarities above enumerated may assist the collector in arriving at some general inferences as to the nature of any fossil remains of birds.

FOSSIL BIRDS.

II. ORNITHOLITES, OR FOSSIL BIRDS.—The fossil remains of birds consist in general of their osseous skeletons, and of detached bones, and rarely of the feathers and eggs.

PLEISTOCENE EPOCH.—Bones of the DODO[722] (see *Wond.* p. 131), a bird which appears to have become extinct by human agency within the last two centuries, have been found, associated with the remains of a recent species of Tortoise, beneath a bed of lava in the Isle of France. And in some caverns in the island of Rodriguez, the bones of one or more large birds allied to the Dodo have also been discovered.

[722] See Penny Cyclopædia, *Art.* DODO, and the beautiful work on the natural history of the Dodo and its Kindred, by the late lamented Mr. Strickland and Dr. Melville, 4to.

DINORNIS (*fearfully great bird*). *Pict. Atlas*, frontispiece, and p. 172—Numerous bones of large extinct birds have been obtained in New Zealand by Mr. Rule, the Rev. W. Williams, Col. Wakefield, Mr. Walter Mantell, and others. These have been referred

by Professor Owen to tridactylous struthious birds (one of which was one-third larger than the African ostrich), resembling the living *Apteryx* of New Zealand (*Wond.* p. 128, *Petrif.* p. 106) in the proportions of the tibia to the metatarsus, and also in the rudimental state of the wings. The bones are found in the recent alluvium, but probably in some cases at least they have been washed by the streams from older alluvial deposits.

An account of the history of the discovery of the gigantic Moa's bones in New Zealand (*Wond.* p. 129) is given in full in *Petrif.* p. 93, *et seq.*; and the scientific description of the various parts of the skeleton of the DINORNIS and PALAPTERYX, chiefly collected from Professor Owen's elaborate and finely illustrated memoirs in the Transactions of the Zoological Society, should be consulted, *Petrif.* p. 108, &c. Of *Dinornis* Professor Owen discriminates seven or eight species; of *Palapteryx*, three species; and indications of a species of a third associated genus, APTORNIS.

Fragments of egg-shell accompany these interesting relics of birds from New Zealand. From Madagascar also bird-bones and eggs have been obtained in a fossil state, that indicate the original bird (*Æpyornis*) to have been even of a greater size than the Dinornis.

ORNITHOLITES OF THE CAVERNS.—Many limestone districts abound in fissures and caves, which vary in extent from more superficial hollows to deep excavations and caverns of considerable magnitude (*Wond.* p. 175, &c.) Beneath the stalagmitic or sparry floors of some of these caverns, the bones of extinct species of Cats, Bears, and

Hyænas, occur in immense quantities; but the full consideration of these phenomena will be reserved for the next chapter. The skeletons and detached bones of several kinds of Birds are often found imbedded with these remains; and under circumstances which seem to indicate that they were brought into these caverns as prey by the carnivora, with whose relics they are now associated. Some examples show that the birds had fallen into the fissure; others, that their bones had been transported to their present situation by the action of water.

In the Cave of Kirkdale, in Yorkshire (*Wond.* p. 179), Dr. Buckland found bones of the Raven, Lark, Pigeon, Duck, and others; and as almost all the specimens were the remains of wing-bones, it is considered probable that they are the relics of dead birds, which had been brought into the cave by the hyænas, whose den it is supposed to have been for a considerable period (*Reliquiæ Diluvianæ*, p. 34).

Similar remains have been discovered in the Kent's Hole cavern, and in that at Berry Head, Torbay; from the latter Professor Owen has obtained the wing-bones of a Falcon (*Brit. Fos. Mam. and Birds*, p. 558).

In France, the Lunel-Viel caverns have yielded a few bird-bones; and many such remains occur in the caves of Brazil, described by M. Lund.

The so-called "bone-breccia" of the coasts and islands of the Mediterranean (*Wond.* p. 185) contains frequent remains of birds: they have been especially noticed at Cette, Nice, Sardinia, and Gibraltar.

In the deposits especially referred to the northern drift or Boulder-clay period, fossil birds appear to be

very rare, although the remains of vertebrate terrestrial animals are locally abundant. Dr. Buckland states that some bones, apparently of a species of goose, found at Lawford, with the remains of Hyæna, Elephant, Rhinoceros, &c., is the only instance he has met with of fossil birds in the drift of England (*Reliq. Diluv.* p. 27).

On the Continent, bird-bones have been found, at Quedlingbourg, Meissen, and in the Lahn Valley, in deposits said to be of this age.

ORNITHOLITES OF THE OLDER TERTIARY DEPOSITS. (*Lign.* 246.)—The very rich pliocene deposits at Œningen (p. 559) have afforded a few fragments of birds' bones.

Three or four species of Ornitholites (Duck, Heron, Flamingo, &c.), and several examples of the eggs of birds, have been discovered in the lacustrine strata of Auvergne. Birds' bones also occur in the fresh-water limestone near Issoire, in the Buy de Dôme, associated with the remains of eocene mammalia. In Germany, bird-bones have been found in tertiary deposits at Wiesbaden, Wiesnau, and Mornbach. In the Siwalik Hills the remains of birds are associated with the fossil reptilia and mammalia, to which reference has already been made (p. 731).

From the quarries of gypseous limestone of Montmartre, near Paris, Baron Cuvier obtained many bones, and some connected portions of the skeletons of several birds related to the Pelican, Sea-lark, Curlew, Woodcock, Owl, Buzzard, and Quail.[723] In several of these examples there are the imprints and remains of the quills and feathers; in some the skeleton has perished, and a pellicle of dark-brown substance, with the configuration of the original,

alone remains (see *Lign.* 246). These Ornitholites are associated with the bones of the Palæotheria, and other extinct mammalia of the eocene period. Two or three Ornitholites have been discovered at Montmartre, in which almost the entire skeleton is preserved. In one example, described by Cuvier, the remains of a bird are displayed in such a manner as to render it probable that the animal had fallen on its belly, and become partially impacted in the surface of the soft gypsum, which is now become solid stone; and that, previously to its being completely enveloped, the principal part of its head and the left leg were removed either by some voracious animal, or by the action of the water. In addition to the other parts of the skeleton, the under side of the bill is very distinctly impressed on the stone, and the left branch is entire; there are also the remains of the cellular basis of the skull; and both the wings are well preserved. Nine or ten species of fossil birds were identified by Cuvier from the Paris eocene strata.

[723] Ossemens Fossiles, tom. iii. p. 302, plates lxxii.—lxxv.

FOSSIL VULTURE.



Lign. 246. Fossil Bird. *Eocene. Montmartre.*
(Cuvier, *Oss. Foss.* vol. iii. p. 318, pl. lxxiii. *fig.* 2.)
The remains of this individual consist only of a thin brown pellicle, in form and proportions of the head, body, and limbs.

LITHORNIS VULTURINUS. *Geol. Trans.* 2d series, vol. vi. p. 206, pl. xxi. figs. 5 and 6.—Under the name of Lithornis (*petrified-bird*), Professor Owen has described the fossil remains of a bird, consisting of two most characteristic bones,—the sternum and sacrum,—and fragments of other bones, obtained from the London Clay of the Isle of Sheppey. These relics present a close agreement with the corresponding bones of the Vulture tribe, but indicate a smaller species of Vulture than any now known to exist.

In his "History of British Fossil Mammalia and Birds," 1846, Professor Owen has also described another sacrum from the Sheppey Clay, a *sternum* from Primrose Hill, and the *cranium* of a bird, probably of the *Halcyonidæ* family, from the same eocene deposit at Sheppey. This has also yielded a portion of shank-bone, which, according to Mr. Bowerbank, indicates a bird of the size of a full-grown albatross. Brit. Assoc. 1851.

Some few specimens of cylindrical bones from the Chalk and the Wealden[724] have been previously referred to Birds, and described as remains of species of that family. These fossils, however, have lately been reexamined in comparison with more perfect bones of similar character; and, with the exception of a few, the structure of which decidedly has the characters belonging to bird's bone, the result of this investigation has assigned them to Pterodactyles. [725] The long thin cylindrical bones from the Stonesfield Oolite are probably all Pterodactylian also, as suggested by the late Mr. Miller.

[724] One fragment of a bone, apparently of an *ulna*, retained a row of small eminences, probably the points of attachment for the quills of the secondary feathers of the wings. This specimen would appear to have a decided reference to ornithic structure, but it was transferred to the British Museum, and is not now to be seen.

[725] See *Quart. Geol. Journ.* vol. ii. p. 96, &c.; and Owen's *Monograph on Chalk Reptiles*, 1851, p. 80, *et seq.* It is to be hoped that the eminent microscopists, Mr. Bowerbank and Professor Quekett, may be enabled before long to elucidate the intimate structure of pterodactylian bone; which, although of an

essentially reptilian type, has characters of its own, offering some resemblances to bird-structure, that have not yet been fully described. Some specimens of bones from the Wealden (for instance, the specimen figured in *Geol. Trans.* 2d ser. vol. v. pl. xiii. *fig.* 6, and *Geol. Journ.* vol. iv. pl. i. *fig.* 9,) exhibit under the microscope an intimate structure resembling that seen in bird-bone, in contradistinction to that characteristic of reptilian bone. But until we are better acquainted with the microscopic structure of the osseous tissue of the Pterosaurians, and are in possession of more perfect specimens of bones, it cannot be satisfactorily determined to what extent the class of Birds existed in the country of the Iguanodon.

ORNITHOIDICHNITES.

III. ORNITHOIDICHNITES. (*Bird-like foot-prints.*) *Ligns.* 247, 248. *Bd.* pl. xxvi. *a*, xxvi.*b*.—The palæontological history of the class of birds, as evidenced by the foregoing pages, is carried back but to a comparatively recent era in the earth's history: and indeed, in the present state of our knowledge, it may be said that all positive evidence of the former existence of this highly organized class of vertebrated animals is confined to the Tertiary and Wealden deposits. A most interesting discovery, however, by Dr. James Deane,[726] of Greenfield, U. S. seems to prove that numerous bird-like bipeds, and some of gigantic size, existed at the period when the Triassic or *New Red* strata were in the progress of formation; that period, as the reader will remember, in which the Labyrinthodonts and other extraordinary reptiles flourished. *Rep. Brit. Assoc.* 1841, p. 230, note.

[726] See "Illustrations of Fossil Foot-prints

of the Valley of the Connecticut," 1849, 4to. with nine plates.

In certain localities of the New Red sandstone in the valley of the Connecticut, numerous tridactyle markings had been occasionally observed on the surfaces of the slabs of stone when split asunder, in like manner as the ripple-marks appear on the successive layers of sandstone in Corncockle Muir, Tilgate Forest, &c. Some remarkable distinct impressions of this kind at Turner's Falls (Massachusetts) happening to attract the attention of Dr. Deane, that sagacious observer was struck with their resemblance to the foot-marks left on the mud-banks of the adjacent river by the aquatic birds which had recently frequented the spot. The conviction that the imprints on the stone were referable to a similar origin with those on the mud was so strongly impressed on his mind, that he immediately collected a series of specimens, and communicated his discovery and opinion to Professor E. Hitchcock, who followed up the inquiry with a zeal and success that have led to the most interesting results. No reasonable doubt now exists that the imprints in question have been produced by the tracks of bipeds, impressed on the stone when in a soft state. The announcement of this extraordinary phenomenon was first made by Professor Hitchcock, in the American Journal of Science (January, 1836); and that eminent geologist has subsequently published full descriptions of the different species of imprints which he has detected, with excellent lithographs, in his "Geology of Massachusetts." (See *Petrif.* pp. 64-73.)

Three highly interesting specimens of the Ornithoidichnites of North America, collected and

developed by Dr. James Deane, have been lately added to the collection of organic remains in the British Museum. They exhibit several varieties of the foot-prints, and are in a very fine state of preservation. The surface of the largest slab is eight feet by six, and bears upwards of seventy distinct impressions, disposed in several tracks, as shown in the *Lign.* 247. The direction and disposition of the foot-tracks are rendered more distinct by the lines drawn from one imprint to another in the consecutive series.

The principal tracks on this slab, *Lign.* 247, are as follow;

Fig. 1 to 1, directed from below upwards, is a track consisting of six large footsteps.

2 to 2, from above downwards; a track of four foot-prints, disposed almost in a right line, and very far apart.

3 to 3, a track of five foot-prints, from above downwards, of a large, heavy animal, like fig. 1.

4 to 4, from above downwards, four foot-prints like *fig.* 2, disposed in a nearly straight track, and far apart.

5, a track of five heavy foot-prints, directed obliquely upwards.

6 to 6, five foot-prints of a large biped, in a track from below upwards.

7, a series of five delicate foot-prints.

8 to 8, a track of eleven very small foot-prints, disposed in zigzag, and extending obliquely from the right extremity to the upper edge of the slab.

9 to 9, a track of four large and distant foot-prints, passing obliquely across the stone from left to right.

I subjoin also a representation of one of the smaller foot-prints, of the natural size, the surface of the stone being sprinkled also with hemispherical

markings produced by drops of rain. (*Lign.* 248.)

A Slab of NEW RED SANDSTONE (*eight feet by six*), from Turner's Falls, Massachusetts, United States, covered with numerous Foot-marks of BIPEDS; indicating the Tracks of ten or twelve individuals, of various sizes. Discovered by *Dr. James Deane*, of Greenfield, Massachusetts. This Specimen is now in the British Museum.—(*From the American Journal of Science*, vol. xlvi. p. 73.)

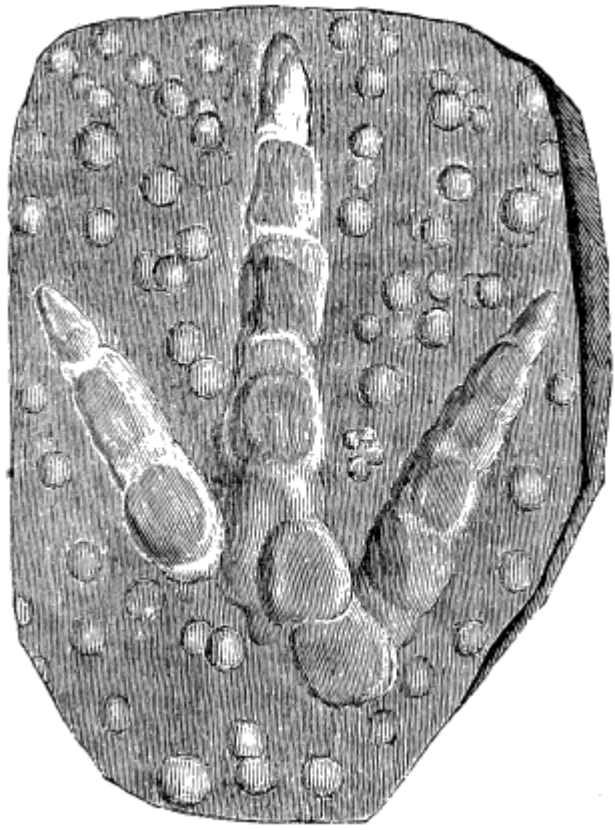


LIGN. 247. ORNITHOIDICHNITES, OR IMPRINTS OF

Click o

ORNITHOIDICHNITES.

The above will suffice to give the reader a general idea of the nature of these extraordinary impressions. A few shapeless fragments of bones are the only vestiges of the skeletons of any animals, with the exception of fishes, that have been found in the strata which have furnished the slabs of Ornithoidichnites. Some Coprolites also have been discovered.



LIGN. 248. BIRD-LIKE FOOTPRINT, AND IMPRESSIONS OF RAIN-DROPS, SANDSTONE (*nat.*). *New Red Formation; Massachusetts.*
[Amer. Journ. of Science, (1843,) vol. xlvi. p. 73.]

The enormous size of some of the foot-marks is

calculated to excite great surprise. I have in my possession (through the kindness of Dr. Deane) imprints that prove the size of the foot to have been fifteen inches in length, and ten inches in width, exclusive of the hind claw, which is present in some species, and is here two inches long. The foot-prints of this biped when in a consecutive series of five or six, are from four to six feet apart; which, of course, must have been the length of the stride; the longest stride was probably made by the animal when running; the shortest, when walking at a moderate pace. These footsteps indicate proportions so far exceeding those of all known living bipeds,—for the foot of the African ostrich is but ten inches long,—that the geologist may be pardoned for having hesitated to adopt the opinions of the American savans, in the absence of any relics of the osseous structure of the supposed birds; although sanctioned by the high authority of Dr. Buckland, who, from the first, concurred in the views of Professor Hitchcock (*Bd.* ii. p. 39): but this objection has been in a great measure removed by the discovery of the remains of the gigantic Moa or Dinornis of New Zealand, with feet equal in magnitude to the largest of the Connecticut foot-prints. See p. 763, and *Pict. Atlas*, frontispiece. Professor Hitchcock is of opinion that upwards of forty species of these biped foot-prints may be distinguished. Foot-prints referable to chelonians, batrachians, and lizards are associated with the above.[727]

[727] Trans. Amer. Phil. Soc. n. s. vol. x. pt. ii. p. 312.

In the New Red Sandstone of Stourton Hill, near Liverpool, Mr. Cunningham has observed tridactylous, webbed foot-prints,[728] $2^1/_2$ inches

long, which he refers to a bird; Mr. Hawkshaw also noticed some bird-like tracks at Lymm; and Professor Harkness met with a trace of a biped at Weston Point, near Runcorn. These appear to be the only indications of ornithoidichnites in the Trias of England; and these are very obscure.

> [728] These are accompanied by cheirotherian prints, and by the cast of an impression quite similar to that made on the sands of the sea-beach of to day, by the Medusa (sea-nettle or jelly-fish) left by the reflux of the tide and exposed to a few hours of sunshine. Mr. Cunningham and Mr. Pidgeon have furnished a figure of this interesting impression of the "jelly-fish," which has left "the solid memorial of its evanescent existence en the ancient strand" of the Triassic sea, showing that the physical conditions of land, water, and atmosphere were the same then as those that now obtain.—*Liverpool Lit. Phil. Soc. Proc.* 1848, p. 128, *fig.* 1. A similar imprint on a Jurassic rock in Germany is referred to at p. 280.

In the Wealden of Hastings and the Isle of Wight, the natural casts of large tridactylous foot-prints have been observed by Mr. Taggart and Mr. Beckles (see *Quart. Journ. Geol. Soc.* vol. ii. p. 267, vol. vii. p. 117, vol. viii. p. 396, and *Geol. Isle of Wight*, p. 328), but as yet no solution of the mystery at present enwrapping these gigantic, tridactylous, biped (?) ichnolites has presented itself: we only know that the creature that left them traversed the borders of the mighty river which floated down the bulky carcases of the Hylæosaur and Iguanodon.

ON COLLECTING FOSSIL BIRDS.

ON COLLECTING THE FOSSIL REMAINS OF BIRDS.—Notwithstanding the extreme rarity of fossils of this class, the student should not be discouraged in his search for the remains of Birds in the secondary rocks. That far more instructive specimens than any that have fallen under my observation may be discovered in the Wealden strata by diligent research, there can be no reasonable doubt. It is also very probable that the Stonesfield slate, which abounds in remains of terrestrial plants and animals, will be found to contain Ornitholites. It is important for the collector to bear in mind, that when only a fragment of the shaft of a bone remains imbedded in the stone, if the imprint of the other portions be preserved, he may obtain a knowledge of the form of the extremities; in the same manner as the external markings of the surface of a shell may be ascertained, when the shell itself is lost or destroyed, and a smooth stony cast of the internal cavity only is left. The same remark will apply to the bones of reptiles and other animals; for example, a perfect leg-bone may be imbedded in a block of limestone; but, when exposed by breaking the stone, a portion of the shaft may alone remain attached, and both extremities be shattered to pieces by the concussion of the blow; yet, if the impression remains, the entire form of the original may be determined.

The *foot-prints*, not only of birds, but of reptiles and other animals, should be diligently sought for on the surfaces of laminated strata of sand and clay, and especially where the presence of ripple-marks, and the impressions of rain-drops, indicate that the beds were deposited in shallow water. The forest-marble flags at Castle Comb, north of Bath, the Stonesfield slates, and the sandstones around Horsham (in Sussex), and particularly at Stammerham (see *Geol.*

S. E. p. 213), are often rippled, and it is therefore probable that the foot-prints of some of the Oolitic and Wealden quadrupeds and bipeds, if such existed, will sooner or later be discovered.

CHAPTER XIX.

FOSSIL MAMMALIA.

The remains of MAMMALIA discovered in a fossil state include an immense number of species, and furnish examples of almost every living genus, and of numerous genera, and even orders, of which no existing species are known. Yet amidst the vast accumulations of the skeletons of the higher orders of vertebrata contained in the tertiary deposits, and in the superficial drift, belonging to species which have successively appeared on the surface of our planet, flourished for indefinite periods of time, and then become annihilated, no vestiges of MAN, or of his works, have been detected. Human skeletons, naturally imbedded, have hitherto only been observed in the silt of modern alluvial plains,[729] in peat-bogs (*Wond.* p. 64), and in conglomerates of recent date, such as are in the progress of formation on the sea-shores, particularly where the water is loaded with the detritus of shells and corals, and the waves transport the calcareous matter along the margins of creeks and bays, or deposit it in the shallows along the coast (see *Wond.* p. 87, and *Petrif.* p. 483).

[729] There seems, however, reason to believe that the human skulls and bones found with elephantine and other remains in the Alps of Swabia, are of contemporaneous origin with these extinct mammals. (See *Literary Gazette*, 1853, p. 1027.)

The geological distribution of fossil mammalia, [730]—the occurrence of the entire carcases of extinct species of Elephant and Rhinoceros in blocks of ice (*Wond.* p. 151),—of recent species in the superficial alluvial clay and silt,—of recent and extinct forms in the Drift or Pleistocene deposits (*Wond.* p. 147),—of the gradual preponderance of unknown species and genera, in proportion as we carry back our retrospect to the most ancient Tertiary strata (*Wond.* p. 254), —the sudden disappearance of all vestiges of the entire Class of Mammalia, with the last bed of the Eocene deposits,—with the exception of a few minute jaws in one set of beds of the Oolite in England (*Wond.* p. 510), and of a few teeth in the Trias (?) of Germany, [731] the sole records of the existence of any of the highest types of animal organization throughout the vast periods of the secondary formations—are so fully treated of in the *Wonders of Geology*, that I need not dwell upon the subject in the present volumes. Neither is it desirable to enter at large upon this department of Palæontology, for it were vain to attempt the elucidation of the anatomical characters of but one extinct species of Mammalia, without giving details of structure, that could only be successfully demonstrated in a work expressly devoted to the subject. Referring, therefore, to Cuvier's *Ossemens Fossiles*, and to Professor Owen's "*History of the British Fossil Mammalia*," 8vo. 1846, I must limit my remarks on the Fossil Mammalia to a brief summary of modern discoveries, with

suggestions for the identification and collection of some of the most interesting or prevalent remains.

[730] For a notice of the distribution of mammalian remains in the Upper Tertiaries of Europe, see Phillips's *Geology*, 1853, vol. i. p. 45, &c.

[731] For an account of these teeth of small insectivorous mammals from the "bone-bed" of Würtemberg, which has an analogous position at the top of the Trias with the "bone-bed" of Axmouth and Aust Cliff, see *Ly.* p. xiv. figs. 529-531.

The fossil remains of Mammalia will be considered under the following heads:—

I. CETACEA, or animals of the *Whale tribe*.
II. RUMINANTIA; including the *Camel*, *Giraffe*, *Deer*, *Sheep*, *Ox*, &c.
III. PACHYDERMATA; comprising the *Proboscideans*, as the *Elephant*, and the ordinary *Pachyderms*, as the *Rhinoceros*, *Horse*, *Swine*, &c.
IV. EDENTATA: animals without teeth, or with only molars, as the *Ant-eater*, *Sloth*, *Megatherium*, *Mylodon*, &c.
V. RODENTIA, or GNAWERS; as the *Hare*, *Beaver*, *Rat*, &c.
VI. MARSUPIALIA; animals with an abdominal pouch, as the *Kangaroo*, *Opossum*, &c.
VII. CARNIVORA; including the *Bats*, *Moles*, and the carnivorous tribes in general.
VIII. QUADRUMANA; *Apes* and *Monkeys*.
IX. BIMANA; or *Man*.

FOSSIL WHALES.

I. FOSSIL CETACEA.[732]—The *Cetaceans*, although

popularly termed fishes, are as perfect air-breathing vertebrated animals, as the terrestrial mammalia, and, like them, give suck to their young. Instead of fore-feet or arms, they have a pair of fins or paddles, but are destitute of hinder extremities, the place of the latter organs being supplied by a powerful cartilaginous horizontal fin, appended to the tail. The Cetaceans, therefore, differ in this respect from the fossil marine reptiles, the Ichthyosaurus and Plesiosaurus (see p. 662), which have two pairs of paddles. This order, as is well known, comprises the most colossal forms of animal existence,—the Whales. Some are herbivorous, others carnivorous; many have powerful teeth; others are edentulous, the jaw being furnished with a series of elongate plates of the substance familiarly known by the name of *whale-bone*.

[732] *Cetacea*: an order of aquatic mammalia, comprising the W hales, Narwhals, Porpoises, Dolphins, and Dugongs.

The fossil remains of Cetaceans have, for the most part, been observed in alluvial silt and beds of drift, in valleys still traversed by rivers; but many examples have been discovered in elevated sea-beaches, proving that, although, geologically speaking, these beds are of modern origin, yet great changes in the relative level of the land and sea must have taken place since these remains were imbedded. Thus, on the banks of the river Forth, near Alloa, in Scotland, the skeleton of a Whale (*Balænoptera*), seventy-two feet long, was discovered imbedded in clay, twenty feet above the highest tide.[733] Cuvier mentions the discovery of bones of a *Lamantin* at Angers; of a Dolphin, and Rorqual, in Lombardy; and of a Grampus, in the pliocene of the Sub-Apennines.

[734]

[733] Dr. Fleming's *British Animals*, p. 39.

[734] For notices and descriptions of Cetacean remains found in England, see Owen's *Brit. Foss. Mammalia*, p. 516, *et seq.*

OTOLITHES OF CETACEANS.—Petro-tympanic bones of several large whales have been found in great numbers in the red Crag of Felixstow; among them is one of the genus Physeter, or Sperm-Whale. [735]

[735] Proc. Geol. Soc. for 1845, p. 41; and Brit. Foss. Mam. p. 526, &c.

BRIGHTON FOSSIL WHALE.—An interesting discovery of the anterior half of one side of the lower jaw of a Whale, undoubtedly coeval with the extinct Mammoth (*Elephas primigenius*), was made in 1828 in the Cliff, east of Kemp Town, Brighton, under the following circumstances. On the face of the Cliff, in the ancient shingle which lies immediately upon the chalk and is surmounted by beds of calcareous rubble, containing bones and teeth of Elephants, to the height of one hundred and twenty feet, some fishermen had observed a huge bone, that had been laid bare by an unusually high tide and now projected two or three feet beyond the face of the Cliff. Unable to remove it, they broke off the extremity, a fragment of which was sent to me. Upon repairing to the spot a few days afterwards, I found that the fishermen had renewed their attack, and demolished a considerable portion of the bone in ineffectual attempts to dislodge it from its bed; and had desisted only from the apprehension of being buried beneath the overhanging cliff, which is composed of loosely aggregated materials.

Unfortunately, the bone extended directly into the cliff, and it required several hours of labour, not unattended with danger, before an excavation was made sufficiently large to expose the entire specimen. It proved to be the anterior nine feet of the left branch of the lower jaw of a whale-bone Whale (*Balæna mysticetus*). It was of a light fawn colour externally, but the internal coarse osseous structure was delicately white; it was extremely brittle, and, upon attempting to move it, broke into a thousand pieces. Time would not permit of the application of a coating of plaster of Paris, for ere we had completed our task the tide was rapidly approaching, or this interesting relic might have been extracted entire. This portion of lower jaw, before it was mutilated by the fishermen, was twelve feet long, and thirty-six inches in circumference at the largest extremity. It must have belonged to a Whale from sixty to seventy feet in length.[736]

[736] The fragments of this jaw that were preserved are now exhibited in the British Museum, in Room V.

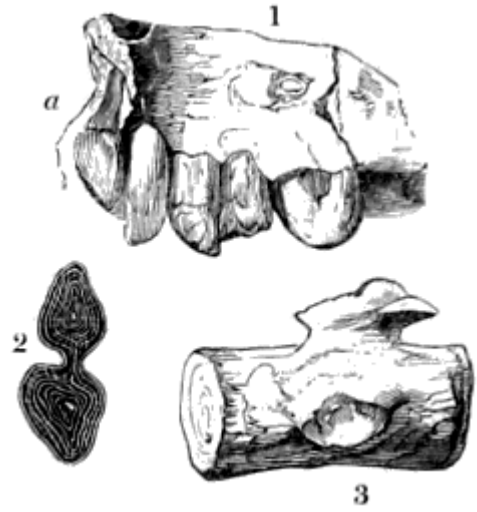
In the fluviatile silt of the valley of the Ouse, near Lewes (*Wond.* p. 63), the skull of a Porpoise and a portion of the cranium, with the socket of the long straight tooth, of a Narwhal (*Monodon monoceros*), were found twelve feet beneath the surface of the soil.

The bones of an herbivorous Cetacean, the *Manatus*, a genus now peculiar to the torrid zone, have been found in the eocene strata in various parts of France, associated with those of the Palæotheria and other extinct mammalia of the Paris basin.

ZEUGLODON.

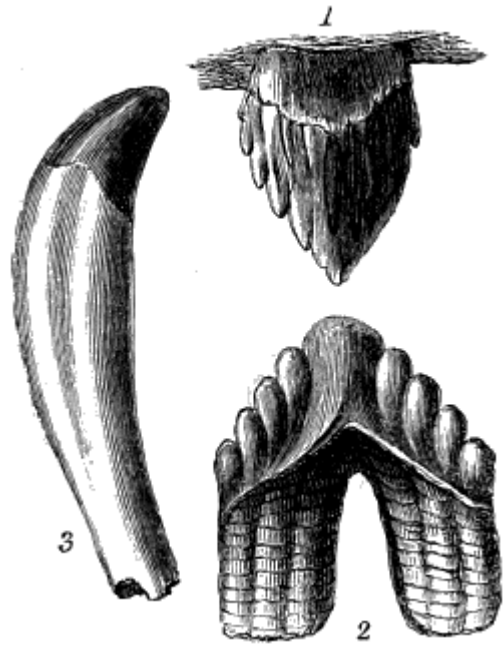
ZEUGLODON CETOIDES. *Lign.* 249.[737]—The remains of a very remarkable Cetacean, of an extinct genus, were first made known by Dr. Harlan, of Philadelphia, who obtained a considerable portion of the jaws with teeth, vertebræ, and other bones of an animal of enormous size, from Alabama and Arkansas, United States. These relics were discovered in tertiary (*eocene*) limestone, associated with a marine shelly conglomerate, from a cliff near the bed of the river Owachita. When first observed, the bones extended along the face of the rock, with intervals between them, to the extent of one hundred feet, and the animal to which they belonged must have exceeded seventy feet in length. Dr. Harlan ascribed these bones to an unknown reptile, which he called Basilosaurus (*king of the lizards*); but a more correct investigation, by Professor Owen, proved their cetacean character, and the peculiar form of the worn molar teeth suggested the name of *Zeuglodon* (*yoke-tooth*).

[737] Owen, *Geol. Trans.* 2d ser. vol. vi. p. 69, &c., plates vii. viii. ix.; Harlan's *Medical and Physical Researches*, p. 337, &c.; Gibbes, *Journ. Acad. Nat. Sc. Philadelphia*, 2d ser. 1847, vol. i. pp. 5 and 16; Bulkley, *Silliman's Journal*, vol. xliv. p. 409; Carus, *Nova Acta Cur. Nat.* vol. xxii. pt. ii. 1848.



LIGN. 249. ZEUGLODON CETOIDES.
PORTION OF THE JAW, WITH TEETH, AND A VERTE
Eocene. Alabama, United Slates.

Fig. 1. Portion of the Upper Jaw, with three teeth: $^1/_8$ *nat.*
— *a.* The exposed fang of a tooth.
2. Transverse section of the base of the crown of a tooth, showing
— the middle: $^1/_4$ *nat.*
3. A caudal vertebra: $^1/_{12}$ *nat.*
—



LIGN. 250. TEETH OF ZEUGLODON: $^{1}/_{2}$ *nat. Eocene. France and N. America.*

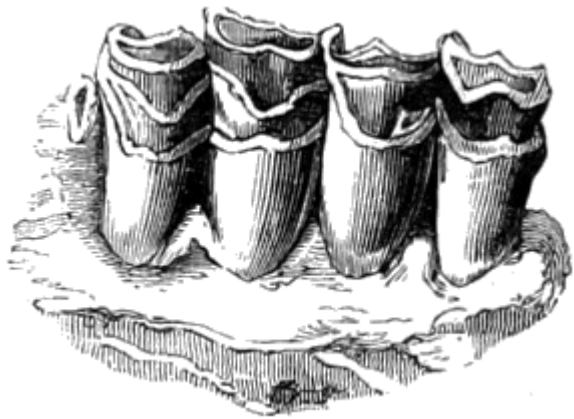
Fig. 1.— Upper tooth of Z. SQUALODON; from near Bordeaux.
2.— Molar tooth of Z. CETOIDES; from Alabama, United States.
3.— Canine tooth of Z. CETOIDES.

The teeth (*Lign.* 250) are of two kinds, some having but one fang, and others two, implanted in separate sockets and placed obliquely in the jaw; they are of a compressed, conical form, with an obtuse apex, the crown being deeply conjugate, or contracted in the middle, as shown in the transverse section, *Lign.* 249, *fig.* 2. They are devoid of enamel, but the dentine is coated with cement, and their structure is decidedly mammalian; and a microscopical examination, Professor Owen states, incontestably proves their cetacean character. The

longitudinal diameter of the middle tooth is three inches.

The vertebræ resemble those of the large cetacean known by the name of *Hyperoodon*; a caudal vertebra is figured *Lign.* 249, *fig.* 3. The original animal was related to the Dugong and Cacholot, and appears to have held an intermediate place between the latter and the herbivorous species.

FOSSIL RUMINANTS.



LIGN. 251. TEETH OF A RUMINANT. *Pleistocene. Gibraltar.* Imbedded in a mass of the "osseous breccia."

II. FOSSIL RUMINANTS. (*Owen's Brit. Foss. Mam.* p. 444, *et seq.*)—The fossil bones of animals of this order are very numerous in the alluvial deposits, in caves, and in pleistocene deposits, in almost every part of the world. They are generally associated with the remains of the next group. The skulls of Oxen, and horns and bones of the Bison and Auroch, have been found in North Cliff, Yorkshire, at Walton in Essex, and other parts of England. The fossil oxen appear to have been one-third larger than the recent species; and the horns are relatively more massive

than in the domestic race; some of the horns measure four feet across, at the widest expansion. In the immense accumulations of large mammalia in the tertiary beds of the Sub-Himalayan or Siwalik range, numerous remains of oxen occur. The teeth of one species are often found in the Elephant-bed at Brighton.

Of the Deer family the relics of several kinds have been discovered in Drift and Caverns. The cave of Kirkdale alone contained the remains of three species.[738] The bones of a species that cannot be distinguished from the common Bed Deer are found in the modern shell-marls of Scotland, associated with the remains of oxen, horse, boar, dog, wolf, and beaver. The bones and antlers of the Reindeer have been found at Brentford and other places (*Brit. Foss. Mam.* p. 479; and *Rep. Brit. Assoc.* 1851. Sect. p. 69). The ossiferous caverns, which contain bones of Carnivora, also yield those of Deer; as the caves of Kirkdale and Banwell, &c. in England, and the celebrated caverns of Muggendorf, on the Continent. A species of Musk-deer has been found at Epplesheim; and bones of deer are associated with those of the Dinotherium, in Rhenish Hesse, in late Tertiary deposits. The teeth and a lower jaw, with other bones, of a species of deer, were obtained from the Brighton Elephant bed (*Wond.* p. 114).

[738] The Rev. Dr. Buckland's *Reliquiæ Diluvianæ*; or, Observations on the Organic Remains found in Caves, Fissures, and Gravel; 1 vol. 4to. 1823, pl. viii. and ix.

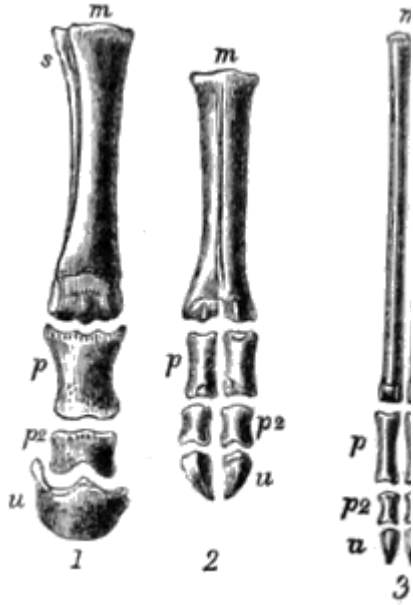
The most celebrated fossil animal of this family is the Gigantic Stag or Deer of Ireland (see *Petrif.* p. 455; *Wond.* p. 132), whose bones and antlers are found in immense quantities in superficial marl, in

Ireland, in the Isle of Man, and occasionally in England. (Geol. Journ. vol. iv. p. 42.) A skeleton that was found, almost entire, in marl abounding in fresh-water shells, at the depth of twenty feet, is six feet high, nine feet long, and nine and a half feet in height, to the top of the right horn. Some antlers are so large, that the interspace from one point to the other exceeds twelve feet.[739]

> [739] See *Pict. Atlas*, pl. lxxi.; a good figure of the skeleton of the fossil Irish Deer is given in the Penny Cyclopædia, vol. viii. p. 364; for a detailed account of this gigantic animal, see Owen's *Foss. Brit. Mammalia*, p. 444, and *Charlesworth's Journal*, p. 87.

The GIRAFFE, the tallest of known quadrupeds, and now restricted to the deserts of Africa, was once a native of Europe and Asia, for fossil bones of a species of this remarkable ruminant have been found at Issoudun, in France, and in the Siwalik mountains, with several varieties of Elk and Deer.

Of the CAMEL, the only ruminant with incisor teeth in the upper jaw, a gigantic species has been discovered by Dr. Falconer and Captain Cautley, in the Siwalik range.



LIGN. 252. BONES OF THE FEET OF HORSE, DEER, ANI

Fig. 1.— Fore-foot of the Horse.

2. — Deer.

3. — ANOPLOTHERIUM GRACILE.

m, m. Metacarpal bones ("canon-bone" in the Horse.)

s, in fig. 1, the "splint-bone," or rudimentary metacarpal.

p, p. First or proximal phalangeal-bones ("pastern" in the Horse).

p^2, p^2. Second phalangeals ("coronet" or "crown-bone" in the Horse).

u, u. Unguals, or bones of the hoof ("coffin-bone" in the Horse).

In this category we must notice another most interesting discovery of the indefatigable and eminent naturalists above mentioned, namely, the *Sivatherium* (see *Wond.* p. 163), an extinct animal, which forms, as it were, a link between the

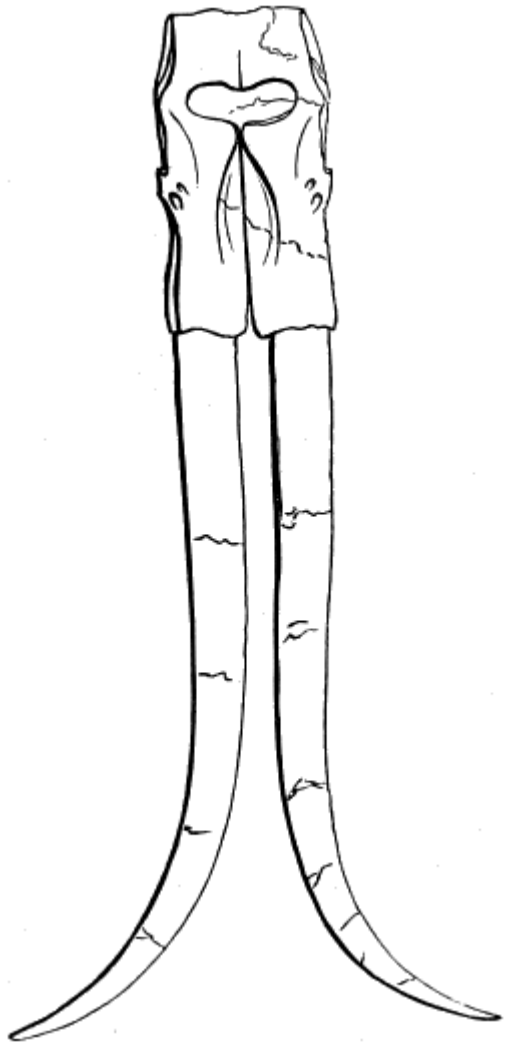
ruminants and the large pachydermata. The skull has four persistent horns, and was furnished with a nasal proboscis. The living creature must have resembled an immense Antelope or Gnu, with a short thick head and an elevated cranium, crested with two pairs of horns. A splendid specimen of the skull of the *Sivatherium* has been placed in the palæontological collection of the British Museum by Dr. Falconer (*Petrif.* p. 456, *Lign.* 98).

ELEPHANT. MASTODON.

III. PACHYDERMATA.[740]—The fossil remains of this order of mammalia are most abundant, and belong to numerous species, comprising many extinct genera of a highly interesting character. See Pictet's *Paléontologie*, new edit. 1853, vol. i. p. 127, *et seq.*

[740] See Owen on the Classification of the Pachydermata, *Quart. Geol. Journ.* vol. iv. p. 127, &c.





LIGN. 253. ELEPHAS GANESA.
Front view of the Cranium and Tusks.
(*The original is 14 feet long.*)

FOSSIL ELEPHANTS AND MASTODONS. *Lign.* 253, 254, 258-260. *Owen's Hist. Brit. Foss. Mam.* p. 217, &c.; *Wond.* pp. 147, 157.—The bones, teeth, and

tusks of Elephants, equal in magnitude to, and distinct from the existing African and Asiatic species, are scattered throughout the superficial alluvial and pleistocene accumulations of Europe.



LIGN. 254. MASTODON GIGANTEUS.
Unworn Molar Tooth: $^{1}/_{3}$ *nat. size.*
Upper Tertiary. Banks of the Hudson, N. America.

The fossil bones and teeth (*Pict. Atlas*, pl. lxxi. lxxiv.) of these gigantic animals are so abundant, that examples may be found in all the provincial, and in most private collections; and the British Museum possesses an unrivalled series of specimens of both groups of these colossal herbivorous mammalia, namely, the Elephants properly so called and the Mastodons (*Petrif.* pp. 463, 471). It contains an invaluable series of specimens from the Siwalik hills, presented by Capt. Cautley and Dr. Falconer (*Petrif.* p. 469); amongst which are remains in which the dental organs present every modification of structure, from that of the mastoid tubercles of the

tooth of the Mastodon, to the vertical laminæ of cement, enamel, and dentine of the Elephant. The Museum also possesses the entire skeleton of the Mastodon (*Petrif. Lign.* 107) formerly exhibited by M. Koch, as well as the fine suite of jaws and teeth obtained by the same indefatigable collector. This collection demonstrates that all the bones and teeth, apparently of several species, and, as some have supposed, of distinct genera, belong but to the one grand Mastodon—the *M. giganteus* of Cuvier; it also clearly proves that the young mastodon had a pair of tusks placed horizontally in the lower jaw; and that but one of these tusks became developed in the adult, and that only in the male.[741]

[741] This remarkable circumstance, in the infancy of palæontological science, gave rise to a very venial error; it was made to constitute the character of a new genus, to which the name *Tetracaulodon* was applied.

It is therefore unnecessary to enlarge upon this subject, for an inspection of a few specimens will afford the student a clearer insight into the structure of the skeletons and teeth of these animals than any description. The form of the teeth, and the disposition of the dental elements, are illustrated in *Wond.* p. 143, and *Ly.* p. 159.

DINOTHERIUM.

DINOTHERIUM. *Petrif.* p. 474; *Wond.* p. 173; *Bd.* i. p. 135, pl. ii.—At Epplesheim, forty miles north-east of Darmstadt, in beds of sand and marl of the median Tertiary formations, the jaws, teeth, skull, and other remains of the Dinothere, one of the most gigantic of terrestrial mammalians, have been discovered; they are preserved in the museum at Darmstadt. The

length of the largest species is estimated at eighteen feet. The teeth had previously been found in France, Bavaria, and Austria; and, from their close analogy to those of the Tapir, were described by Cuvier as belonging to an extinct colossal animal of that genus. But subsequent discoveries have shown that the *Dinotherium* was probably a proboscideal animal, and had two large curved tusks directed downwards in the anterior extremity of the lower jaw.[742]

[742] There are some fine specimens, and good models of the Darmstadt specimens, in the British Museum (*Petrif.* p. 474).



LIGN. 2
I
Restored
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CUVIERIAN PACHYDERMS.

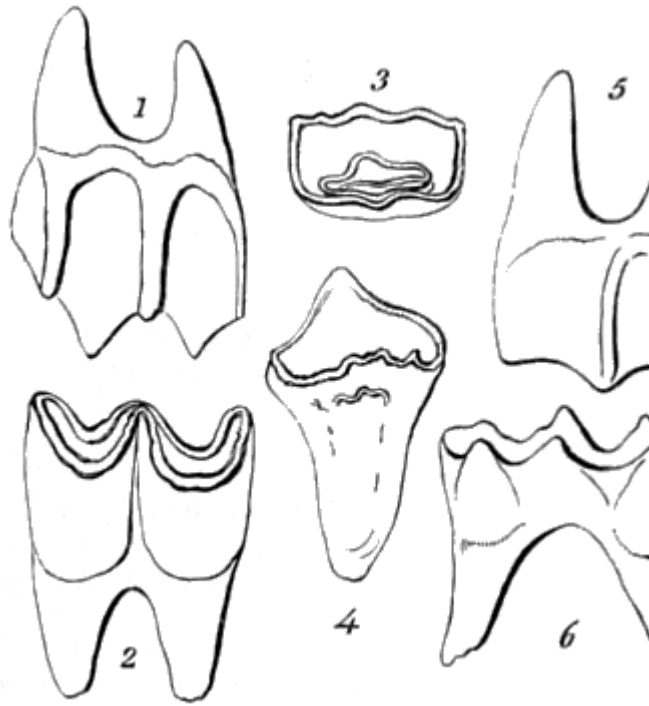
CUVIERIAN PACHYDERMS. *Lign.* 255, 256. *Owen's Brit. Foss. Mam.* p. 299, &c.; *Wond.* p. 254; *Bd.* i. p. 81; *Petrif.* p. 475.—A large proportion of the numerous bones and teeth which are found in the Tertiary gypseous deposits at Montmartre, near Paris, are referable to the several extinct genera of Pachydermata, which the genius of Cuvier first made known. The *Palæotheria* and *Anoplotheria* must be familiar to the intelligent reader, for the restored outlines of several species are appended to almost every work that treats of the ancient inhabitants of our globe. The details of their anatomical characters are given at length in *Oss. Foss.* tom. iii., illustrated with numerous plates.

The PALÆOTHERIA (*Brit. Foss. Mam.* p. 316, *et seq.*) resembled the Tapirs in their head and short proboscis, while their molar teeth approached those of the Rhinoceros, and their feet were divided into three toes, instead of four, as in the Tapirs. Upwards of eleven species have been discovered, varying from the size of the Rhinoceros to that of the Hog. Their remains are extensively diffused in the Upper Eocene strata in various parts of France; and have been found in the Isle of Wight.

The LOPHIODON (*crested-tooth*), a genus distinguished from the former by the characters of the teeth, which more nearly resemble those of the Tapirs, comprehends twelve species, all found in the fresh-water Tertiary marls of France. A canine tooth of a species of *Lophiodon* was found in the London Clay, in sinking a well on Sydenham Common, near the railway.[743]

[743] See Mr. Douglas Allport's interesting *History of Camberwell*, p. 17, and Owen's *Brit. Foss. Mam.* p. 306.

The ANOPLOTHERIA have two characters not observed in any other animal, namely feet with two toes (see *Lign.* 252), the metacarpal and metatarsal bones of which do not unite into a single piece, as is the case in the ruminants; and teeth placed in a continued series without any interval between them (*Petrif.* *Lign.* 111); man alone has the teeth arranged in the same manner. I subjoin figures of molar teeth of *Palæotherium* and *Anoplotherium* (*Lign.* 256).



LIGN. 256. TEETH OF PALÆOTHERIUM AND ANOPLOTHERI
Upper Eocene. Isle of Wight and Montmartre.

Fig. 1. Upper molar tooth (external surface) of PALÆOTHERIUM MAG

2. Lower molar of PALÆOTHERIUM MAGNUM.

3. Grinding surface of first upper molar of ANOPLOTHERIUM SEC
— *Binstead.*

4. Inner side view of right upper canine of ANOPLOTHERIUM CO
—

5. Upper molar of ANOPLOTHERIUM COMMUNE. *Montmartre.*
—

6. Lower molar of the same animal.
—

There are also sub-genera, as for example, *Xiphodon* and *Dichobune*, characterized by peculiarities of dental and osteological structure; and *Anthracotherium* (so named from two species having been found in a bed of Anthracite or Lignite, near Savone), a genus intermediate between the Palæotheria and Hogs. The skeletons of these remarkable animals are imbedded with the remains of carnivora, marsupialia, bats, birds, crocodiles, tortoises, and fishes.

In England, no remains of the extinct Pachydermata of the Paris Tertiary strata were discovered until a few years since, and they are still exceedingly rare. There have been found in the fresh-water limestone at Binstead, near Ryde, and at Seafield, Isle of Wight, (see *Geol. I. Wight*, 1854, Prefat. Note,) teeth and portions of the jaws of two species of Anoplotherium, four of Palæotherium, and one of *Chæropotamus*, an animal allied to the Hog Tribe (*Geol. Trans.* 2d ser. vol. vi. pl. iv.; and *Brit. Foss. Mam.* p. 413, &c.).

The *Hyopotamus* (*Lign.* 257) is a genus of Anthracotherioid pachyderms, two species of which have been determined by Prof. Owen (*Quart. Geol. Journ.* vol. iv. p. 103, &c.), from specimens of teeth found in the upper eocene of the north-west coast of the Isle of Wight, by the Marchioness of Hastings.

The *Palæotherium*, *Dichobune*, *Dichodon*, *Paloplotherium*, and others occur in the upper eocene fresh-water deposits of Hordwell Cliff (see *Charlesworth's Journal*, No. 1, p. 5, and pl. ii.; *Quart. Geol. Journ.* vol. iv. p. 17, and pl. iii.; and *Rep. Brit. Assoc.* 1851, *sect.* p. 67).

Two species of a new genus, intermediate between the Hog and the Hyrax, named by Professor Owen *Hyracotherium*, have been discovered in the eocene sands at Kyson, in Suffolk, and in the London Clay of the cliffs at Studd Hill, about a mile to the west of Herne Bay.[744] The latter specimen consists of a mutilated skull, about the size of that of a Hare, with the molar teeth perfect.

[744] Geol. Trans. 2d ser. vol. vi. pl. xxi. p. 203; and *Brit. Foss. Mam.* p. 419, &c.

The *Paloplotherium*, an allied genus, from Hordwell Cliff, is described in *Geol. Journ.* vol. iv. p. 103.

The other large fossil Pachyderms, belonging to the two existing genera of Rhinoceros and Hippopotamus, are found very extensively distributed in alluvial debris, in the ossiferous breccia of caverns, and in other pleistocene deposits; and their remains are frequently dug up in the superficial marls, clays, gravel, and sand of England. As the teeth of these animals will occasionally be met with by the collector, a brief explanation of their form and structure may be useful.



LIGN. 257. HYOPOTAMUS.
Incisor Teeth: *nat. size*. *Upper Eocene. Isle o*

Fig. 1.— Inner surface of an incisor of *Hyopotamus*.
3.— Lateral view of an upper incisor of *Hyopotamus*.
4.— Outer aspect of the crown of the same tooth.
5.— Inner aspect of ditto.
2.— Lateral view of the upper incisor of recent Hog (*Sus scrofa*).
(These figures are from plate vii. *Quart. Geol. Journ.* vol. iv.; but the reversed.)

TEETH OF MAMMALIA.

TEETH OF MAMMALIA.[745]—The organization of the teeth in the herbivorous mammalia essentially consists in the adaptation of the three elements of dental structure to the peculiar conditions required

by the habits and economy of the different species. Thus, in the Elephant (*Lign.* 259, 260), Horse (*Lign.* 263), &c., the dentine, cement, and enamel are disposed in vertical plates more or less inflected, the enamel and cement penetrating the body of the tooth, and embracing corresponding processes of dentine; an arrangement by which a grinding surface, composed of three substances of unequal densities, is produced and maintained in every state of detrition (*Owen*). But these teeth do not possess the symmetrical and complicated structure observable in those of many of the reptiles and fishes we have previously investigated. In the carnivorous mammalia, the enamel constitutes an external shell or case, investing the body of dentine and presenting sharp cusps or trenchant ridges, adapted for the laceration of flesh, as in the Tiger, or modified so as to form instruments for snapping and crushing bones, as in the teeth of the Hyæna. In the Mastodon, the crown of the tooth, when first emerged from the gum, presents a series of strong conical eminences (*Lign.* 254), that become worn down by use, at first into disks (*Ly.* p. 157), which, by further detrition, coalesce. The tooth of the Elephant (*Lign.* 259 and 260), on the contrary, consists of vertical plates of dentine, with an immediate investment of enamel, over which there is an external layer of cement that binds together the entire series of plates, often amounting to twenty or more; the horizontal surface produced by the detrition of such a structure, gives rise to the well-known grinding surface of the molars of the elephant (*Lign.* 259, 260; *Wond.* pp. 143 and 160; *Ly.* p. 159; Owens *Brit. Foss. Mam.* figs. 88-90, &c.). Detached plates of the teeth of Elephants, particularly of those which belong to the back part of the posterior grinder, and have not come into use,

are puzzling to the inexperienced collector of fossil remains; and the first indication I obtained of the existence of the remains of fossil Elephants in Brighton Cliffs (*Wond.* p. 150), was from a mass of this kind, dug up in sinking a well in Dorset Gardens, and sent to me as a "petrified cauliflower."

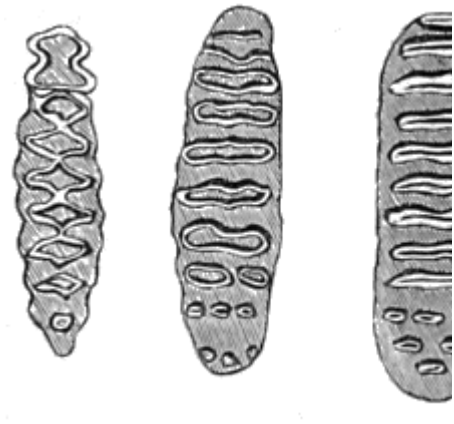
[745] For the minute structure of the dental organs, the modes of dentition prevalent in the mammalia, and the homologies of the teeth, we must refer to Prof. Owen's often-quoted works, the matchless *Odontography*, and the lucid and compendious Article on Teeth, in the *Cyclopædia of Anatomy and Physiology*.



LIGN. 258.
TOOTH OF MASTODON ELEPHANTOIDES: $^{1}/_{6}$ *nat. size.*
Upper Tertiary. Ava, Burmah.



LIGN. 259.
TOOTH OF ELEPHAS PRIMIGEN *nat. size.*
Upper Tertiary. Big-bone-lick. N.



LIGN. 260. TEETH OF ELEPHANTS: $^{1}/_{6}$ *na*

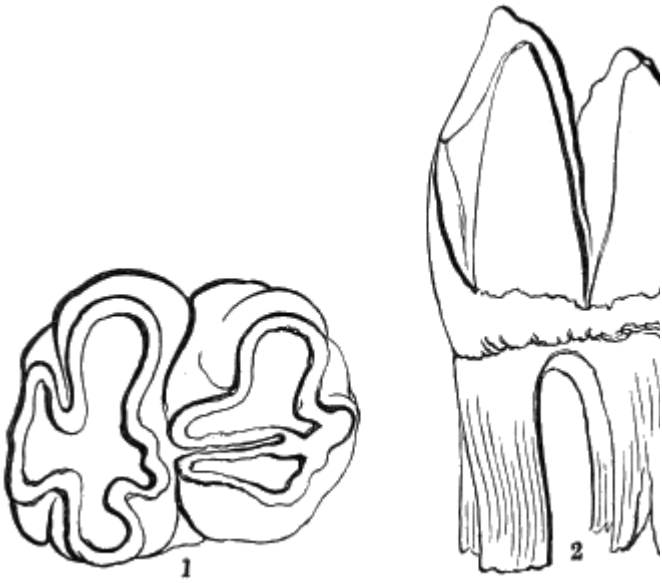
The grinding surfaces of the teeth exhibit the arrangement of the
analogous, but somewhat different distribution in the teeth of th

Fig. 1.— The worn surface of a molar tooth of the African Elephant.

2.— That of the Fossil Elephant or Mammoth (*Elephas primigenius*).

3.— That of the Asiatic Elephant.

HIPPOPOTAMUS.



LIGN. 261. FOSSIL MOLAR TEETH OF HIPPOPOTAMUS: 2/
Pleistocene.

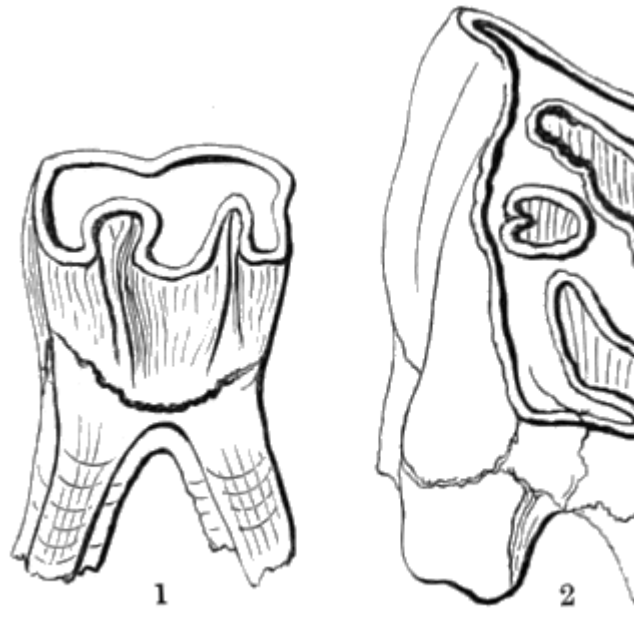
Fig. 1. Grinding surface of a molar tooth, with the cusps partially wo
— *Cavern, Devonshire.*

2. Perfect molar tooth, seen laterally. *Hertfordshire.*
—

I subjoin (*Lign.* 261, *fig.* 1) a figure of the crown of a fossil molar tooth of a Hippopotamus, from Kent's Cavern, Devonshire; in this specimen the summits of the cusps are worn down by use; and another, *fig.* 2, representing a perfect molar, with the conical cusps of the crown entire, found in Hertfordshire by W. D. Saull, Esq. The form of the worn surfaces of the molars of the Rhinoceros,[746] is shown in two different stages in the fossil teeth represented *Lign.* 262. Sir C. Lyell has given figures of the teeth of the Horse, Ox, Deer, &c. (*Ly.* p. 160); but teeth of the recent species are so readily obtained, and so much more instructive, that I would

recommend the student to procure teeth of the domestic herbivorous, carnivorous, and rodent animals, and preserve them in his cabinet as objects for comparison with the fossil mammalian teeth he may discover (see *Pict. Atlas*, pl. lxxii.).

[746] See Translation of a Memoir by Giebel on the fossil remains of Rhinoceros in the *Quart. Journ. Geol. Soc.* vol. viii. part ii. p. 9, &c.



LIGN. 262. FOSSIL MOLAR TOOTH OF RHINOCEROS: *Pleistocene.*

Fig. 1. A molar tooth much worn down by use; with the fangs nearly — *Petteridge Common, Surrey.*

2. Large molar, very much worn by use; the fangs broken off. —

HORSE.

FOSSIL HORSE. *Lign.* 263; and Owen's *Brit. Foss. Mam.* p. 383, *et seq.*—The bones and teeth of one or more species of this widely distributed genus are found in the alluvium, in osseous breccia, and in caverns in numerous localities in Europe, Asia, and America. The teeth and bones of the horse are often met with in the Elephant-bed in Brighton cliffs; they are referable to a small species, about the size of a Shetland pony. The blue alluvial clay or silt of our existing river-valleys contains abundance of the remains of a horse not distinguishable from the recent.



LIGN. 263. TEETH OF FOSSIL HORSE: *nat. size*.
Pleistocene. England.

Fig. 1. Right lower canine tooth of young EQUUS PLICIDENS; from the
— Cave at Oreston (Owen's *Foss. Mam.* p. 394).
2. Upper molar of a fossil Horse; from the *Elephant-bed* of Brighto
— Cliffs.

In the Siwalik hills, collocated with the gigantic pachydermata, ruminants, and carnivora, the remains of two or more species of Horse have been discovered. One form (*Hippotherium*) is remarkably distinguished from any previously known by the extreme length and slenderness of its I legs, in which respect it must have closely resembled the Antelope; it did not surpass in size the common Deer.

IV. FOSSIL EDENTATA. *Petrif.* p. 476.—The remains of extinct colossal mammalia, related to the existing diminutive SLOTHS in the essential characters of their organization, but modified to suit the peculiar conditions in which they were placed and the enormous increase in bulk of their colossal frames, are strewn all over the vast area of those alluvial plains of South America, called the PAMPAS (*Wond.* p. 164). The deposits of these regions[747] consist of—1. Beds of clay, sand, and limestone, containing marine shells and teeth of sharks; these are the lowermost strata. 2. Indurated marl. 3. Red clayey earth with calcareous concretions, in which the bones of colossal terrestrial mammalia are abundant. This vertical section demonstrates, that an extensive bay of salt-water was gradually encroached upon, and at length converted into a muddy estuary, by detritus brought down from the interior of the country, and in which carcases of land-animals floated and ultimately became engulphed in the silt. It is in these last deposits, which now form the immediate subsoil of the Pampas, that the teeth of the *Megatherium*, *Mylodon*, *Glyptodon*, *Mastodon*, *Horse*, &c. have been found.[748]

[747] See "Buenos Ayres," &c., by Sir Woodbine Parish, 1852, pp. 209-223.

[748] See the charming volume entitled, "Journal of the Voyage of H. M. S. *Beagle*," by Charles Darwin, Esq; see also Prof. Owen's descriptions in the "Zoology of the *Beagle*," and his Report, laid before the British Association in 1847.

The MEGATHERIUM (*Petrif.* p. 478, *Lign.* 112, 113; *Wond.* p. 167; *Bd.* p. 139, and pl. v.) is the best known to the general reader, from the graphic exposition of its configuration and habits by Dr. Buckland, and the splendid remains of its skeleton presented to the Hunterian Museum by Sir Woodbine Parish; but this animal is only one of several species of *Edentata*, equally interesting, and almost rivalling it in magnitude, which the labours of our own naturalists, Sir W. Parish, Mr. Darwin, and Mr. Pentland, and of Dr. Lund and other foreign savants, have brought to light. I can only advert to two other genera, namely, the *Glyptodon* and *Mylodon*.[749]

[749] An able memoir in the Penny Cyclopædia, Art. MEGATHERIDÆ, and another under the title "UNAU," will present the student with an epitome of all that is at present known of these extinct beings.

GLYPTODON.

GLYPTODON (*sculptured-tooth*) CLAVIPES. *Lign.* 264.—The bony tesselated carapace, or shield, which was formerly assigned to the Megatherium (*Bd.* i. p. 159) has been proved,[750] by the discovery of other specimens, to belong to a gigantic animal, whose bones are occasionally found associated with those of the Megatherium, and which is closely allied to the Armadillo. This discovery was made by my friend, Sir Woodbine Parish, to whose indefatigable exertions the Hunterian Museum is indebted for its

most splendid relics of fossil Edentata.[751] The bony dermal coat of the Glyptodon (a fine specimen of which is in the Hunterian Museum) was not disposed in rings as in the Armadillo, but is made up of polygonal pieces, accurately articulating with each other, and continuous over the whole of the upper part of the body and part of the tail; the tail also is enclosed in a case of this kind, like a sword in its scabbard (*Petrif.* p. 359, *Lign.* 75).

[750] See *Geol. Trans.* 1835, p. 438, &c.; and Prof. Owen's elaborate Memoir on the Glyptodon in *Geol. Trans.* 2d ser. p. 81, pl. x. xiii.

[751] A restored figure of the Glyptodon, together with the skeletons of the Megathere and the Mylodon, are beautifully illustrated in the interesting volume on "Buenos Ayres and the Provinces of Rio de la Plata." 2d Edit. By Sir Woodbine Parish, K. C. H. &c.

The teeth of this animal, which are eight in number on each side of each jaw, are sculptured laterally, by two wide and deep channels (*Lign.* 264, *fig.* 1), which divide the grinding surface of the tooth into three portions (*Lign.* 264, *fig.* 2). The hind foot is very peculiar (see *Lign.* 264, *fig.* 3), presenting an extreme modification of the same general plan of structure as that of the Armadillo. The skeleton of this animal constitutes the type of a distinct genus (*Glyptodon*), related to the Armadillo (*Dasypus*).



LIGN. 264. GLYPTODON CLAVIPES.
Tooth and Bones of the Left Foot of a colossal Quadruped allied to the Armadillo (*reduced size*).
Pleistocene, near Monte Video.

Fig. 1. Side view of a tooth, showing the deep lateral channels. The — original four inches long.
2. Grinding surface of the same.
—
3. Outside view of the left hind-foot. Length of the original about — fourteen inches, from the heel to the toe.
(*From the Geol. Trans. 2d. ser. vol. vi. pl. x.*)

MYLODON.

MYLODON.[752]—By this name is designated a gigantic edentate animal, allied to the Sloth, and formerly described as a species of Megalonyx, an almost perfect skeleton of which has been obtained from a fluviatile deposit, a few leagues to the north of the city of Buenos Ayres, and is now articulated

and exhibited in the Museum of the Royal College of Surgeons of England.[753] The animal appears to have been imbedded entire, and soon after its death, for the parts of the skeleton were found but little displaced, and the very few bones that are wanting, are such as might easily have escaped the search of the collector. But this magnificent specimen of the extinct fauna of South America must be seen to be properly appreciated. The skeleton measures eleven feet from the fore part of the skull to the extremity of the tail, the latter being three feet in length; the circumference of the trunk around the tenth pair of ribs is nine feet nine inches; the Megatherium is eighteen feet in length, and its girth fourteen and a half feet. These particulars will serve to convey an idea of the relative size of these gigantic animals. From certain peculiarities in the construction of the skeleton of the Mylodon, Prof. Owen, perceiving from the teeth that it was a vegetable feeder, and probably lived on leaves and the tender buds of trees, and its enormous bulk and weight forbidding the assumption that it climbed up trees and suspended itself by the branches, like the diminutive existing Sloths,—assigns to this creature the task of uprooting and felling trees, and feeding upon the foliage of the forests it laid prostrate. A remarkable development of the substance of the bones of the skull is presumed to hare been a provision against the fatal effects of a fracture of the cranium, to which the Mylodon, from its supposed uprooting propensities, is conjectured to have been peculiarly exposed; and the skull of the specimen in the College bears proofs of having had two fractures, from both of which the animal recovered. But whoever looks at the skeleton will perceive that the fore-feet are admirably adapted for seizing and wrenching oft the

branches, and the hinder feet for clasping the trunk of a large tree; and there is nothing to forbid the supposition, that the animal could obtain a constant and ready supply of food, by climbing up the stem to a sufficient height, and wrenching off the branches. Prof. Owen states, that the Mylodon unites the two great groups of the *Unguiculata* (animals with nails and claws), and the *Ungulata* (hoofed animals), for it has both hoofs and claws on the same feet.

[752] Signifying *molar-tooth*,—a name intended to express that the animal has only teeth adapted for grinding; but this term is equally applicable to all the other megatheroid animals.

[753] See "Description of the Skeleton of an extinct gigantic Sloth (*Mylodon robustus*)," &c., by Richard Owen, F.R.S. Hunterian Professor of the Royal College of Surgeons, 1 vol. 4to. with twenty-four plates, 1842. The lithographs in this work, by Mr. Scharf, are of the highest excellence: the figure of the entire skeleton of the animal, on a scale of two inches to a foot, is admirable.

The dental organs consist of four molars on each side the lower, and five on each side the upper jaw. The teeth are implanted in very deep sockets, and are of the same size and form throughout, with a conical pulp-cavity at the base, indicating that their growth continued during the life of the animal. In structure they resemble those of the Megatherium and Sloth (*Bradypus*); being composed of a pillar of coarse dentine, traversed by numerous vascular or medullary canals, which is invested with a layer of very fine, dense dentine, with minute calcigerous tubes, and the whole surrounded by a thick coating of cementum: no enamel enters into their

composition. (*Owen.*)

V. FOSSIL RODENTS.—Of the mammalia termed *Rodentia* or Gnawers (see *Wond.* p. 143), of which the Mouse, Rabbit, and Beaver are examples, the remains of several genera are found in a fossil state; particularly in the caverns containing the bones of Carnivora. Dr. Buckland collected from Kirkdale Cave-bones of a species of Hare or Rabbit, Mouse and Water-Rat (*Reliq. Diluv.* pl. xi.).

In the eocene gypseous strata of France, two species of Dormouse and two of Squirrel have been found. From the tertiary sand at Epplesheim, with the bones of the Dinotherium, those of a species of Hamster or German Dormouse (*Cricetus*) were obtained.

Fossil teeth of a species of Porcupine (*Hystrix*) occur in the pliocene deposits of Tuscany.

Of the Beaver (*Castor*), some undoubted remains have been collected in this country. Those of a species apparently identical with the recent Beaver of the Danube, have been discovered in the fresh-water deposits of Essex,[754] Norfolk, Cambridgeshire, and Berks, and in Scotland; and the remains of the very large extinct species first observed in Russia (and named, by M. Fischer, *Trogontherium*,) have been found in the subterranean forest at Bacton, in Suffolk.[755]

[754] See Mr. Brown's Paper on Copford, *Quart. Geol. Journ.* vol. viii. p. 188.

[755] See *Hist. Brit. Foss. Mam.* p. 184, &c.; *Quart. Journ. Geol. Soc.* vol. iv. p. 42; and *Petrif.* p. 357.

VI. FOSSIL MARSUPIALIA.[756]—That the remains of an extinct species of gigantic *Kangaroo* should be found in the fissures of the rocks and in the caverns of Australia, a country in which marsupial animals are the principal existing mammalia, is a fact that will not excite much surprise; but that beings of this remarkable type of organization should ever have inhabited the countries situated in the latitude of the European continent and of Great Britain, would never have been suspected, but for the researches of the geologist. The fossil remains of this class discovered in Australia[757] occur in the pleistocene deposits of Darling Downs, Melbourne, &c. and in fissures and caves in the limestone of Wellington Valley, imbedded in red ochreous loam, and are often incrusted by stalactitic concretions. One of the species exceeds the largest existing Kangaroo, and its bones are associated with those of the Wombat, and other marsupial animals (*Ly.* p. 155).

[756] Marsupialia; animals that carry their young in a pouch (*marsupium*), as the Kangaroo.

[757] Rep. Brit. Assoc. 1844, p. 223.

A species of Didelphys (*Opossum*) has been discovered in the gypseous limestone of Montmartre, and is figured and described by Cuvier (*Oss. Foss.* vol. iii. pl. lxxi.; see also *Brit. Foss. Mam.* p. 76). It consists of a considerable part of the skeleton of a small animal, imbedded in gypsum; the block containing the specimen has been split asunder, and some of the bones are attached to the surface of one moiety, and the remainder to the other. From the character of the jaws and teeth, Cuvier pronounced that the animal was related to the Opossum, and confidently predicted that the two peculiar bones

which support the pouch in these animals would be found attached to the fore-part of the pelvis; accordingly he chiselled away the stone, and disclosed these *marsupial* bones; thus proving the truth of those laws of correlation of structure, which he was the first to enunciate and establish. But as there are true marsupials in which the *ossa marsupialia* are merely rudimentary, for example, in the Dog-headed Opossum, or "Hyæna" of the Tasmanian colonists (*Thylacinus Harrisii*), in which they are merely two small, oblong, flattened fibro-cartilages, imbedded in the internal pillars of the abdominal rings, and are only six lines long and three or four lines broad,—it follows that in a fossil state the pelvis of a true marsupial animal may be destitute of those appendages which are commonly supposed to be an essential character of the marsupial skeleton. Thus the fossil pelvis of the Thylacinus, had that species been long ago, as it is soon likely to be, extinct, would not have afforded the certain evidence of its marsupial character to which Cuvier triumphantly appealed in demonstration of the Didelphys of the gypsum quarries of Montmartre; yet the Thylacinus would not therefore have been less essentially a marsupial animal.[758]

[758] See Prof. Owen, *Zoological Society's Proceedings*, Dec. 1844.

FOSSIL MAMMALIA.

In the Eocene sand at Kyson, near Woodbridge, in Suffolk, among other mammalian remains (*Ly.* p. 203), Mr. Colchester, of Ipswich, whose researches have been rewarded by many interesting fossils, found a fragment of the jaw, with one premolar

tooth having two fangs, of a small animal (*Didelphys Colchesteri*, Owen); and which Mr. Charlesworth (Curator of the Philosophical Institution of York) ascertained to belong to a marsupial animal allied to the Opossum.[759]

[759] See *Mag. Nat. Hist.* 1839, p. 450; *Rep. Brit. Assoc.* 1842, p. 73; and *Brit. Foss. Mam.* p. 71, *fig.* 22.

But the specimens above described are far surpassed in interest by those discovered in the Triassic Bone-bed of Würtemberg and in the Oolite of Stonesfield; the latter consisting of several jaws and teeth of marsupial animals.

TRIASSIC MAMMALIAN TEETH.—In the thin layer of rolled bones, teeth, scales, and coprolite, so extensively spread over the top of the Trias and at the base of the Lias, both in England and in Würtemberg, and well known to collectors as the "Bone-bed" of Aust Cliff, &c. (*Wond.* p. 529), a few minute *mammalian* teeth have been discovered by M. Plieninger at Diegerloch, near Stuttgart, Würtemberg. They appear to have belonged to one or more small Insectivorous quadrupeds, and have been described by Plieninger and Jäger. Sir C. Lyell, in the Prefatory Note to his Manual, 1852, fully treats of these interesting and most ancient mammalian remains, and gives several exact figures of the teeth.

STONESFIELD MAMMALIA.

FOSSIL MAMMALIA OF STONESFIELD.[760] *Lign.* 265. (*Bd.* pl. ii. *Ly.* p. 268. *Wond.* p. 510.)—The best known examples of the fossil remains of mammalia in the Secondary formations, and, excepting the teeth

just mentioned, of the highest antiquity, according to our present knowledge of the earth's physical history, are several mutilated lower jaws with teeth, of some very small animals, which are supposed to belong to insectivorous marsupial quadrupeds.[761]

[760] See Owen's *Brit. Foss. Mam.* pp. 29-70, figs. 15-20; and *Petrifactions*, p. 401, *et seq.*

[761] A small mammalian vertebra from Stonesfield is in Mr. Morris's collection, and has been figured by Mr. Bowerbank, *Quat. Geol. Jour.* vol. iv. pl. i. fig. 4, and pl. ii. fig. 6.



LIGN. 265. LOWER JAWS OF MAMMALIA; *nat.*
Great Oolite. Stonesfield.

Fig. 1. PHASCOLOTHERIUM BUCKLANDI. The right branch of the lower
— with seven grinders, one canine tooth, and three incisors.
2. AMPHITHERIUM BRODERIPII. The left branch of the lower jaw t
— and canine teeth are wanting The upper figures are enlarged vi
(*Geol. Trans.* 2d ser. vol. vi. pl. vi.)

These most important organic remains have all been found in the oolitic calcareous flag-stones of Stonesfield: deposits which, as we have already had occasion to notice, teem with other relics of great interest. Two specimens of the natural size are represented *Lign.* 265, and will serve for reference to the collector who may visit that interesting locality.

The existence of undoubted mammalia in the

secondary formations was first made known by Dr. Buckland (in 1823), who, upon the authority of Cuvier, stated that the two specimens then discovered at Stonesfield belonged to marsupials allied to the Opossum (*Didelphys*). These fossils were the left branches of two lower jaws; both were imbedded in the stone by the external surface, the inner side only being exposed. One of the specimens has ten molar teeth in a row; the other (the beautiful fossil, *fig.* 1, *Lign.* 265, now in the British Museum,) has seven molars, one canine tooth, and three incisors. Five other specimens have since been found. [762]

[762] See *Brit. Foss. Mam.* pp. 15-70, for ample details of their anatomical characters, and physiological relations.

The *Amphitherium* had thirty-two teeth in the lower jaw, that is, sixteen on each side; it is presumed to have been insectivorous, and to have belonged to the *placental* mammalia. The *Phascolotherium* had four true molar teeth, and three or four false molars, one canine, and three incisors in each branch of the lower jaw; and closely approximates to *marsupial* genera now restricted to New South Wales and Van Diemen's Land. It is, indeed, as Professor Phillips first remarked, an interesting fact, that the other organic remains of the British Oolite correspond with the existing forms now confined to the Australian continent and neighbouring seas; for in those distant latitudes, the *Cestracionts*, *Trigoniæ*, and *Terebratulæ* inhabit the ocean, and the *Cycadeæ* and *Araucariæ* flourish on the dry land (*Wond.* p. 894).

Thus we have evidence of the existence of the Marsupial order during the Secondary and Tertiary

formations, a proof, as Dr. Buckland observes (*Bd.* p. 73), that this order, instead of being, as was once supposed, of more recent introduction than other orders of mammalia, was, in reality, the most ancient condition under which animals of this class first existed in the earlier geological epochs, and was coexistent with many other orders throughout Europe in the Eocene period; while its geographical distribution in the existing fauna is restricted to North and South America, and to New Holland, and the adjacent islands.

VII. FOSSIL CARNIVORA.—The fossil bones and teeth of numerous species of *Carnivora*, the order comprising the mammalia which prey on other animals, of which the Weasel, Bear, Cat, Dog, &c. are examples, abound in fissures and caverns, in conglomerated rocks, and in drifted sand and gravel. The remains of the colossal Pachyderms, the Mastodons and Elephants, lie buried, for the most part, as we have previously shown, in the superficial alluvial deposits; but the Carnivora, although occasionally entombed with the Herbivora in superficial gravels and loams, are principally found imbedded in the floors of extensive caverns.[763] In many instances, such immense quantities of bones and teeth of individuals of all ages, and belonging to but one or two species, occur in certain caves, as to render it probable that these were for a long period the dens of the extinct species of Bears, Hyænas, &c. whose bones they enclose.

[763] *Rep. Brit. Assoc.* 1842, sect. p. 62. For an account of the ossiferous caves of the Brazils, see *Petrif.* p. 483.

Another remarkable geological condition in which fossil bones of Carnivora occur, is that of an

ossiferous conglomerate, or *bone-breccia*; that is, a conglomerate formed of fragments of limestone and bones, cemented together into a hard rock by a reddish calcareous concretion. This breccia is found in almost all the islands on the shores of the basin of the Mediterranean Sea; as for example, at Gibraltar, Cette, Nice, Cerigo, Corsica, Palermo, &c. The most celebrated of the bone-caves are situated in Franconia, and in many parts of the Hartz. That of Gailenreuth has long been known for its fossil treasures, which principally consist of the bones and teeth of two extinct species of Bears. One of these is equal in size to a large horse, and is termed *Ursus spelæus* (Bear of the Caverns); and skeletons have been found of all ages, from the adult to the cub but a few days old (see *Wond.* pp. 176, 177). There are numerous caverns in the neighbouring district, some of which are equally rich in the remains of Carnivora.[764] Similar fossils are also found in the consolidated gravel and drift in various parts of Germany, and in the fissures of rocks containing iron-ore, at Kropp, in Carniola.

[764] A highly interesting account of the Ossiferous Caves of the Hartz and Franconia, by Sir Philip Grey Egerton, Bart, was published in 1834, *Geol. Proc.* vol. ii. p. 94. See also Captain Montagu's notice of the Sophienhöhle further on, at p. 820.

BONE-CAVERNS.

Even in Australia, caves with ossiferous breccia are numerous; but the bones belong to extinct marsupial animals of genera still existing in the country (see *Rep. Brit. Assoc.* 1844; *Petrif.* p. 133; and *Wond.* p. 188). In England, several caverns presenting similar phenomena have been discovered.

That of Kirkdale, near Kirby Moorside, Yorkshire, is well known from the celebrity it acquired by the graphic illustration of its contents by Dr. Buckland. [765] This cave, or rather fissure, for its dimensions were too limited to merit the name of cavern, was situated in oolitic limestone; it was two hundred and fifty feet long, from two to fourteen high, and six or seven wide. The floor was occupied by a bed of indurated mud, covered over with a thick crust of stalagmite; the roof and sides being invested with a similar calcareous sparry coating, as is commonly the case in all fissures in limestone rocks.[766] From this cave were obtained numerous bones of Hyænas, associated with bones, more or less fractured, of Tiger, Bear, Wolf, Fox, Weasel, Elephant, Rhinoceros, Hippopotamus, Horse, Deer, Ox, Hare or Rabbit, Mouse, Water-rat, and fragments of skeletons of Ravens, Pigeons, Larks, and Ducks. Many of the bones exhibited marks of having been gnawed, and crushed by the teeth of some animals. From all the facts observed, and which are detailed by Dr. Buckland with his wonted graphic power, it is inferred that the cave was inhabited for a considerable period by Hyænas; that many of the remains found there were of individuals carried in and devoured by those animals, and that in some instances the hyænas preyed upon each other. The portions of bone referable to the elephant seem to prove that occasionally the large mammalia were also obtained for food; but it is probable that the smaller animals were either drifted in by currents of water, or fell into the chasm through fissures now closed up by stalactitical incrustations.

[765] Dr. Buckland’s celebrated work, "Reliquiæ Diluvianæ," contains an admirable description of these caverns and their contents,

with numerous plates. The student, in consulting this volume, must separate the *facts* from the diluvial theory, which, at the period of its publication (1823), they were supposed by Dr. Buckland and other eminent geologists to confirm.

[766] For a general description of the cave at Kirkdale, see *Wond.* p. 179; and for details, *Reliq. Diluv.* pp. 1-19. The ossiferous caves at Kirkdale, Torquay, and Banwell are noticed, *Petrif.* p. 482.

Kent's Cave, near Torquay, Oreston Cave, near Plymouth, and several other caves in Devonshire, have yielded great numbers of bones and teeth of Carnivora and Pachydermata (see *Reliq. Diluv.* p. 67).

KENT'S HOLE is the most productive ossiferous cavern in England, and its vicinity to Torquay renders it of easy access. An extensive collection of teeth and bones was obtained from this cave by the late Rev. J. MacEnery, comprising, in addition to the usual extinct Carnivora, skulls and teeth of Badger (*Meles taxus*), Otter (*Lutra vulgaris*), Pole-cat (*Putorius vulgaris*), Stoat or Ermine (*P. erminius*), &c. A selection of the choicest specimens in this collection is deposited in the British Museum.

In Glamorganshire, two large caverns, called Goat's Hole, and Paviland Cave, containing numerous bones of Bear, Hyæna, Wolf, Fox, Rhinoceros, Elephant, &c., are situated in a lofty cliff of limestone, between Oxwich Bay and the Worm's Head, on the property of Earl Talbot, fifteen miles west of Swansea (*Reliq. Diluv.* p. 82).

FOSSIL CARNIVORA.

In the western district of the Mendip Hills, in

Somersetshire, there are several ossiferous fissures and caves. The most interesting are those of Hutton, on the northern escarpment of Bleadon Hill; and of Banwell, lying about a mile to the east of Hutton. They contain remains of two species of bear, one (*Ursus spelæus*) of immense size and strength; and of Tiger, Hyæna, Wolf, Fox, Deer, Ox, and Elephant. [767]

[767] See a Memoir "On the Caverns and Fissures in the Western District of the Mendip Hills," by the late Rev. D. Williams. Proc. Royal Society, June 2, 1831, p. 55.

From the caves at Hutton, the Rev. D. Williams obtained the milk-teeth and other remains of a calf-elephant, about two years old, and those of a young tiger, just shedding its milk-teeth; also the grinders of a young horse, that were casting their coronary surfaces; and remains of two species of hyæna.

But one instance of the fossil bones of Carnivora has been observed in the south-east of England. It occurred in a fissure in a quarry of sandstone at Boughton, near Maidstone; among other bones, the lower jaw of a Hyæna (see Frontispiece of Vol. I.), with the teeth, was obtained.[768]

[768] See *Mag. Nat. Hist.* 1836, vol. ix. p. 593; and *Quart. Journ. Geol. Soc.* vol. vii. p. 383.

In the modern silt of our alluvial districts, the remains of carnivorous animals, formerly indigenous to this island, are occasionally met with; and the skeleton of the Brown Bear (a species which inhabited Scotland eight centuries ago), and of the Wolf, whose extinction is of a yet later date, have been discovered. The Woodwardian Museum at

Cambridge contains an entire skull of the Brown Bear (*Ursus arctos*), found in the Manea Fen of Cambridgeshire;[769] in an ancient fresh-water deposit, near Bacton, in Norfolk, the right lower jaw of the Bear of the Caverns (*Ursus spelæus*), has been discovered;[770] and the phalangeal bone of a large Bear has been found by Mr. J. Brown in the pleistocene deposits at Copford, Essex, with the remains of Beaver, Elephant, Stag, &c. (*Geol. Journ.* vol. viii. p. 187.)

[769] A beautiful lignograph of this specimen is given in *Hist. Brit. Foss. Mam.* p. 77, *fig.* 24.

[770] Hist. Brit. Foss. Mam. p. 89.

Thus the remains of fossil Carnivora discovered in England comprise several kinds of Bear[771] (including the two species of the caverns of Germany, *U. priscus* and *U. spelæus*), and of Tiger, Hyæna, Wolf, Fox, &c.

[771] *Petrif.* p. 398. In the *Pict. Atlas*, pl. lxxiii., is a good figure of a large Bear's tooth. Teeth of Bear, Tiger, Hyæna, and Arvicola, are figured in *Ly.* p. 161.

Although we cannot dwell on foreign localities of Carnivora, I may mention that the lacustrine pliocene formation of Œningen occasionally yields fine remains. A splendid specimen, obtained from that locality by Sir R. I. Murchison, displays almost the entire skeleton of a Fox-like animal, the *Galecynus Œningensis* of Prof. Owen.[772]

[772] See *Geol. Trans.* 2d ser. vol. iii. pl. xxxiii.; and *Quart. Geol. Journ.* vol. iii. p. 55.

The SEAL, which is one of the marine carnivorous

mammalia, also occurs in a fossil state in England. A femur of a species of *Phoca* has been found, with the remains of a Monkey and Bat, in a tertiary deposit in Suffolk. In the tertiary strata of Malta an extinct species of Seal has also been discovered. In the bone-beds of New Zealand my son frequently found bones and teeth of Seals, probably of the species now inhabiting the South Pacific. (*Petrif.* p. 130.)

Of the INSECTIVORA, the fossil remains of several genera occur. In England, the jaw with teeth of a large species of Mole (named PALÆOSPALAX,[773] *ancient mole*), has been discovered in a lacustrine deposit at Ostend, near Bacton, on the coast of Norfolk, associated with bones of Elephant, Deer, Roebuck, and Beaver. This animal must have been as large as a hedgehog. The only part of the skeleton hitherto obtained is a portion of the left side of the lower jaw, containing six molars; its natural affinities have therefore been inferred from the characters of the crowns of the teeth.

[773] *Hist. Brit. Foss. Mam.* p. 25.

FOSSIL CHEIROPTERA AND QUADRUMANA.

The CHEIROPTERA (*hand-wings*) or BATS, are mammalia which have the power of flight, from the bones of the phalanges or fingers being enormously elongated and giving support to a fine membranous expansion; they are rarely found fossil, although, from their habits of haunting and hybernating in fissures and caves, their skeletons often occur mingled in the earth of the floor of caverns, and imbedded in crannies of rocks, with bones of extinct animals.

The remains of a considerable portion of the

skeleton of one species of Bat was discovered by Cuvier in the gypsum of Montmartre,[774] and another example in a gypseous deposit, at Köstritz, in Germany, with remains of extinct species of other mammalia. Two instances of British fossil Bats are recorded;[775] the one from Kent's Cavern, collocated with the extinct Carnivora, and referred to the Horse-shoe Bat (*Rhinolophus*); the other from Kyson, in Suffolk, found in the same deposit with the remains of the Monkey, presently to be noticed.

[774] Discours sur les Révolutions de la Surface du Globe, par Baron G. Cuvier, 4to. 1826, pl. ii. *fig.* 1.

[775] *Rep. Brit. Assoc.* 1842, and *Brit. Foss. Mam.* pp. 11-18.

VIII. FOSSIL QUADRUMANA, OR MONKEYS.—The illustrious Cuvier, when commenting on the extraordinary fact, that among the innumerable fossil relics of the mammalia which peopled the continents and islands of our planet, through the vast periods comprehended in the tertiary formations, no traces of MAN or of his works occur, emphatically remarked, that it was a phenomenon not less surprising, that no remains of the quadrumanous races, which rank next to Man in physical conformation, should have been found in a fossil state; and that the circumstance was the more remarkable, because the majority of the mammalia found in the younger and older tertiary strata have their congeners at the present time in the warmest regions of the globe; in those intertropical climates where the existing quadrumana are almost exclusively located.[776]

[776] Discours sur les Révolutions de la Surface du Globe, p. 171.

FOSSIL APE OF FRANCE.—But the remains of this order have at length been discovered in the most ancient of the tertiary deposits, and under circumstances which admit of no doubt as to the antiquity of the fossils or the strata in which they were imbedded; and almost at the same time in France and in the Sub-Himalayas; and very recently in the Brazils and in England. The first European specimen was discovered at Sansan, near Auch,

about forty miles west of Toulouse, by M. Lartet, with remains of the Rhinoceros, Deer, Antelope, Palæotherium, &c. It consists of the lower jaw, almost complete, with all the teeth, of an adult animal, of an extinct species, related to the long-limbed and tailed monkey, called *Semnopithecus*, of which the Negro Monkey is an example. A fragment of another jaw has been found in the same locality.

FOSSIL MONKEY OF THE SUB-HIMALAYAS.—In the inexhaustible mine of fossil bones, discovered by British Officers in India, the upper jaw of an Ape was found by Messrs. Baker and Durand, and fragments of other jaws and some bones were subsequently collected by Dr. Falconer and Captain Cautley. These relics conjointly established the existence of a gigantic quadrumanous animal in the groves of India at the Eocene epoch, when the gigantic Tortoise, the lofty Sivatherium, and the colossal Mastodon tenanted the plains, and Hippopotami frequented the marshes and rivers. This fossil Ape also is related to the *Semnopithecus*.

FOSSIL MONKEY OF SOUTH AMERICA.—Dr. Lund, the eminent Danish naturalist, to whose indefatigable researches, and successful determination of the colossal Edentata, we have previously alluded, has discovered the bones of a gigantic Ape, four feet in height, related to the Capuchin Monkey, in the ossiferous breccia of the caves of Brazil.

BRITISH FOSSIL MONKEYS, *Ly.* p. 202.—The first fossil relic of a quadrumanous animal from the British strata was obtained in 1839, from a bed of Eocene sand, at Kyson, a few miles east of Woodbridge, in Suffolk, by W. Colchester, Esq. The first specimen found consisted of a small fragment of

the right side of the lower jaw, with the last molar tooth entire in its socket; another relic is the crown of one fang of the first molar tooth, of the same species. These relics have been referred to an extinct species of Monkey, related to the *Macacus*, which has been named *Macacus eocænus*, in allusion to the geological age of the stratum in which the remains were discovered.[777] In this Eocene sand have also been discovered the remains of a Bat (p. 813), and of a Marsupial (*Didelphys*, p. 805), and numerous fish-teeth (*Lamna*, p. 594); whilst in the clay overlying this sand were found the vertebra of a Serpent (*Palæophis*, p. 738) and several teeth of a Pachyderm (*Hyracotherium*, p. 791). Prof. Owen in the *Hist. Brit. Foss. Mam.* p. xlvi. figures and briefly notices the relics of another species of *Macacus*, from the newer pliocene, or pleistocene, brick earth at Grays, Essex.

[777] Owen, British Fossil Mammalia, p. 1, figs. 1, 3.

FOSSIL HUMAN BONES.—In the Swabian Alps, human teeth and several perfect human skulls are said to have been found in deposits in which elephantine remains also occur. This subject was brought before the meeting of the German Association for the Advancement of Science at Tubingen, by Fraas and Jäger, and, if correctly reported, naturally leads to the conclusion that human beings were contemporaneous with the extinct elephants and some of the other large pachydermata in the regions referred to.

ON COLLECTING FOSSIL MAMMALIA.

ON COLLECTING AND DEVELOPING THE FOSSIL REMAINS OF MAMMALIA.—But few directions for the developing and repairing of the fossil remains of

mammalia will be required in this place, the suggestions already offered, and particularly those in vol. i. pp. 45-49, embracing full instructions on this head.[778] On the method recommended in p. 46, for strengthening the friable bones of the large mammalia, I may observe, that the *drying-oil* is prepared by boiling *litharge* in oil, in the proportion of one ounce of the litharge to a pint of oil.

> [778] CEMENT.—The following formula was given me by an eminent collector and developer of fossils:—
>
> Gum mastic, one ounce;
>
> Rectified spirit of wine, sufficient to dissolve it.
>
> Isinglass, one ounce, soaked in water until soft; then dissolve it in pure rum or brandy until it is in the state of stiff glue: add to this a quarter of an ounce of gum ammoniacum, well rubbed and mixed.
>
> Put the two solutions together in an earthen vessel, over a gentle heat; when thoroughly melted and united, put the mixture into smooth, well-corked bottles.
>
> *Use.*—Immerse the bottle in hot water until the cement is sufficiently liquid for use.

The search for fossils of this class is attended with much less certainty of success than for other animal remains. In the following list, page 818, the localities most likely to be productive are enumerated; but we have no caverns, as in Germany, so rich in remains of this kind as to ensure the discovery of specimens by the casual visitor; for the treasures of the most productive cave, that of Banwell, are prohibited; the proprietor carefully preserving every fragment. A

short residence near some of the best localities and daily research are required for obtaining interesting specimens. For example, a residence at Ryde, for a search in the fresh-water tertiary limestone at Binstead; at Torquay, for Kent's cavern; or some other town or village near the other caves in Devonshire; Herne Bay, for the London Clay at Studd's Hill, that produced the Hyracotherium; Woodbridge or Kyson, for the Suffolk mammalia; Walton and Clacton, in Essex, for remains of Elephants in the pleistocene deposits of that coast.

In searching for bones and teeth in an unexplored cave, the following suggestions by Dr. Buckland will be found of great value. Select the lowest parts in the cavern or fissure into which any mud or clay can have been drifted or accumulated; and then break through the stalagmitic crust of the floor, and dig down into the silt and pebbles, &c. below, in which bones and teeth will be found, if the spot contains any relics of this kind. As a test for distinguishing the ancient bones found in these caves from those which may have been recently introduced, the tongue should be applied to them when dry, and they will adhere in consequence of the loss of their animal gluten, without the substitution of any mineral substance, such as we commonly find in the fossil bones of the regular strata. Human bones found in caves always possess too much animal gluten to adhere to the tongue when dry.[779]

[779] Dr. Buckland on Fossil Bones of Bears in the Grotto of Osselles, near Besançon, in France. *Geol. Proc.* vol. i. p. 22.

Along the eastern coast of England, and often off the mouth of the Thames, the fishermen dredge up teeth, tusks, and bones of Elephants; and good

specimens may sometimes be thus procured. The Ramsgate fishermen employed in trawling in the North Sea and English channel, frequently bring up in their gear fragments of fossil bones of Mammoths, and other mammalia. From the bank of the Goodwin-sands, large tusks have been procured. On the shore near Herne Bay, very fine mammalian remains are occasionally obtained. In the Museum at Canterbury, there was (and I believe is) a good collection of fossil bones of large Pachydermata procured from the neighbouring coast. It is a remarkable fact, that immense quantities of the bones of Mammoths, or fossil Elephants, are strewn over the bed of the German Ocean and English Channel.[780] The late Mr. Woodward informed me, that the teeth and tusks of Elephants collected along the Norfolk and Suffolk coasts, within his own cognizance, must have belonged to upwards of five hundred individuals.

[780] *Geol. Trans.* 2d ser. vol. vi. p. 161.

BRITISH LOCALITIES OF FOSSIL MAMMALIA.

Bacton, Norfolk. See *Ostend*.

Banwell Cave, fifteen miles from Bristol, and three from Banwell Station. Bones and teeth of Bears, Hyænas, a Felis larger than the Lion; but chiefly of Deer and Oxen.

Berry Head, Devonshire; Cave. Carnivora; as Bear, Badger, Tiger, Pole-cat, Stoat.

Binstead, near Ryde, Isle of Wight. *Upper Eocene.* Fresh-water limestone. Teeth and bones of Anoplotherium, Palæotherium, Chæropotamus, Dichobune.

Brighton Cliffs. Between Kemptown and Rottingdean, in the beds above the Chalk. *Pleistocene.* Teeth and bones of Elephant, Horse, Deer, Oxen; jaw of a Whale.

Copford, Essex. *Pleistocene.* Elephant, Stag, Ox, Beaver, Bear, &c.

Crayford, Kent. *Pleistocene.* Elephant, Horse, &c.

Easton, a mile and a half north of Southwold. Mastodon tooth, and Carnivora.

Folkstone, Kent. *Pleistocene.* On the top of the west cliff and in the valley; bones of Elephant, Hyæna, Hippopotamus, Ox, Horse, Stag, &c. (*Quart. Geol. Journ.* vol. vii. p. 257.)

Grays, Essex. *Pleistocene.* Elephant, Monkey, &c.

Harwich, Essex. *Pleistocene.* Elephant's teeth, &c.

Herne Bay. In *London Clay*; Hyracotherium, Chæropotamus. In *Pleistocene* deposits; Elephant, Whale.

Hoe, near Plymouth, raised Beach at. *Pleistocene.* Elephant, Rhinoceros, Bear, Deer, Whale, &c.

Horstead, Norfolk. *Pleistocene.* Mastodon tooth.

Hutton Caves, near Banwell, Somersetshire. Carnivora, Pachydermata, &c. See p. 783.

Isle of Man. *Pleistocene.* The gigantic Irish Deer (*Cervus megaceros.*)

Kent's Cave, near Torquay. The most productive of the British ossiferous caverns (see p. 813). Bear, Badger, Tiger, Wolf, and other Carnivora; Rhinoceros, Elephant, and other Pachydermata.

Kirkdale, by Kirby Moorside, Yorkshire (see p. 783). I know not if any accessible part of this celebrated cave remains.

Kyson, near Woodbridge, Suffolk. On the side of the river Deben, about a mile from Woodbridge, in the parish of Kyson (Kingston). The strata consist of, 1. Red crag, the uppermost. 2. London clay, about twelve feet. 3. White and yellow sand. In this lower Eocene bed the relics of *Monkey*, *Didelphys*, and *Bat*.

Manea Fen, Cambridgeshire. *Pleistocene.* Skull of Bear.

Newbourn, Suffolk. *Pleistocene.* Mastodon tooth. Leopard.

Newbury, Berks. *Pleistocene.* In the peat and shell-marl, Boar, Ox, Roebuck, Stag, Beaver, Wolf, Ass, &c.

Norwich. *Pleistocene.* Mammoth's teeth and bones.

Oreston Cave, near Plymouth. Carnivora, Wolf, Bear, Hyæna, &c.

Ostend, near Bacton, on the coast of Norfolk. In a lacustrine deposit of dark clay and greenish sand, with charred trunks and branches of trees. A section presents—1. Uppermost: Drift. 2. Black earth, with shells. 3. Reddish sand. 4. Norwich crag, in patches. 5. Chalk. Nos. 2 and 3 are lacustrine; and in these Pleistocene beds have been found Gigantic Mole (*Palæospalax*), Elephant, Deer, Roebuck, fossil Beaver (*Trogontherium*), jaw of Bear (*Ursus spelæus*). See Hist. Brit. Foss. Mam. p. 85.

Paviland Cave, fifteen miles west of Swansea; between Oxwich Bay and the Worm's Head, Glamorganshire. Rhinoceros, Mammoth, Hyæna, Wolf.

Plymouth. Caverns near elevated Beach, at the Hoe. Elephant, Rhinoceros, Bear, &c.

Postwick, near Norwich. *Pleistocene.* Tooth of Mastodon.

Seafield, Isle of Wight. *Upper Eocene.* Palæotherium.

Southbourn, Sussex. *Pleistocene.* The plain of alluvial mud and clay, called the "*Wish:*" a section seen on the sea-shore between the Sea-houses and the foot of the chalk hills. Elephant, Hippopotamus, Deer, Horse, Ox.

Southwold, Suffolk. *Pleistocene.* Elephant, Rhinoceros, Horse, Deer, Mastodon: Otter, in Red Crag.

Stonesfield, near Woodstock, Oxfordshire. *Great Oolite.* The only known locality in England of remains of mammalia of the Secondary period. See p. 805.

Studd Hill, a mile westward of Herne Bay. *London clay. Hyracotherium.*

Swansea (Paviland Cave, near). See Paviland.

Wirksworth, Dream Cave. A perfect skull of Rhinoceros; in Dr. Buckland's museum, at Oxford.

Woodbridge, Suffolk. At Kyson, near Woodbridge. *Eocene.* Teeth of Monkey, &c.

Note.—For notices of the occurrence of Mammalian Bones at Betchworth, Brighton, Dover, East Bourn, Folkstone, Maidstone, Marden, Peasemarsh, the valley of the Wey, Stonesfield Slate, Thames Valley, &c., see *Quart. Journ. Geol. Soc.* vol. vii. (consult Index). Of foreign localities, Tibet, Upper Punjab, Siwalik Hills,

Vichy, &c., are also referred to in the same volume.

BONE CAVES IN FRANCONIA.

⁂ Captain Willoughby Montagu having favoured me in 1844 with an account of the state of the principal caves in Franconian Switzerland, which he had lately visited, the subjoined extract may be useful to the continental traveller. The cave of *Sophienhöhle* appears to be highly interesting; the stalactites remaining uninjured, and the ossiferous floor in the state in which it was discovered; whilst the much-frequented caverns have been stripped of every relic by the spoliations of visitors during the last century and a half.

"The northern part of Bavaria, which is denominated 'Franconian Switzerland,' is situated about the centre of a triangle, formed between Bamberg on the N.W., Bayreuth N.E., and Nuremberg S.; the best road from this latter city diverging beyond Erlangen to the north.

"The nearest route from London is through Belgium, from Ostend or Antwerp, by the line of railroad which (since October, 1843) passes on from Liege and Verviers, by Aix-la-Chapelle to Cologne. Thence by steam up the Rhine, by Coblentz to Mayence, and again by railway to Frankfort. In summer there are steam boats up and down the Maine, as far as Wurzburg, daily, and higher up, between Schweinfurt and Bamberg, which latter distance is performed in eight hours going up. and five down. Or there is a diligence (*eilwagen*) from Frankfort direct to Nuremberg, from which place (or Bamberg, &c.) a carriage must be hired to Muggendorf, the principal village of that interesting district. It lies about half way on the post road between Erlangen and Bayreuth, and has two tolerable country inns; the people are civil, and moderate in their charges, at least for the freshest trout and good wine of Bavaria.

"This charming spot and neighbourhood attracts not only the geologist and lover of the picturesque, but also the angler, who finds excellent fishing in the clear, rapidly-winding streams of the Wiesent, with its tributary waters, all of which are romantically placed in the suddenly deep dales of this table-land. The Wiesent flows through Forchheim into the Regnitz, westward, and this into the Maine, north.

"As to the time necessary to get there, during the summer days it would only require one to pass through Belgium to Aix, including the transit of this frontier into Prussia, with slight search

of baggage. Then, in between four and five hours to Cologne, where the steamers generally wait for the arrival of these trains; and, taking the first boat up, it is possible to reach Bingen (if not Mayence late) the same evening. From Frankfort, by diligence, starting at 11 A.M., and travelling all night, Nuremberg may be reached on the second day; and the centre of operations, about Muggendorf, on the fifth from quitting the sea-coast. In returning by the Maine,—from Wurzburg to Mayence maybe performed in one long day, and then on the Rhine, the descent being much quicker than the upward course against the streams, the return homewards may be accomplished in one day less.

"The nearest way to Ostend is by the South-Eastern Railroad to Dover, and embark for Belgium.

"The newly-discovered cave, called *Sophienhöhle*, lies on the right bank of a streamlet, which gives its name to a romantic and rocky valley, *Ahorn-thal*, and flows S.W. toward Gösweinstein, until it falls into the Wiesent. The situation of the cave is near Klaustemerhöhle, and opposite to Ludwigshöhle: and it is far easier of access than Gailenreuth, and may be inspected by ladies with the greatest facility. An intelligent female showed us through its lofty and interesting details. This cave is nearly 300 feet wide, and 150 feet in height. The quantity of fossil bones strewed about the floor was very great, notwithstanding many of the finest specimens had been removed, and were to be seen in the neighbouring castle of Count S——; added to this, the long, pendant curtains of stalactite, and the stupendous size of the cavern, contributed to make it appear to me far surpassing in interest that near Gailenreuth, called *Zoolithen-Höhle*, which I had visited the day before. The keys of this cavern—for this, as well as the other celebrated caves, is locked up, to guard against depredations—are kept at the large farm or steward's house, hard by. The state of the weather prevented our visiting Forstershöhle (*Forest Cavern*), which lies further N.E. beyond the little town of Weischenfeld, near Zeubach; but which, we were informed, was equal in interest to this of Sophienhöhle. The tourist desirous of visiting this interesting district, will find Mr. Murray's Handbook of Southern Germany an excellent guide: I can vouch for its accuracy."

RETROSPECT.

"Ce que nous connaissons est peu de chose; ce que nous ignorons est immense."

LA PLACE.

We have now arrived at the close of this argument; we have taken a general survey of the fossilized relics of the various classes of the animal and vegetable kingdoms, and have explained the methods by which the inscriptions on these "Medals of Creation" may be deciphered.

But numerous as are the facts that have passed in review before us, and great as the accession of geological knowledge has been during the last fifty years, the data hitherto obtained are insufficient to elucidate many of the obscure pages of the earth's physical history; and to future discoveries must be left the full interpretation of many phenomena as yet obscurely presented to us.

In vain we endeavour to penetrate the veil which shrouds from our view many of the mighty events that preceded the history of our race, for,—although the shades of colossal and unknown forms belonging to the remote ages of a past eternity obey the spell of the true magician Science,—yet of the innumerable beings which through countless centuries

"The Earth has gather'd to her
breast again,
And yet again, the millions

that were born
Of her unnumber'd,
unremember'd tribes
—"

how few, comparatively, could even the transcendent genius of Cuvier reveal!

If we endeavour to trace the order of succession, in which the extinct and existing types of animal and vegetable organization have appeared upon the face of our globe, as demonstrated by fossil remains, we at once perceive how imperfectly our knowledge enables us to present a true picture of the development of organic life as it existed in the remotest ages. Ascending from the *Granite*—that shroud which conceals for ever from human ken the earliest scenes of the earth's physical drama—the first glimpses we obtain of animated nature are a few sea-weeds, shells, and Crustacea. But can we doubt for a moment that that ancient sea had its boundaries and its shores—that then, as now, there were islands and continents, and hills and valleys, and streams and rivers, teeming with appropriate inhabitants? The little Lycopodiaceous seed-vessels in the Ludlow bone-bed afford as certain indication of dry land, as the olive branch which the dove brought back to the Ark; one fact of this kind overthrows a host of theories based upon negative evidence.

Throughout the lower palæozoic rocks organic life presents numerous modifications; and the remains of small placoid fishes appear in the uppermost Silurian. In the Devonian we meet with rare reptilian remains and foot-prints. In the Carboniferous rocks the sauroid Batrachians have left

their relics and their foot-tracks. In the succeeding period these reptiles predominate; and on the sands of the Triassic ocean we have the foot-prints of monster reptiles and the tracks of bipeds—colossal bird-footed creatures—of which no other vestiges remain, and to which the existing order of creation affords no parallel.

The last bed of the Trias affords the first indication of Mammalian life.

We now enter upon that marvellous epoch, during which reptilian organization obtained its fullest development—when the Iguanodon and Megalosaurus—

"Mighty Pre-Adamites who
walked the earth,
Of which ours is the wreck—"

BYRON.

were the principal inhabitants of vast islands and continents. But here, as at an earlier period, we have proof that warm-blooded animals existed; and the diminutive marsupial insectivorous Mammalia of the Oolite and the birds of the Wealden attest that the system of animal creation was complete.

Leaving behind us the Age of Reptiles, we approach that of the colossal Mammalia, when extensive countries were peopled by the enormous herbivorous Megatheres, the Mastodons, and gigantic Pachyderms, long since become extinct. But with these lost forms many existing races were contemporary; including the Monkey tribes, which, of all animals, approach nearest to man in their physical organization. Thus, by slow and almost

insensible gradations, we arrive at the present state of animate and inanimate nature. But even after the existing continents had attained their present configuration, in the period immediately antecedent to the human epoch, innumerable tribes of carnivorous animals swarmed throughout the temperate climates of Europe; the Tiger, Hyæna, and Bear prowled through the woods and inhabited the caverns; and the Horse and Elephant, with gigantic Deer and Oxen, tenanted the plains.

But of MAN and of his works not a vestige appears throughout the vast periods embraced in this review. Yet were any of the existing islands or continents to be engulphed in the depths of the ocean, and loaded with marine detritus, and in future ages be elevated above the waters, covered with consolidated mud and sand, how different would be the characters of those strata from any which have preceded them! Their most striking features would be the remains of Man, and the productions of human art—the domes of his temples, the columns of his palaces, the arches of his stupendous bridges of iron and stone, the ruins of his towns and cities, and the durable remains of his earthly tenement imbedded in the rocks and strata—these would be the "Medals of Creation" of the *Human Epoch*, and transmit to the remotest periods of time a faithful record of the present condition of the surface of the earth, and of its inhabitants.[781]

[781] See Sir H. Davy's Last Days of a Philosopher.

APPENDIX TO PART III.

PROFESSOR OWEN'S CLASSIFICATION OF THE ANIMAL KINGDOM.

(*From the Hunterian Lectures for 1843.*)

Kingdom—ANIMALIA (*animals*).

Sub-kingdom—VERTEBRATA (*having a spinal col*

Class— MAMMALIA (*animals that give suck*).
AVES (*birds*).
REPTILIA (*reptiles*).
PISCES (*fishes*).

Sub-kingdom—ARTICULATA (*having external-join*

Class— CRUSTACEA (*having an external crust, o*
ARACHNIDA (*spiders*).
INSECTA (*insects*).
ANNELATA (*composed of rings*).
CIRRIPEDIA (*having curled-feet*).

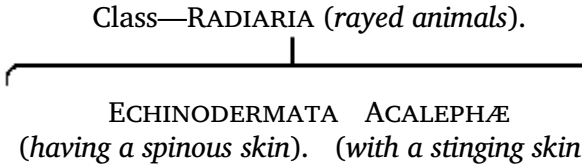
Sub-kingdom—MOLLUSCA (*soft animals*).

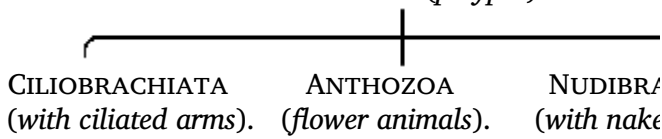
Class— Class—CEPHALOPODA (*feet around the*
GASTEROPODA (*belly-feet*).
PTEROPODA (*wing-like feet*).
LAMELLIBRANCHIATA (*with lamellated g*
PALLIOBRANCHIATA (*mantle-gilled*).
TUNICATA (*enveloped in a cloak*).

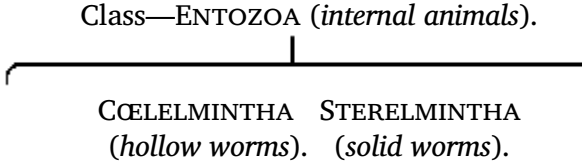
Sub-kingdom RADIATA (*radiated animals*).

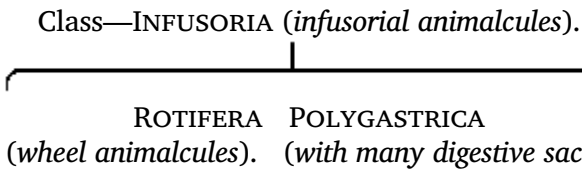
NEMATONEURA ACRITA

(*with thread-nerves*) (*with indistinct nerves*)









PART IV.

NOTES OF EXCURSIONS,

IN ILLUSTRATION OF THE

MODE OF INVESTIGATING GEOLOGICAL PHENOMENA,

AND OF COLLECTING

ORGANIC REMAINS.

GEOLOGICAL EXCURSIONS.

———— "Let the moon
Shine on thee in thy solitary
walk;
And let the misty mountain
winds be free
To blow against thee; and in
after years,
When these wild ecstasies
shall be matured
Into a sober pleasure,—when
thy mind
Shall be a mansion for all
lovely forms,
Thy memory be a dwelling
place
For all sweet sounds and
harmonies, oh! then
If solitude, or fear, or pain, or
grief
Should be thy portion, with
what healing thoughts
Of tender joy wilt thou

remember me
And these my benedictions!"

WORDSWORTH.

I now propose to conduct the reader to a few British localities, and point out the mode of examining geological phenomena in the field, and of collecting organic remains from the rocks and strata; in other words, afford a practical illustration of the advantages to be derived from the knowledge acquired by our previous investigations. But from want of space, only one or two excursions can be described in detail; and I must restrict myself in a great measure to extracts from my note-book, and explanatory remarks and suggestions for the guidance of the student and collector. The subjects will be arranged in the following manner:—

1. Instructions for collecting specimens.

2. Excursions illustrative of the geological character and organic remains of the Tertiary deposits of the London and Hampshire basins; namely, to the Isle of Sheppey, Bracklesham Bay, &c.

3. Notes for a geological Excursion over the Chalk and Wealden districts of the South-east of England; from London, by Tilgate Forest, to Brighton. Also, from Brighton to Rottingdean.

4. Geological notes of various places on the line of the Great Western Railway, from London to Clifton.

5. Excursion to Matlock and its vicinity; to examine the nature and position of the mountain limestone and associated strata of that part of Derbyshire.

6. Geological Notes for an examination of the central group of the plutonic or igneous rocks of England, and of the Carboniferous and Slate strata through which they are protruded: in an Excursion to Charnwood Forest, by Leicester, Mount Sorel, Swithland, Woodhouse, &c. to Whitwick.

CHAPTER XX.

GENERAL INSTRUCTIONS FOR THE COLLECTION OF SPECIMENS.

"And some rin up hill and down dale, knapping the chucky stones to pieces wi' hammers like sae many road-makers run daft—they say 'tis to see how the world was made."

ST. RONAN'S WELL.

Before we proceed on a geological excursion, it is necessary to be provided with suitable instruments to detach specimens from the rocks, and extract fossils from the strata in which we may find them imbedded, and with materials for packing up our treasures, and noting their localities on the spot. For this purpose, the following articles will be found more or less requisite, according to the particular object of the collector:—

1. A hammer of one of the forms figured in *Lign.* 266. Fig. 3 will be found most generally useful.

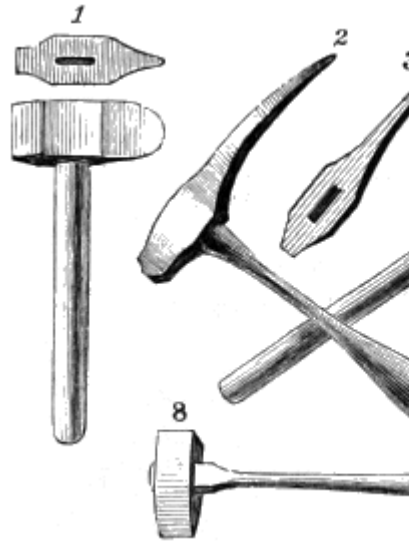
2. A leather or strong camlet bag, and one or two

of smaller size; the former with strings, or with a strap for the shoulder. If travelling in a carriage, a box or basket may also be provided.

3. Stout and thin paper, and some of a soft kind, for wrapping up specimens.

4. Chip boxes, and raw cotton, wadding, or tow, for the same purpose.

5. String, sealing-wax, and writing paper gummed on one side, for labels to affix to specimens on the spot.



LIGN. 266. GEOLOGICAL AND MIN

Fig. 1. and 4, 6, are adapted for breaking large stones or masses of l trimming fragments to a moderate size. The head should be fi crown, and from two to three pounds in weight; the length of

2 and 3.—This is my favourite hammer, and will be found most g pick for splitting stones, and extracting fossils of moderate siz of the crown one and a half inch; handle from twelve to fourt convenience of a firm hold. If the handle be graduated as a foo

5 and 8, 7, are smaller hammers for breaking and chipping stones one and a half pound in weight; the handle one foot long.

[782] Hammers of this kind may be obtained at Messrs. Knight's, Foster-lane, London; and at 49, Cockspur-street, Charing Cross: care should be taken that the heads are of well-tempered steel, and the handles of tough wood.

6. A strong pair of gloves, and a pair of eye preservers; common spectacle frames covered with fine black crape will be more agreeable than glass.

7. A measuring tape, a pocket compass, and drawing materials will be required, if the observer intend to note the geological characters of the district.[783]

[783] On the construction of geological maps and sections, see the Appendix to De la Beche's *Geological Observer*.

8. A good geological map of the country; if this cannot be procured, the best geographical map.

9. A strong double-bladed knife; one or more chisels.

10. A pocket set of single lenses of three powers, to examine minute objects; blank memorandum books.

Such are the articles that will be required for a geological excursion intended to comprehend a scientific examination of a district; but for a mere trip to collect fossil remains, several may be dispensed with. Some years since, an eminent geologist, Dr. Fitton, drew up some excellent instructions for collecting specimens, for the use of

the party employed under Captain King to survey the Western coast of Australia; by permission of the author, they are here subjoined.[784]

[784] For the collection of rock specimens, and for the mode of observing the phenomena of physical geology, Sir H. De la Beche s instructive volume, "*How to Observe*," should be consulted.

INSTRUCTIONS FOR COLLECTING GEOLOGICAL SPECIMENS.

"It may be proper to premise, that two of the principal objects of geological inquiry are, to determine—1st, the nature of the *materials* of which the earth is composed: and, 2dly, the relative *order* in which these materials are disposed in relation to each other.

"1. Specimens of rocks ought not, in general, to be taken from loose pieces, but from large masses in their native place, or which have recently fallen from their natural situation.

"2. The specimens should consist of the stone unchanged by exposure to the elements, which sometimes alter the characters to a considerable depth from the surface. Petrifactions, however, are often best distinguishable in masses somewhat decomposed; and are thus even rendered visible in many cases where no trace of any organized body can be discerned in the recent fracture.

"3. The specimens ought not to be very small;—about three inches square, and three quarters of an inch in thickness, is a convenient size.

"4. seldom happens that large masses, even of the same kind of rock, are uniform throughout any considerable space; so that the general character is ascertained by geologists, who examine rocks in their native places, from the average of an extensive surface. A collection ought, therefore, to embrace specimens of the most characteristic varieties; and *the most splendid examples are, in general, not the most instructive*. Where several specimens are taken from the same place, a series of numbers should be added to the note of their locality.

"5. One of the most advantageous situations for obtaining specimens and examining the relations of rocks is in the sections afforded by cliffs on the sea-shore; especially after recent falls of large masses, t commonly happens that the beds thus exposed are more or less inclined; and in this case, if any of them be inaccessible at a particular point, the decline of the strata will frequently enable the collector to supply himself with the required specimens, within a short distance.

"6. To examine the *interior* of an unknown country, more skill and practice are required; the rocks being generally concealed by the soil, accumulations of sand, gravel, &c., and by the vegetation of the surface. But the strata are commonly disclosed in the sides of ravines,—in the beds of rivers and mountain-streams; and these, especially where they cross the direction of the strata, may be found, by careful examination, to afford instructive sections.

"The mud and gravel in the beds of rivers and in deltas often contain grains of *gold*, *platina*, and other native metals, rubies, sapphires, and other precious stones; and a general knowledge of the rocks of an unexplored country often may be gained from the detritus at the embouchure of a river.

"7. Among the contents of the strata, the remains of organized bodies,—shells, corals and other zoophytes,—the bones and teeth of animals,—wood, and the impressions of vegetable stems, roots, or leaves, &c. are of the greatest importance; affording generally the most marked characters of the beds in which they occur. These should, therefore, be particularly sought after, and their relative abundance or rarity in different situations noticed. The fossils should, if possible, be kept united with portions of the rock or matrix in which they are found; and where they are numerous,—in sand, clay, or any moist or friable matrix,—it is, in general, better to retain a large portion of the whole mass, to be examined afterwards, than to attempt their separation at the time of collecting.

"8. The *loose substances* which are found above the solid rocks, in the form of gravel, silt, rolled pebbles, &c., should be carefully distinguished from the *solid strata* upon which they rest. And the more ancient of these water-worn materials, found on the sides or summits of hills, &c., should be distinguished from the recent mud, sand, and gravel, brought down by land-floods or by rivers. The bones and teeth of quadrupeds are not unfrequently found in the more ancient gravel; and the collection of these remains from distant quarters of the globe is an object of the greatest interest to geology.

"9. Besides a note of the locality, there ought, if possible, to accompany every specimen a short notice of its geological circumstances; as, for example, whether it be found in large shapeless masses, or in strata? If in strata,—what are the thickness, inclination to the horizon, and direction with respect to the compass, of the beds? If these cannot be measured, an estimate should always be recorded while the objects are in view. Are they uniform in dip and direction?—curved, or contorted?—continuous, or interrupted by fissures or veins? Is the whole cliff, or mass of strata in sight, of uniform composition?—or does it consist of different kinds of stone? If the strata be different, what is the order in which they are placed above each other successively?

"10. A *label*, distinctly written, should accompany every specimen, stating its native place, its relative situation, &c., and these labels should be attached to the specimens immediately, on the spot where they were found. This injunction may appear to be superfluous; but so much valuable information has been lost to geology from the neglect of it, that every observer of experience will acknowledge its necessity. It is useful to mark on the labels the day, and even the hour, when each specimen is collected. This, with a corresponding note in the memorandum-book, prevents confusion, and will be found to assist the memory.

"11. A *sketch* of a coast or cliff, however slight, frequently conveys more information respecting the disposition and relations of rocks, than a long memorandum. If numbers, denoting the situation of the specimens collected, be marked upon such sketches, much time may be saved at the moment of collecting. But in all such cases, the memorandum should be looked over soon afterwards, and labels, distinctly explaining their situation, &c. be attached to the specimens.

"12. The specimens should be so packed, that the surfaces may be defended from exposure to air, moisture, and friction: for which purpose, if strong paper cannot be obtained, dry moss, or straw, or leaves may be employed. Where paper is used for wrapping the specimens, they are best secured by fastening the envelope with sealing-wax.

"Lastly. The collector must not be discouraged, nor be prevented from collecting, by finding that the place which he may chance to visit in a remote situation has not a stinking appearance, or the rocks within his view a very interesting character; *since it frequently, and even commonly happens, that facts and specimens, in themselves of very little importance, become valuable by subsequent*

comparison; so that scarcely any observation, if recorded with accuracy, will be thrown away."

These general instructions will suffice to prepare the reader for an excursion to some known locality, where his researches will certainly be rewarded by many interesting organic remains; and he may be so fortunate as to meet with some rare fossils, and perhaps with one or two that have not previously been discovered; for there is always a chance of finding relics hitherto unknown, even in a cliff or quarry that is daily visited by collectors. And as an old sportsman desirous of inspiring a novice with a love of field sports, takes him at first to preserves where game is plentiful, in like manner I would initiate my reader in the delightful pursuit of collecting *Medals of Creation*, by conducting him to a spot where these antiquities of nature are scattered about in great profusion and variety.

CHAPTER XXI.

EXCURSIONS ILLUSTRATIVE OF THE GEOLOGICAL CHARACTERS AND ORGANIC REMAINS OF THE TERTIARY DEPOSITS OF THE LONDON BASIN.

In leaving London for any part of England, the reader will remember that the area on which the metropolis is situated, as well as the surrounding district to a distance varying from a radius of ten to

twenty or thirty miles, consists of the marine Tertiary *eocene* strata (see p. 24), which have been deposited in, and still occupy, a depression, or excavation of the Chalk, called the *London Basin* (*Wond.* p. 229). Around this formation, the Chalk forms a distinct boundary on the south, west, and north, rising up into chains of hills or downs; but on the east the range is broken, and the Tertiary basin lies open to the sea, affording a passage for the Thames and its tributary streams. From this geological character of the metropolitan district, it results, that all the lines of railroad proceeding from London traverse, for the first ten or twenty miles, beds of clay, loam, and loosely aggregated sand and gravel; hence the numerous slips that have taken place in the embankments; as for example, at New Cross, Wandsworth Common, near Hanwell, &c.; and in all these lines it is obvious, from the nature of the strata and the steepness of many of the cuttings, that similar catastrophes will again occur.

The next geological feature observable in the lines of all the London railroads is the CHALK, which is invariably passed either by steep cuttings, or tunnels, or both; as for example, from near Croydon to Merstham, by the South-Eastern; from near Basingstoke to beyond Winchester, by the South-Western; from Maidenhead to beyond Wallingford, by the Great Western; and from beyond Watford to near Ivinghoe, by the Birmingham line.

After passing through the Chalk, and over the marls and sandstone strata of the Cretaceous formation, the Oolitic group (consisting of Portland stone, Kimmeridge clay, &c.), the Lias, New Red or Triassic, and Carboniferous deposits successively appear on the lines of railroad; excepting on those of

the South-Eastern, which, upon leaving the Chalk-formation, traverse the fluviatile beds of the Wealden, as we shall hereafter more particularly describe.

EXCURSION TO THE ISLE OF SHEPPEY.

Every one knows that Sheppey is a small island about ten miles in length, lying at the mouth of the Thames, at the distance of between forty and fifty miles east from London; but every one does not know that the Isle of Sheppey is an inexhaustible mine of fossil treasures; and that from its cliffs, and on its shores, may be gathered innumerable relics of tropical plants, of quadrupeds, birds, serpents, turtles, fishes, crabs, lobsters, shells, &c. all belonging to species that now no longer exist.

A visit to the town of Queenborough afforded me, when a boy, the first opportunity of beholding fossil remains in such a state of preservation, and in such profusion, as to excite in my mind an uncontrollable desire to investigate the nature and origin of objects which I had been taught to believe were either produced spontaneously in the earth, or were left in their present situations by the waters of a universal deluge. At a short distance from the inn where we sojourned, was a vitriol manufactory, and considerable plots of ground were covered with the pyritous clay, obtained from the neighbourhood. To my great astonishment, I perceived that masses of this fossil earth were almost wholly made up of stems, twigs, and fragments of wood, with innumerable fruits, seed-vessels, and berries, of kinds altogether unknown to me. These fossils were of a dark colour, some quite black, very heavy, and permeated with the mineral substance termed

sulphuret of iron, or pyrites. Many were so brittle as to fall to pieces upon being handled, but others were of a stony hardness, and I quickly filled a handkerchief with my newly discovered treasures, and hastened home to examine them at leisure. They consisted of the usual kinds of fossil fruits so abundant in the island (see *Lign.* 63 and 64, p. 188), with casts of shells, and a few claws of crabs, and teeth of fishes.

Most of the specimens fell to pieces in the course of three or four months, but a few were durable, and these still occupy a corner in my cabinet as precious mementos of my juvenile researches. Many years afterwards I revisited Sheppey, and made a large collection of its fossils, which is now in the British Museum. Of late years, the increasing taste for Palæontology has brought numerous visitors to the island, which steam navigation has now placed within a few hours' distance of the metropolis; and the demand for choice fossils has given rise to several local dealers. The student may, with but little trouble or expense, visit the island, make himself familiar with its geological character, and return laden with the fruits of the ancient spice islands, of whose ruins this mass of clay, in the embouchure of the Thames, is almost wholly composed. As it is some years since I last visited this interesting spot, I have obtained, as a Cicerone for the reader, the most indefatigable and successful investigator of its fossil Flora, MR. BOWERBANK; and as the courtesy of this gentleman is equal to his intelligence and scientific attainments, the traveller will have no reason to regret the absence of the author. A trip from London to Sheppey and back, affording time to procure a good collection of fossils, may be easily accomplished in three days.

EXCURSION TO THE ISLE OF SHEPPEY, BY J. S. BOWERBANK, ESQ. F.R.S.[785]

[785] Abridged from the Annals of Philosophy, by permission of the author.

"The best conveyance is by the Southend and Sheerness steam-packets, which leave London-bridge on Tuesdays, Thursdays, and Saturdays, at 11 o'clock in the morning, and reach Sheerness about 4 or 5 o'clock in the afternoon. The town is divided into two parts,—the one contained within the limits of the garrison being designated the Blue town, while that beyond the fortifications to the north-east is designated the Mile-town; and it is to this portion that I should recommend the visitor to proceed, and take up his quarters either at the Royal Hotel, or at the Wellington: the latter is an exceedingly snug and comfortable house, to which I have resorted for many years. After having established himself in the inn, he should request the attendance of Mr. Hays (better known perhaps by the name of *Paddy Hays*), from whom he may purchase, at a reasonable rate, some good fossils, such as crabs, lobsters, heads and portions of fishes, and numerous species of fossil fruits. Our traveller will then have accomplished all that can be done towards the acquisition of fossils until the following morning; there not being, I believe, any other collector in the town from whom purchases can be made.

"On the following morning an early breakfast is desirable, as a considerable extent of ground is to be traversed. It is advisable to go provided with live or six sheets of soft paper, to wrap fragile specimens in; and a few cotton or linen bags, of about four or five inches in diameter, to separate the large from the

small fossils; the whole to be carried in a good-sized blue bag, or haversack; a chisel and light hammer are the only instruments required. If the geologist has a desire to view the great section of the London Clay, afforded by the cliffs on the north shore of Sheppey, and is content with the comparatively few fossils which he may be able to procure by his own exertions, he may proceed in the following manner:—Leaving Sheerness by the new town, he will pass along the sea-wall, towards Minster, until he reaches Scaps-gate, where the cliffs begin to rise from the low lands of the western end of Sheppey. A few cottages are scattered round this point, some of the inhabitants of which work upon the beach, collecting either cement-stone or *pyrites*, the latter being better known by the name of *copperas*. To these application should be made for 'curiosities,' and very frequently excellent specimens, and at a small price, may be thus procured. From this point the route will be under the cliffs upon the shingle, amidst which, dark patches, ten or fifteen yards in length, will be observed, composed of nodules of *pyrites*, intermixed with pyritized fragments of branches of trees, in great abundance. It is at such spots that the numerous and beautiful specimens of fossil fruits are found; but, to ensure success, the collector must be content to go upon his knees, and carefully search among the fragments. The whole of the beach, from about the parallel of Minster church to Warden Point, abounds with these patches of *pyrites*; and I have by this means obtained in the course of a morning upwards of one hundred fine fruits of various sizes. Care must be taken in such an investigation of the coast, that it be undertaken during the falling of the tide, or unpleasant consequences may arise from being shut in between

the banks of mud which are projected into the sea at many points of the coast.

"If the principal object be the attainment of the greatest quantity of fossils, a different course should be pursued. The collector should then, after having made his purchases at Scaps-gate, direct his steps towards Minster church, passing which, he will proceed on the road towards Warden. About three-quarters of a mile beyond the church there is a lane on the left hand, leading towards the Royal Oak, in which lives a woman named Mummery, and several others, who work upon the beach, and from whom fossils are frequently to be procured. These people will direct him to the cottage of a family named Crockford, who have usually a good assortment of fossils; and to many other parties who also work upon the beach, and reside between this point and Hensbrook, to which place he must now direct his steps. At Hensbrook inquiry should be made for a man named Pead, who has generally a considerable number of good specimens in his possession. From this point (Hensbrook) the collector must proceed along the top of the cliff towards Warden, calling at the various cottages in his way, until he arrives at Warden Point, at which place he must inquire for Mud-row, many of the inhabitants of which work upon the beach, and from whom a considerable addition to the specimens already collected may be purchased. Beyond this point nothing will be obtained, and the best way to return to Sheerness, is by the road which runs through the most level portion of the country; the path along the north cliff undulates very considerably more than the road.

"The course of proceeding thus sketched applies to the supposition that the time is limited to three

days, but if a longer period can be spared, I should recommend the tourist not to leave Sheerness without viewing the dock-yard; and the return to London may be made by the way of Chatham and Gravesend, affording the gratification of a view of the dock-yard and lines at Chatham, and of the fine old cathedral and castle at Rochester; at the same time, enabling him to arrive in London on the evening of the day that he quits Sheerness."

HERNE BAY. GRAVESEND.

If the student's time will permit, a day or two may be profitably spent at Herne Bay on his return; and search should be made for fossils under Swale Cliff and Studd Hill, where numerous fruits and some unique mammalian remains have been found by William Richardson, Esq. (see p. 791). Should he land at Gravesend, as recommended by Mr. Bowerbank, he should proceed towards the lime-kilns which lie on the London side of the pier, on the right bank of the Thames. To the left of the lime-kilns he will perceive a road leading by some bold chalk cliffs to the high ground above Gravesend; and on the right hand there is a row of cottages, or rather huts, inhabited by the labourers that work in the quarries and kilns. Many of the usual fossils of the Kentish Chalk may be obtained of the women or children in these huts; and sometimes *Cidares*, or turban Echinites (p. 314), with spines; and Star-fish (p. 306). A visit to the chalk-pits at Purfleet, on the opposite side of the river, is very desirable; many interesting fossils having been found in that locality. The Kentish Chalk in this district is much softer than that of Sussex, and the fossils may be easily cleared with a penknife, or by brushing in water; care should be taken not to wash them roughly, as they will

readily separate from the chalk.

The fossils procured from the Isle of Sheppey, by such an excursion, will probably consist of portions of stems and branches of trees, and fragments of wood, perforated by Teredines (see p. 193); specimens of the fruits of palms, resembling the recent *Nipas* of the Moluccas (p. 188), and of plants allied to the Cucumber, Bean, Cypress, Laburnum, &c. (p. 189); claws and fragments of the shields of Crabs (p. 512); bones of Crocodiles, Serpents, and Turtles; bones and teeth of Sharks (p. 591); Rays (p. 598), and other fishes; and several species of the usual shells of the London Clay (p. 383), and a specimen or two of Nautilus (p. 469).

NOTES FOR AN EXCURSION TO BRACKLESHAM BAT, ON THE WESTERN COAST OF SUSSEX.

The line of low cliffs extending from Selsea Bill to the mouth of Chichester Harbour exhibits a section of the Eocene deposits, varying in height from five or six feet to ten or twelve; it is covered at its base by a bed of shingle, fifteen or twenty yards wide, that extends towards the sea. The space between the termination of the shingle and the limit of low-water-mark is occupied by a bed of dark grey and greenish sand; and at certain seasons, numberless specimens of the fossil shells common in the Eocene strata of the London and Paris basins are thickly spread over this area.

Mr. Webster first directed attention to this locality, in his celebrated Memoir on the Tertiary Strata of England; and my friend, the late John Hawkins, Esq. of Bignor Park, followed up the

inquiry. In 1821 I made a fine collection of the Bracklesham fossils, and published a list of them in *Foss. South D.* and *Geol. S. E.* Messrs. Bowerbank, Saull, Dixon, Coombe, &c. have subsequently made considerable and important additions to the catalogue; and besides many new species of shells, the vertebræ and other bones of Turtles, Serpents, and Crocodiles have been discovered. An excellent notice of this locality, from the pen of Mr. Bowerbank, appeared in *Mag. Nat. Hist.* (1840); and I am indebted to the kindness of the author for the following notes for the guidance of my readers.

"The part of the bay most interesting to the geologist is that immediately in the neighbourhood of Bracklesham Barn, especially at about a furlong to the east of that spot, where there is a small break or chine in the low clay cliff. At this place, and at a few paces east and west of it, beneath about six or seven feet of clay, there is a stratum of light green marly sand, abounding in remains of *Venericardia planicosta* and other shells, but which is often entirely hidden by thrown-up shingle, and it is very rarely that more than a few feet in length of this bed can be seen. It is from this bed, or from one exceedingly like it, somewhat lower in the series, that perhaps most of the interesting shells of this district are to be procured. If we proceed from this little break or chine westward, for about forty paces parallel to the coast, and then in the direction of a line at right angles to the cliff, and at the time of low water, we shall find, near the low-water-mark, the bed we have described as abounding in fossils exposed by the action of the sea in the most favourable manner. At this spot *Venericardia planicosta* is found literally by thousands, with the valves united, the shells resting upon their edges, and packed close to each other, exactly in the manner that we might expect to have found them, supposing them to have been recent shells with the animals yet inhabiting them. Comparatively very few are gaping, and their condition and position strikingly impress upon the mind the idea that when alive they must have inhabited the spot from which they are now disinterred; especially as there are numerous small and fragile species of other well-known London Clay shells, which could not have remained whole had they been subjected to much attrition amid the larger shells surrounding them. On the sands in the vicinity of this spot, I found large masses of *Nummulites*

lævigatus cemented together, and numerous detached specimens of the same shell.

"At the eastern extremity of this bed, which, at the time of my visit, was opened for about fifty yards, I found *Sanguinolaria Hollowaysii*, a rare and fragile, but very beautiful shell, in a fine state of preservation. At about twenty or thirty yards westward of the western end of this interesting patch of shells, there are large blocks of this bed, which, being of a firmer texture than the surrounding parts of the deposit, have suffered less from the action of the water, and project about twelve or eighteen inches above the surrounding sand, and, by presenting an obstruction to the ebbing tide, they usually induce the formation of a small pool amidst which they stand. At the south-eastern side of this pool on one occasion I found the stratum, which is usually covered by the sand, completely exposed. At this spot there was scarcely a specimen of *Venericardia planicosta* to be seen, but instead of this shell, *Turritella conoidea* and *T. edita* were imbedded in a dark green marly sand; and among them, together with *Fusus longævus* and other well-known London Clay shells, I found *Venericardia acuticostata* and *V. mitis*, and a splendid specimen of *Conus deperditus*, fully equal in size to the one figured by Deshayes. Westward of this point I did not meet with anything particularly interesting.

"About midway between Bracklesham Barn and the Thorney coast-guard station, a series of patches of a deposit of chalk-flints was exposed; the first of these was nearly at low-water-mark, and the remainder of them ran, at short distances from each other, in a diagonal line towards the coast, nearly in the direction of a straight line drawn from their western extremity to the Thorney station-houses. Apparently, this stratum of flints has not, at any time, exceeded eight inches or a foot in thickness; they are, indeed, so thinly scattered, as rarely to occur piled upon each other: very few of them have suffered from attrition, and the greater part retain their original form and whitened surface. They are imbedded in the same light green marly sand which I before described as occurring at the bottom of the London Clay in the neighbourhood of the little chine near Bracklesham Barn. Amongst the flints there are numerous remains of the roots of trees, in the state of soft bog-wood; which indicate that this portion of the strata has been very thinly covered by the superimposed clay.

"Upon one of the bouldered flints, firmly imbedded in the marly sand. I found the most interesting of the valuable series of fossils which I had the good fortune to obtain during this excursion, namely, a fine specimen of *Astræa*[786] attached to the

upper and exposed surface of a flint."

[786] *Astræa*, a species of coral; see p. 262.

As to the accommodation that may be procured near this interesting geological locality, Mr. Bowerbank informs me that homely fare can be obtained at the little inn at Bracklesham, but there is only one spare bed. At Selsea, about six miles distant, there is a much better inn.

NOTES FOR AN EXCURSION TO THE TERTIARY STRATA OF THE ISLE OF WIGHT.

[See Geological Excursions round the Isle of Wight, and along the adjacent Coasts of Dorsetshire, by the Author. 8vo. 3d edit. With Prefatory Note by T. Rupert Jones. 1854. Bohn. London.]

Land at Cowes; examine the blocks of fresh-water limestone along the shore, which abound in shells. Drive to Alum Bay (*Wond.* p. 241), taking Calbourn in your route, where there are quarries of the fresh-water limestone, with innumerable casts of Paludina, Helix, Bulimus, &c. Put up at Groves' Hotel, on the summit of the hill, commanding a glorious view of Alum Bay, with the Hampshire coast, and the Isle of Purbeck on the right, and Portland Island looming in the remote distance; and on the left, the vertical cliffs of Chalk, and the Needles. The pathway that leads down to the sea-shore traverses a chasm, separating Headon-hill on the right, from Alum Bay on the left; in the former, fresh-water shells—in the vertical beds of clay, in the latter, marine shells—may be obtained in great abundance and variety.

If you land at Ryde, the small quarries at Binstead are worthy of constant research, for the chance of

mammalian remains (see p. 791).

The following extract from the splendid work of Sir Henry Englefield on the Isle of Wight describes certain geological changes still in progress on the shore near Ryde, that are well deserving the visitor's attention.

"A great and very singular change has taken place within no very distant period of time on the shores of the Solent, near to Ryde; and which seems to be still sensibly proceeding. When Fielding, in the year 1753, was at Ryde, on his voyage to Lisbon, he describes the town as totally inaccessible by sea except at or near high-water; as the tide, on its recess, left a vast extent of mud, too soft to bear the lightest weight. This mud-bank is now entirely covered by a stratum of fine white sand, smooth and firm enough to bear wheel-carriages, and which renders the bathing at all times safe and agreeable. This bed of sand now reaches to Binstead, having covered at least two miles of the shore within the last half-century; and the inhabitants say that it is still extending to the westward. On digging through the sand, the old mud presently appears, the sand stratum being very thin. To what cause this change is owing it is difficult to guess; but it is an example of the alternation of deposits from the action of the sea, in circumstances apparently unchanged, which may afford cause for reflection to the geologist."[787]

[787] Sir H. Englefield's Isle of Wight, p. 16.

If the visitor have leisure, he should make a tour of this interesting island, from Ryde to Shanklin and Ventnor, along the beautiful scenery of the Under Cliff, formed by the slips of the Lower Green Sand; to Black Gang Chine, and Fresh-water Bay; visiting Brook-Point (*Wond.* p. 378) to collect fossils from the Wealden strata on the sea-shore.

CHAPTER XXII.

NOTES FOR A GEOLOGICAL EXCURSION, OVER THE CHALK AND WEALDEN FORMATIONS OF THE SOUTH-EAST OF ENGLAND, FROM LONDON TO BRIGHTON, AND FROM BRIGHTON TO ROTTINGDEAN.

IN travelling from London to Brighton by the railway, the following geological features of the country may be observed; by a reference to *Wond.* p. 360, the structure of this remarkable district may be easily understood.

Leaving the station at London Bridge, the *London Clay*, with its characteristic fossils, is seen beyond Deptford, by New Cross, Sydenham, &c.; and approaching Croydon, beds of gravel appear, with interspersions of olive-green sand. These strata belong to the Eocene formation, and lie above and upon the Chalk. The valley beyond Croydon (Smitham Bottom), along the side of which the railroad is carried, is composed of gravel resting on chalk; beyond the station called *Stoat's Nest*, there is a fine section of the chalk, with layers of flint, and two parallel seams of marl, at the distance of six or eight feet from each other. These extend, with but little interruption, several miles, preserving their parallelism, although the strata in many places have sustained considerable disturbance. The Merstham Tunnel, through the Surrey chalk hills, is now entered. At Merstham the chalk, chalk-marl, and firestone are intersected, and the Lower Greensand of Red Hill appears; and from thence to Horley station,

the lower sands and clays of the Chalk formation are passed over or cut through; affording sections of sandstone, ironstone, and fuller's earth.

The strata we have hitherto traversed are of marine origin, and contain fossil shells, fishes, Crustacea, &c., and remains of other inhabitants of former oceans. But we now enter upon the series of river deposits[788] which form the Wealden, and contain the relics of terrestrial or fresh-water animals and plants.

[788] A limited intercalation of a marine character occurs in the Hasting Sands of Swanage Bay; this was discovered by Mr. R. A. C. Austen, and is noticed *Quart. Geol. Journ.* vol. vii. p. lix.

At Horley the weald clay appears, and is succeeded by sand, sandstone, and shale, to Crawley. Passing through the tunnel of the Wealden strata, we arrive at Balcombe, where sandstone in laminæ and in thick beds, having the surface at the lines of junction covered with ripple marks, is seen on each side the railroad; the dip of the strata is to the *north-east*. After crossing the deep valley at Balcombe, over the magnificent viaduct, the line runs along alternations of sand and clay, dipping *south-west*; we have thus passed over what is termed the anticlinal axis of the Wealden. Arriving at Hayward's Heath station, the tunnel exposes a good section of the Wealden sand, sandstone, shale, and blue marl or oak-tree clay, to a depth of about thirty-six yards. The strata are disposed in the same order and thickness as in the quarries around Cuckfield; namely, fawn-coloured sand and sandstone, like those of Little Horsted, with beds of calciferous grit

or Tilgate stone; and, beneath, layers of the blue clay. The strata are very barren in organic remains; several hours' research only afforded imperfect vegetable relics, such as comminuted stems and leaves of the various species of ferns, which occur in Tilgate Forest (see *Wond.* p. 392). Some of the grey laminated sandstones and shales at this place very closely resemble certain strata of the Coal measures.

Proceeding over the Weald clay with the Sussex marble of St. John's Common, the line encounters the Lower Greensand of Sussex, at Stone-pound gate. Here then we quit the fresh-water strata of the Wealden, and again enter upon the marine deposits of the Chalk-formation. At the foot of the northern escarpment of the South downs, the Chalk is penetrated at the base of Clayton Hill, the tunnel running through the lower members of the Chalk—the Galt and Chalk-marl—and emerging at Piecombe through the White Chalk; from thence to Brighton, the sections and tunnels intersect or perforate the same cretaceous deposits.

LONDON AND BRIGHTON RAILWAY.

In our traverse we shall have seen that the various strata cut through, are repeated on the north and south of a line drawn from east to west through the Forest Ridge (see *Wond.* Geol. Map, pl. 1). Thus, the railroad has to pass through two ranges of chalk hills by tunnels those of Merstham and Clayton; two principal ridges of Wealden strata—at Balcombe and Hayward's Heath; and the Shanklin or Lower Greensand at Red Hill, in Surrey, and near Hurstpierpoint, in Sussex. There is no railroad in the kingdom that, in the distance of fifty miles, exhibits geological phenomena of greater variety or interest.

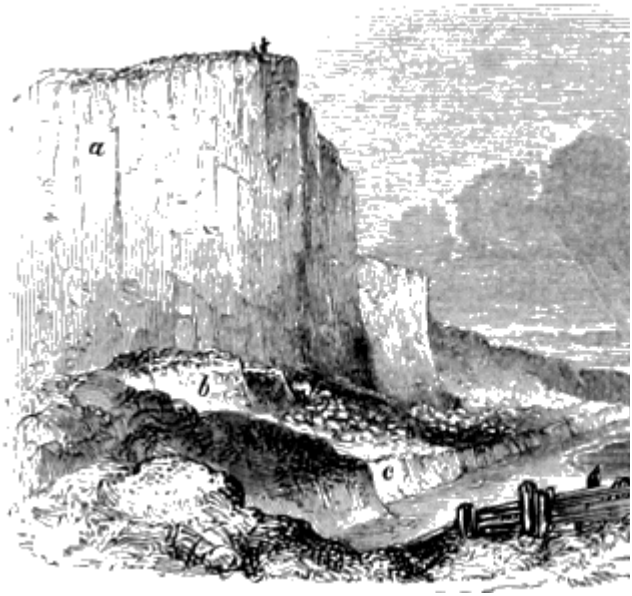
If the student will refer to *Wond.* p. 362, the stratification above pointed out will be better comprehended. The sections visible on the turnpike road from London to Brighton are described, *Wond.* p. 363.

The neighbourhood of Balcombe station will afford some sections of easy access; and from Hayward s Heath station, Cuckfield is about two miles distant. The quarries on the hill above that town were formerly very productive, and the usual Wealden fossils may still be obtained; namely, casts of several species of fresh-water shells (p. 416), scales and teeth of fishes (*Lepidotus*, p. 604), bones of reptiles, and vegetable remains.

GEOLOGICAL STRUCTURE OF BRIGHTON CLIFFS.

"Yes! where the huntsman
winds his matin horn,
And the couch'd hare
beneath the covert
trembles;
Where shepherds tend their
flocks, and grows the
corn;
Where Fashion on our gay
Parade assembles—
Wild Horses, Deer, and
Elephants have
strayed,
Treading beneath their feet
old Ocean's races."

Horace Smith.



LIGN. 267. BRIGHTON CLIFFS, NEAR KEM
From the Sea-shore, looking East, or towards
a.—The Elephant-bed.
b.—An ancient Sea-beach, composed of shingle and boulders of granite
c.—The Chalk which forms the base of the cliff.

A stroll from Kemptown along the sea-shore to Rottingdean is replete with interest, for the strata of which the cliffs are composed clearly demonstrate that in very remote periods great changes have taken place in the relative position of the sea and land along the Sussex coast.

Some years since, the bare face of the Cliffs, from the entrance to the esplanade of the Chain-pier at the Old Steyne, to Kemptown, was completely exposed, and presented a most interesting section of the strata. But at the present time, as every one knows, no portion of the cliffs is visible west of the *groin* below

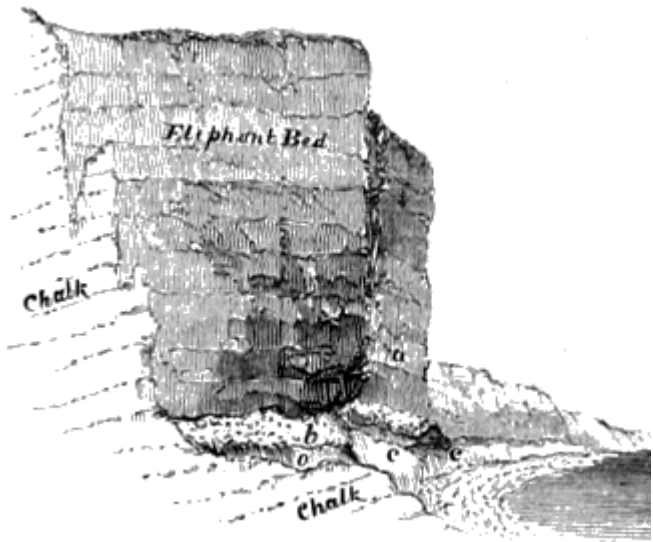
Kemptown and the sections in my first work (*Foss. South D.* pl. iv. and v.) are the only records of the appearances formerly presented, and now concealed by the sea-wall. Even the cliffs immediately beyond Kemptown are rapidly diminishing from the action of the waves, which dash with greater violence against their base in consequence of the means taken to protect the adjoining terraces from the encroachments of the sea.

The appearance of the Cliffs east of Kemptown is shown in the sketch, *Lign.* 267. But further along the shore, towards Rottingdean, in a ravine excavated by the encroachments of the sea, the ancient chalk-cliff behind the mass of strata seen above is exposed; this is represented in *Lign.* 268. A description of the appearances at this point will elucidate the nature of the strata of which these cliffs are composed.

Upon examining the shore at low-water, masses of chalk, covered with fuci (*sea-weed*), &c. are seen protruding through the sands; and towards the base of the cliff a bed of sea-beach is spread upon the sand; a low wall or terrace of white chalk constitutes the boundary of this shingle, as seen in *Lign.* 267, *c*. Thus we perceive, that the present shore is formed by the continuation of the chalk strata of the neighbouring Downs, partially covered with sand and beach, which are the detritus of the flints that have been washed out of previously existing layers of chalk, and ground down by the action of the waves. Now, along the eastern part of the coast, towards Rottingdean and Newhaven, the chalk rises into mural precipices immediately from the sea-shore; but at this place the cliffs are composed of very different materials.[789]

[789] *Wond.* p. 113; and *Quart. Journ. Geol. Soc.* vol. vii. pp. 365, 396.

1. In the first place, there is, lying immediately on the terrace of chalk that forms the boundary-wall of the base of the cliff (*Lign.* 267, *c*, and *Lign.* 268, *c c*,), a bed of sand (denoted by the letter *o*, *Lign.* 268), of irregular thickness and variable extent: from this sand marine shells and the jaw of a Whale (see p. 778), have been obtained.



LIGN. 268. CLIFFS BETWEEN KEMPTOWN AND ROTTINGDEAN:
a.— Elephant-bed; calcareous strata, containing teeth and bones of E
b.— Ancient Shingle, or sea-beach.
o.— Red of Sand; containing bones of Whales, and marine shells.
c, c.— Strata of undisturbed Chalk, dipping towards the Downs.

2. Upon the sand is a bed of loose shingle—a regular sea-beach appearing in no respect different, to the common observer, from that forming at the foot of the cliffs at the present moment; this bed is marked *b*, in *Lign.* 267, and 268. Upon examining

this shingle, it is found to contain numerous pebbles and boulders of granite, porphyry, syenite, and other plutonic rocks (see p. 34), none of which occur in the present beach. And in this ancient shingle, teeth and bones of extinct species of Elephant, Horse, and Deer have been discovered. We have here, then, unquestionable evidence that this beach has been formed under conditions altogether different from those which now prevail; for not only is this shingle-bed elevated above the present sea-level, but its contents are of such a nature as could not have been thrown up by the sea, in its present relation to the countries that form its shores.

3. A series of loosely aggregated calcareous deposits, obscurely stratified, rests upon this bed of shingle, and forms the upper portion of the cliff, varying in total thickness from fifty to one hundred and twenty feet. These strata are composed of chalk rubble and loam, with flints partially water-worn, and boulders and pebbles of tertiary sandstone; the whole promiscuously intermingled, and deposited in nearly horizontal layers, from one to three or four feet thick. But the face of the cliff generally presents a weather-worn and crumbling aspect, and large masses are constantly falling down, in consequence of the removal of the ancient shingle, by the effects of the waves at the spring-tides. From the loose state of aggregation of these beds, the fallen masses are speedily washed away, but here and there blocks of great hardness, provincially termed *Coombe-rock*, remain upon the shore; and, but a few years since, there was a group of high rocks of this kind near the Chain-pier. This compact conglomerate has been produced simply by an infiltration of calcareous spar, which has cemented together the fragments of chalk, flint, &c. In some places, this infiltration has reached

the bed of ancient shingle below, and large blocks are occasionally found, consisting of pebbles of flint, granite, &c. held together by veins of calc-spar, in acicular or needle-like crystals. In these sparry conglomerates, the teeth and bones of the mammalia previously noticed are sometimes found.[790]

[790] My daughter discovered part of the lower jaw of a Deer, with teeth, imbedded in this conglomerate, in a mass on the shore near Rottingdean.

It is in this accumulation of calcareous strata that numerous bones and teeth of the Mammoth, or fossil Elephant, have been discovered; I have therefore designated it, the Elephant-bed, to distinguish it from other loose calcareous deposits.

As seen immediately beyond Kemptown (*Lign.* 267), the cliffs appear to be entirely composed of the materials above described; but farther on, the face of the ancient chalk-cliff is exposed (see *Lign.* 268); and if we extend our walk to Rottingdean, we find in many places the Chalk alone forming the present cliff; the Elephant-bed and its associated shingle and sand having been swept away. A like destruction awaits the remainder of these interesting deposits at no very distant period.[791]

[791] See *Foss. South D.* p. 277, pl. iv.; and *Geol. S. E.* p. 30; *Wond.* p. 113.

After collecting specimens of the Elephant-bed, both of the friable varieties, and of the coombe-rock, and a few of the pebbles of granite, porphyry, &c. from the ancient beach, and also some of the sand beneath the shingle, to examine microscopically on our return home, let us sit down on this mass of fallen chalk, and consider the nature of those

changes in the relative position of the land and sea, which the phenomena before us appear to indicate.

We have seen that these cliffs are composed of the following deposits:—1. The Elephant-bed (*Lign.* 267 and 268, a); a series of calcareous strata, with bones and teeth of Elephants, Horses, Deer, and Oxen. 2. An ancient sea-beach (*b*), with pebbles and boulders of plutonic rocks, and bones of mammalia; and a bed of sand beneath, in which cetacea and mollusca (apparently of existing species) have been found. 3. Lastly, the regular Chalk-strata (*Lign.* 268, *c, c*), extending far out to sea.

These appearances demonstrate the following sequence of physical changes, namely—

1stly. The Chalk terrace (*c, c*), on which the ancient shingle-bed (*b*) rests, was on a level with the sea for a long period; for this beach must have been formed, like the modern, by the action of the waves on the then existing chalk cliffs (see *Lign.* 268, *Chalk*). But there must have been some cause in operation, by which pebbles and boulders of granite, porphyry, and other rocks, foreign to our shores, and bones of Elephants, &c. were thrown up on the strand, and imbedded in the beach then in the progress of formation. These transported materials may have been floated to the Sussex coast by icebergs; an agency by which the delicate bones and teeth might be deposited without injury, although surrounded by the water-worn detritus (see p. 43).

2dly. The whole line of coast, with the ancient shingle, must have subsided to such a depth, as to have allowed of the deposition of the calcareous strata, forming the Elephant-bed. And from the absence of gravel and beach, and the circumstance of

the chalk-rubble, of which they are largely composed, often presenting angular fragments, it would appear that this deposition took place in some tranquil bay or inland sea.

Lastly. The land was elevated to its present level; and at this period the formation of the existing sea-beach and line of cliffs commenced.

The reader must not conclude, from our remarks being restricted to the cliffs before us, that the phenomena here contemplated were limited to this district; on the contrary, if our space would permit, it might be shown that they are referable to extensive geological changes, which took place in the period immediately antecedent to the present. In all the valleys of the South-east and East of England that open into the sea, traces, more or less extensive and important, of similar deposits exist. The level plain, called the *Steyne*, at Brighton, is entirely formed of the Elephant-bed, which extends up the valley to Preston and Patcham; in the latter place bones and teeth of Elephants have been found. At Southbourn, the plain at the foot of the Chalk hills, called "*The Wish*," containing remains of the Elephant, Rhinoceros, and Hippopotamus, evidently belongs to the same epoch. At Folkstone, Mr. H. Carr has discovered large blocks of *Coombe-rock*, and Mr. S. J. Mackie abundance of bones; and at Dover, above the Chalk, similar masses occur. On the opposite coast of Franco there are also indications of these deposits. All these phenomena are no doubt connected with the occurrence of immense quantities of mammalian remains in the superficial loam, &c. on the eastern coasts of England, and are referable to the same geological epoch.

Imbedded in the Chalk, which is exposed at low water along the shore, very large Ammonites may sometimes be found between Kemptown and Rottingdean; and numerous examples of fossil sponges and other amorphozoa (p. 219).

The teeth and bones of mammalia are rare in these cliffs, and it is not probable that any will be obtained in a first visit; but from the fishermen and boys seen strolling along the shore, specimens may often be purchased.

CHAPTER XXIII.

GEOLOGICAL NOTES OF VARIOUS PLACES ON THE LINE OF THE GREAT WESTERN RAILROAD, FROM LONDON TO CLIFTON.

THAT splendid railway, the Great Western, by which the geologist may be transported in five or six hours from the Tertiary strata of the metropolis to the magnificent cliffs of Mountain limestone at Clifton, exposes in its course several fine sections, and passes within a moderate distance of some interesting localities of organic remains.

This railroad traverses the *Tertiary* strata by Ealing, Hanwell, and Slough, entering the *Chalk* near Maidenhead, and pursuing rather a circuitous route to Wallingford, beyond which station it passes over

the *Oolite*, and displays some bold sections of the limestones and clays of that formation. Near Bath it emerges on the Lias, and crossing a narrow belt of the *New Red*, passes on to the *Carboniferous* strata of the Bristol coal measures.[792] In this route, there are four places particularly deserving a visit from the geological student, and collector of organic remains, namely, Farringdon, Swindon, Caine, and Chippenham.

[792] See Geological Map of England.

VISIT TO FARRINGDON.—The railway station is reached in from two to two and a half hours from London; and an omnibus meets the morning and evening trains, to convey passengers to the town of Farringdon, which is about five miles distant.[793] There are two Inns in the town, the Crown and the Bell, where comfortable accommodation may be obtained.

[793] As there is not a conveyance from Farringdon to meet every train that stops at the station, the visitor who objects to a long walk should previously ascertain the time when the omnibus or coach does arrive, and select a train accordingly.

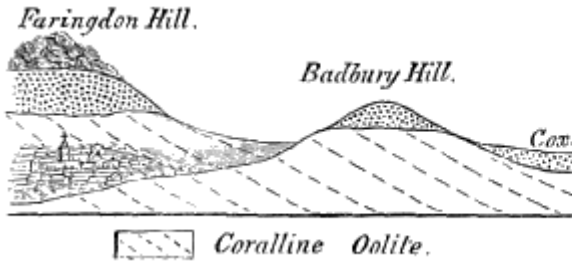
The town is situated in a valley, between Farringdon Hill, an eminence seen from a considerable distance in the approach from Oxford, and Badbury Hill (see *Lign.* 269). A small stream divides the town into two tithings, called Port and West-port, and flows into the Thames on the north. The summits of the highest eminences near Farringdon consist of beds of sand and gravel, resting on Coral Bag and Kimmeridge Clay, and belonging to the Cretaceous formation, being the littoral deposits

in this area of some sea of that period. The Lower Green or Shanklin Sand, the Galt, Chalk-marl, and Chalk successively appear in the valley below Coxwell Furze up to the White Horse Downs.

EXCURSION TO FARRINGDON.

I have not observed any organic remains in the strata on the top of Farringdon and Badbury Hills, but from the pits in the low country numerous fossil sponges and other *amorphozoa* (see pp. 227-229) maybe obtained. One of the most productive "gravel-pits," as they are here termed, is situated on the road to Little Coxwell, about three quarters of a mile from Farringdon. It lies on the left of the road leading to the pretty village of Shrivenham. In this pit, the strata consist of a coarse aggregate of siliceous particles, with some lenticular masses in the state of compact conglomerate; the lower beds are of a whitish grey, the upper of a deep ferruginous colour. The Windmill public-house, close by, is kept by the owner of the pit (Panting), and specimens of the "petrified salt-cellars" (see p. 228) and other sponges may generally be obtained of the inmates; but the collector, in a few hours, will be able to gather an extensive and interesting collection; the pick-hammer, *Lign.* 266, *fig.* 2, will be found the most convenient instrument. There are two other pits within a moderate distance of Panting s pit, which are also rich in fossils. The principal organic remains to be obtained from these beds are the zoophytes figured p. 227, and *Wond.* p. 637. The reader should recollect that the beautiful cup-shaped sponge, *Chenendopora fungiformis* (*Lign.* 71), is the "petrified salt-cellar" of the quarry-men. As many specimens as possible of the interesting coral, *Verticellipora* (p. 227, *Lign. 70, fig. 4*,) should be procured, to examine

the internal structure at leisure. The cup-shaped sponges should be collected uncleared, for they are often full of minute corals, shells, echinital spines, &c. There are also numerous specimens to be met with of *Terebratulæ*, *Ostreæ*, *Nautili*, and other shells; also rolled *Belemnites* from the Oolite, and bones of *Plesiosauri* and *Ichthyosauri*.



LIGN. 269. SECTION OF THE STRATA AT FARRINGDON, BERKS
The summits of Farringdon and Bradbury Hills, and Coxwell Furze, are
Coralline Oolite are not intende

NOTE:—See Memoirs on the Farringdon Sands, by Mr. R. A. C. Aus

FOSSILS OF THE CORALLINE OOLITE.—At a short distance from the town there is a large quarry of Coral-rag, called Lamb-close-pit, from which *Cidarites* (p. 316) and spines, and several species of corals and shells may be procured. Occasionally Ammonites and Belemnites are met with in the limestone at this place.

Stanford pit, about three miles south-east of Farringdon, is well worthy of a visit; it consists of the following strata:—

1. Uppermost; *Coral-rag*, three and a half feet.
2. Limestone, containing an abundance of shells, particularly and a half feet.

3. Portland sand, of an olive-green colour, three feet.
4. Kimmeridge clay.

Some shells are extremely numerous; principally of the genera *Trigonia*, *Gervillia*, *Pecten*, *Ostrea*, *Terebratula*, &c.; fine *Belemnites* also occur. The oolitic structure is very apparent in the upper beds of limestone.

SWINDON, WILTS.—Fourteen miles beyond the Farringdon station of the railway, we arrive at that of Swindon. About a mile from this station, on the rising ground to the south, stands the little, and formerly retired, town of SWINDON. Here, when a schoolboy, my curiosity was strongly excited by the so-called petrified "*ram's horns*," and "*oak*," so abundant in the solid masses of stone in the neighbouring quarries, and which daily came under my notice in my rambles around the town. It is indeed a locality most prolific in the Ammonites and other shells, and in the fossil wood peculiar to the upper division of the Oolite formation—the Portland beds; the hill on which the town is built consisting of those strata; the Kimmeridge Clay, on which they rest, is exposed in the railway cuttings in the valley on the north. There are two little Inns, the Bell and the Goddard Arms, where the visitor may meet with accommodation. The quarries, which are in the immediate vicinity of the town, abound in Ammonites, Trigoniæ, and other shells: and some layers are entirely composed of the casts of several species. The Ammonites are principally of two kinds, viz. *A. biplex* and *A. triplicatus*, and vary in size from a few inches to upwards of three feet in diameter; the specimens are casts only, no vestiges of the shells remaining. At Aylesbury the same species occur in clay, with the shells entire (see p. 481). A large

collection may be made in a few hours; and from some of the quarry-men the less common forms may probably be obtained. Casts of the bivalves called *Gervillia* and *Perna* abound in the quarry on the right hand of the road. I have collected from this place, in addition to those above mentioned, casts of the genera *Buccinum*, *Cardium*, *Cytherea* or *Venus*, *Nerita*, *Terebra*, *Pullastra*, *Pecten*; and of the large species of *Pleurotomaria* which occurs in the Kimmeridge clay of Hartwell, with the shell perfect (p. 428); also vertebræ of *Ichthyosauri*.

A section of the strata from Swindon to the nearest point of the chalk hills would pass over, in succession,—1. Portland Oolite; 2. Lower Greensand; 3. Galt; 4. Upper Greensand; 5. Chalk-marl; and, 6. Chalk.

EXCURSION TO CHIPPENHAM AND CALNE.

CHIPPENHAM AND CALNE.—In from three and a half to four hours the traveller from London reaches the town of Chippenham, ninety-three miles from London, and situated on the Oxford clay; the locality where Mr. William Bye obtained those interesting specimens of *Belemnoteuthis*, that contain vestiges of the soft bodies and arms (see page 459, and *Lign.* 145).

CALNE, about six miles from Chippenham, stands on Oolitic limestone; and the quarries around the town have long been celebrated for the perfection and abundance of their fossil remains; particularly of various species of the turban echinites (*Cidarites*, see p. 316), and their spines. A day or two at each of these towns will be well spent by the geologist and the collector of organic remains.

BATH AND BRISTOL.—The immediate vicinities of these cities are rich in interesting localities for the geologist. A visit to the public museums in Bath and Bristol cannot fail to gratify the student, and will at once point out to him the places most worthy his examination. That of Bristol is admirably arranged, and contains, among other treasures, the specimen of fossil *Squaloraia* (see p. 596); the remains of the reptiles of the magnesian conglomerate, the *Thecodontosaurus* (p. 713); and the celebrated collection of Crinoidea (p. 283) formed by the late Mr. Miller.

EXCURSION TO CLIFTON.

CLIFTON.—The stupendous rocks of mountain limestone which flank both sides of the Avon in its course from Clifton to the Severn are too well known to render a general description necessary, and our limits will not admit of details. The geological student should first obtain a *coup d'œil* of the appearance and position of the strata, by sailing down to the embouchure of the river in a steam-packet, and afterwards visit on foot the most interesting localities. On the right bank of the river, near the "Black Rock," the teeth of several kinds of fishes of the genera *Psammodus* (p. 587), *Hybodus* (p. 591), *Ceratodus* (p. 587), &c. may be obtained, and shells and corals of the mountain limestone. Polished specimens of the coralline marbles may be purchased at the shops.

Portishead, a pretty little village on the south-east bank of the Severn, is well worth a visit; and, by going in the morning steamer and returning in the evening, several hours may be agreeably spent along the shore below the hotel; and fossil plants and

shells, from the blocks of millstone grit, and numerous rock specimens may be collected.

A sail to *Chepstow*, and up the Wye as far as Tintern Abbey, returning on foot, or in a carriage, by Piercefield to Chepstow, is an excursion replete with the highest interest and enjoyment. The picturesque beauties of the Wye are dependent, like those of Clifton and Matlock, on the disruptions which the strata of mountain limestone have sustained. The magnificent scenery as we pass up the river, and the interesting associations connected with the ruins of Tintern Abbey, cannot fail to delight the traveller; but the enchanting scene that bursts upon the sight from the heights of Piercefield is magnificent in the extreme, and equal to the grandest views on the Rhine. Looking down from those elevated pinnacles of rock, which are covered with the most luxuriant vegetation, and crested with forests of pine, oak, and beech, we perceive the Wye pursuing its tortuous course at our feet, and winding along, around promontories of limestone, towards Chepstow; while immediately beyond, and apparently separated from the opposite bank of the river only by a precipitous rampart or mountain limestone, the Severn appears as a vast inland sea, bounded in the remote distance by the country around Gloucester, and extending on the right to the Bristol Channel.

Among other interesting geological sites within a few miles of Clifton and Bristol, may be mentioned—

1. Aust Cliff; a section of the Lias, from which many interesting fossils have been procured.

2. Banwell Cave; which is particularly deserving of examination (see p. 809).

3. Cheddar Cliffs; which are equally interesting to the geologist and to the lover of picturesque scenery. They are about twenty miles from Bristol; and a carriage and pair will be required, if the visitor intends to return the same day. The best arrangement is to visit the cavern at Banwell, remain in the neighbouring town the following night, and make an excursion to Cheddar Cliffs the next day.

There has lately been opened at Cheddar a cavern which surpasses in the beauty of its stalactites any hitherto discovered in England. The Rev. W. D. Conybeare states, that it is the only one that at all realizes any idea we have of the far-famed *Grotto of Antiparos*. It consists of one grand arch, or porch, and three or four lateral branches and narrow fissures, about ten or twelve feet broad, and from thirty to forty feet high, vested and draped with the most fantastic hangings of stalactite. The floor is a mass of stalagmite, covering a bed of gravel of the mountain limestone, which fills up about ten feet of the bottom. I am not aware that any fossil bones have been observed.

When visiting Banwell, inquiry should be made if there be any Cave at Hutton accessible to the visitor.

The above remarks must be regarded only as suggestions; for it would require a volume to particularize the geological objects of interest within a short distance of Bristol. The coal-mines in the neighbourhood of Bath and Bristol should be visited, and fossil plants collected.

CHAPTER XXIV.

GEOLOGICAL EXCURSION TO MATLOCK.

------ "In famed Attica such
lovely dales
Are rarely seen; nor can fair
Tempè boast
A charm they know not."

LORD BYRON.

The beautiful and romantic Dale of Matlock, although one hundred and forty-two miles distant, is now brought within nine hours of the metropolis. Leaving London from the Euston-square station of the Birmingham Railway, at eleven o'clock (taking the precaution to have a ticket that will ensure a passage from Rugby by the *Midland* Counties Railroad to Derby), we pass over in succession the clays, sands, and beds of gravel, composing the *Tertiary* strata of the London basin; and at Watford, steep cuttings of these deposits are seen on each side of the station. A long tunnel through the *White Chalk* of Hertfordshire is then passed; and at Tring we arrive at the termination of the Chalk, and obtain a fine view of the north-west escarpment of the Downs, which is seen extending on the right towards Ivinghoe, and attaining an elevation of 900 feet. The railway then proceeds over the Chalk-marl, Galt, and Lower Greensand, to near Leighton, where these members of the Cretaceous system are succeeded by the *Oolite* of Buckinghamshire and

Northamptonshire; and the line crosses the Grand Junction Canal near the emergence of the *Lias*; the Rugby station being situated in the midst of that formation. We then enter the Midland Counties line, and pass on to Stoney Stanton, where the Lias terminates, and the *Triassic* or *New Red* strata appear; proceeding towards Leicester, clays and marls of a dull red colour, denoting the Triassic deposits, constitute the slopes on each side the railway. As we approach Leicester, the craggy summits of Charnwood Forest appear in the distance On the left, with here and there an isolated conical hill, indicating the protruded masses of granite, porphyry, and syenite, which belong to the group of plutonic rocks of the central county of England. The granitic mass of Mount Sorel is seen along the railway from Sileby to Barrow, Charnwood Forest appearing in the distance.

Leaving Leicester for Derby, the route continues along Triassic strata; and a good section of the variegated marls, with veins of white fibrous gypsum, may be observed at *Red Hill*, where a short tunnel perforates a ridge of the same deposits. The railroad then emerges on the verdant alluvial plain through which the Trent, its waters increased by the confluence of the Dove and the Soar, pursues its course towards the north, and joins the Humber at Alkborough, whence the united streams flow on, and empty themselves into the German Ocean.

At Derby, where the train arrives at half-past five, half an hour is allowed for dinner; and we then proceed by the *North Midland* line, by Duffield and Helper, through a beautiful valley watered by the Derwent, which is seen winding its way towards Derby. The high grounds skirting this valley are

composed of the millstone-grit and sandstone of the Carboniferous system (see p. 31). Ten miles beyond Derby, we arrive at Amber Gate station, where an omnibus and other conveyances are in waiting, to convey passengers to Cromford and Matlock.[794]

[794] As it frequently happens that more passengers are brought by the train, than the omnibus or coach can convey, some activity is necessary to secure an outside place, which it is most desirable for the s geological tourist to possess, that he may command a good view of the splendid scenery, which will be constantly opening on his sight, through the romantic pass that leads to Matlock.

EXCURSION TO MATLOCK DALE.

The road from Amber Gate leads through a succession of picturesque scenes of surpassing beauty. At Whatstandwell-bridge[795] (see *Lign.* 273), over which the Derwent is crossed, the view is most imposing. The river is seen rapidly pursuing its course between richly wooded ravines, fringed with luxuriant foliage to the water's edge.[796] As we advance, the bold mountain ridge of *Crich Hill* appears on the light, with the village of Holloway at a considerable elevation, and Lea Mills near the base of the range; while on the left are the hills and overhanging woods of Alderwasley. Ascending to the Inn at Cromford, the road turns suddenly to the right, and by an opening cut through a mass of strata twenty feet thick, called *Scarthing Rock*, conducts to the southern entrance of Matlock Dale. On passing this chasm, the glorious features of this enchanting region burst on the view. On the east is a range of limestone cliffs, richly wooded, with Willersley Castle, the seat of the Arkwrights, embosomed in

trees on a commanding eminence; and on the west, a rocky precipice, crested with forests, and its sides partially covered with copses and brushwood; while the river, dashing through the ravine on the right, completes the magic of the picture—

"So wond'rous wild, the whole
might seem.
The scenery of a fairy dream."

LADY OF THE LAKE.

[795] HOTSTANDWELL in the guide-books; *Whatstandwell* in the Ordnance Map.

[796] The pedestrian should alight at the little Inn at Whatstandwell, and walk on to Matlock the following morning.

At the distance of about half a mile, we pass the toll-gate, and a bold mural precipice of mountain limestone suddenly appears on the eastern bank of the river; while on the western, a steep slope, clothed with verdure, rises rapidly to the lofty pine-clad eminence called MASSON HILL, an elevation of upwards of 1,000 feet. The base of this mountain stretches directly across the dale in front, and apparently presents a barrier to an egress from the valley on the north; but as we advance, the road is seen to wind round its foot by a defile along the left bank of the river; and the magnificent rock called the HIGH TOR rises in majestic grandeur on the right. The valley now gradually expands, and, at the distance of about two and a half miles from the entrance at Scarthing's rock, terminates in the champaign country beyond Matlock village.[797] From the precipitous nature of the escarpment of mountain limestone which forms the eastern

boundary of the dale, the buildings at Matlock Bath are confined to the left or western side of the Derwent, and are scattered here and there among the trees, on the projecting plots and terraces formed by the fallen cliffs of sandstone, which, during the lapse of ages, have become partially disintegrated and are more or less concealed by vegetable soil; the projecting rocks are covered with lichens, mosses, and ferns.

[797] The proper name of the hamlet in the valley, generally called Matlock, is *Matlock Bath*.

The hotels, of which there are several, are all delightfully situated; but the *Temple Hotel*, which stands on a terrace on the side of Masson Hill, about a hundred feet above the river, has the preference in my estimation; its elevated situation, its seclusion from the noise and bustle of the village, and its bowers and hedge-rows of sweet-briar and roses, imparting a character of sylvan beauty to the spot, peculiarly grateful to the traveller who wishes to enjoy a quiet sojourn at Matlock Dale. The local guide-books afford the necessary information to direct the visitor to the celebrated picturesque spots of this beautiful region; our immediate object is to point out the most important geological phenomena. [798]

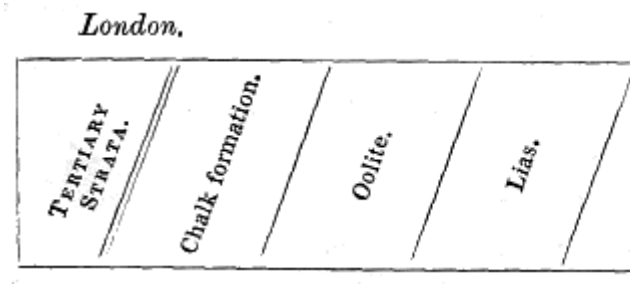
[798] The book entitled "The Gem of the Peak," by W. Adams, price Is., and the "*Brief Remarks on the Geology and Botany of Derbyshire*," by the same author, price 1*s.*, will be found to contain much valuable information. The "*Derbyshire Tourist's Guide*," with plates, 8vo., by E. Rhodes, price 6*s.*, is a delightful hand-book.

LONDON TO MATLOCK.

GEOLOGICAL POSITION OF MATLOCK DALE.—That the reader may clearly comprehend the geological character of the romantic district in which he is now situated, we will briefly enumerate the several formations over which we passed, in our rapid transit from London; by the aid of the geological map, the following description will be easily comprehended.

Our route from the metropolis commenced from the centre of the *Tertiary* strata, upon which London is situated, and which fills up an extensive depression or basin in the Chalk; we then passed over, or rather (by the tunnel) through the north-west boundary of the *Chalk* basin, and successively came upon the *Portland* stone and other beds of the *Oolite*, and the *Lias*; the strata of these formations successively rising from beneath each other as we proceeded. In Leicestershire, the beds of the *New Red* or *Triassic* formation emerged from under the Lias; and at the Trent Junction the nature of the deposits was concealed by the alluvial plains of the river. Beyond Derby, we entered upon strata of the *Carboniferous* system, the *Millstone grits* and *sandstones*, and finally reached the Mountain limestone and its associated *Magnesian limestones*,

which compose the mountainous district of Derbyshire. The following diagram will serve to illustrate this description.



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The immediate vicinity of Matlock is, therefore, a region of Carboniferous limestone and millstone strata, which, as we have previously explained (see p. 31), are of marine origin; and those beds that contain organic remains abound in extinct species of shells and crinoidea. These rocks are also the grand depository of the ores of lead (see *Wond.* p. 681), calamine, &c., and contain a variety of minerals of great beauty and interest. This district has also been the theatre, in very remote periods, of great physical changes, and the strata have been upheaved and displaced by volcanic action, the solid rocks rent asunder, and beds of mineral substances, rendered fluid by intense heat, have been injected between the layers, and into the fissures of the sedimentary strata; to these revolutions, the present bold and picturesque features of the country are attributable. Here then are phenomena replete with the highest interest; the very beds of lava may still be seen—the rents and fissures caused by their explosive action, and now lined with rich metallic ores and spars, may be examined—and the thermal waters, rising in

perpetual fountains from an incalculable depth, testify that the internal fires, the sources of these catastrophes, though latent, are not extinguished.

MATLOCK INCRUSTING SPRINGS.

A WALK TO THE INCRUSTING SPRINGS.—The so-called "petrifying springs and wells" of Derbyshire are celebrated throughout England for the incrusted birds' nests, baskets, &c. which are very generally purchased by visitors, as mementos of a trip into this county. The nature of this deposition of calcareous matter has already been explained (see p. 39; and *Wond.* p. 75); and, although the objects above mentioned are scarcely worthy of notice, the natural operations by which the tufa and travertine are produced, are extremely interesting.[799]

[799] If the proprietors of these springs could be induced to follow the example of the Italians at San Filippo (see *Wond.* p. 75), or of the French, in Auvergne, or the Germans at Carlsbad, elegant bas-reliefs and other beautiful objects might be obtained, for the incrusting power of the Matlock waters is very considerable.

Our first stroll shall therefore be to the beds of tufa which have been formed in remote ages by this operation and which now constitute the terrace on which the Old Bath and two other hotels, and the elegant modern Church are situated. Proceeding from our Inn, the tufaceous rock may be seen protruding in masses on the right hand, in front of the beautiful parterres of the hotels; and upon crossing the road, where a narrow path leads down to the bed of the river, and nearly opposite to the new church, the lower beds of tufa are exposed in a

quarry, from which large blocks of the coarse, porous stone are extracted for grotto and rock-work. From this spot I collected very fine impressions of the foliage of the oak, elm, and hazel, leaves of adder's tongue (*scolopendrium*), &c. and large portions of moss, beautifully incrusted.[800]

> [800] I could not obtain any specimens of this kind from the quarry-men nor from the shops or museums, as they are termed; such objects not being deemed "curiosities" by the good folks of Matlock; and the workmen forbade me to search for more in the quarry!

The origin of this deposit of tufa, which covers so huge an area along the western flank of the mountain range of Masson Hill, is attributable to the thermal springs having, at some very remote period, issued from a much higher source than at present, and flowing down the side of the hill into the river at its foot, the water, as it cooled, deposited the lime with which it was charged on the stems, branches, leaves, and other extraneous bodies. At this time the springs escape from crevices in the rocks at an elevation of about one hundred feet above the bed of the river; the waters, at their source, have a temperature of from 66° to 68°, and contain free carbonic acid and minute quantities of muriates and sulphates of magnesia, lime, and soda. Their origin is now concealed, and the water conducted by pipes to the various baths and fountains; but wherever a rill escapes, and flows down the hill, the moss, &c. is quickly incrusted. I was informed, that in about eight mouths a basket of eggs would be entirely enveloped in a thick mass of tufa. The uniform high temperature of these waters shows that they emanate from a very deep source; and it is probable that they originate from steam, which is cooled and condensed

as it approaches the surface of the earth. The miners assured me, that the springs burst out from beneath the volcanic rock, here termed *toadstone*, and that the water, when it first issues, is of a higher temperature than the Matlock Bath water; but its heat is reduced by the cool land-springs with which it becomes intermingled.

Most waters that flow through limestone districts deposit travertine more or less abundantly; and I observed several streams in my rambles in the neighbourhood of Matlock which appeared to possess this property in as great a degree as the thermal springs. There is a lovely waterfall, which issues from the side of a mountain that flanks the road leading by Via Gellia to Middleton Moor, at an elevation of two hundred feet, and flows into the adjacent valley, bounding and dancing from one mossy knoll to another, and appearing from the opposite hill like a stream of molten silver, undulating through a carpet of emerald green. The waters of this cascade have formed a thick bed of travertine along the side of the hill; and the stone is of so firm a texture, that the walls of a cottage hard by are constructed of it.

I gathered from the banks of this waterfall, bundles of moss and groups of small shells incrusted with a beautiful white tufa; and impressions of leaves, twigs, &c. were observable in the blocks of travertine recently quarried.

In contemplating the effects produced by these limpid streams, by which perishable leaves and fragile shells are preserved for ages in solid masses of rock, we are reminded of the forcible and eloquent remarks of Sir Humphry Davy, when observing

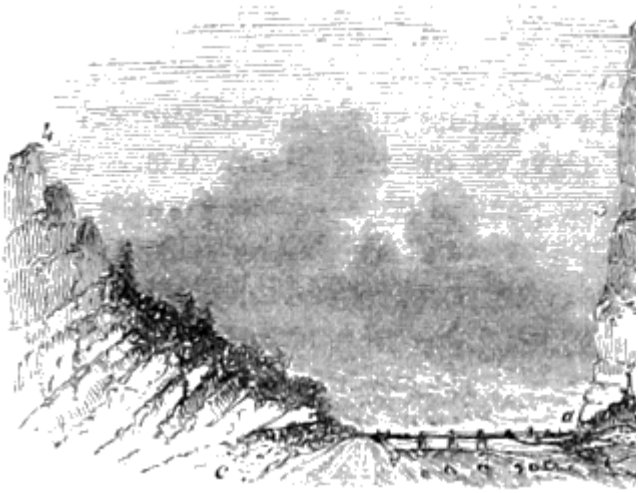
similar phenomena in the volcanic regions of Italy. "How marvellous are those laws, by which even the humblest types of organic existence are preserved though born amidst the sources of their destruction; and by which a species of immortality is given to generations, floating, as it were, like evanescent bubbles on a stream raised from the deepest caverns of the earth, and instantly losing what may be called its spirit in the atmosphere!"[801]

[801] "Consolations in Travel; or, the Last Days of a Philosopher;" by Sir Humphry Davy. See also *Wond.* p. 77.

CAVERN OF THE HIGH TOR.

VISIT TO THE CAVERN OF THE HIGH TOR.—After the visitor has taken a general view of the romantic scenery around him, a visit to the cavern at the foot of the High Tor will enable him to comprehend the nature of those physical changes which have imparted to this district its picturesque character. Descending into the valley and passing northwards, through the only street in Matlock Bath, along the banks of the Derwent, which are beautifully overshadowed by copses and forest trees, the bold cliff of mountain limestone, called the High Tor, the most imposing feature in the dale, suddenly appears on the right bank of the river. This rock rises to the height of four hundred feet; the upper half forming a bare and nearly perpendicular wall of limestone; the lower portion being concealed by brushwood and luxuriant foliage to the river s edge. At this spot, a rude wooden hand-rail is stretched across the Derwent, which is here of considerable breadth, and dashes along over fallen masses of rock in its course towards the south. The High Tor (*Lign.* 270) consists of a capping of Drift and of Millstone grit (2); of a

series of beds of limestone with encrinites and shells, slightly inclined southward (1); of a layer of volcanic matter, termed in Derbyshire *toadstone*, from its mottled yellow and greenish appearance (3); and of a bed of *Trap*, or *toadstone* (*b*), at the base, and near the floor at the entrance of the fissure or excavation in the limestone forming the cavern (*a*); which trap rock also appears on the opposite bank of the river (*c*), beneath the highly inclined and dislocated masses of limestone, forming part of the base of Masson Hill. The upper bed of *toadstone* (3) cannot be seen, for the face of the cliff (although represented bare for the sake of perspicuity in the plan, *Lign.* 270) is entirely concealed, half-way up, by dense foliage; but an intelligent miner assured me that such was the fact, and that, in sinking a shaft in the opposite hill, *toadstone* was found in a corresponding situation. Upon entering the cavern, which is not of considerable extent, the first phenomenon to be observed is the bed of *toadstone*, which protrudes near the floor, beneath a stratum of limestone. The limestone in contact with the trap is in some places changed to a light green colour, and has a slaty texture, from the effects of intense heat under great pressure; it is often permeated with veins of pyrites, and white calcareous spar. The inner recesses of the cavern are literally covered, both on the floor and sides, with very large rhomboidal crystals of carbonite of lime, of the form commonly called *dog-tooth spar*; the cave surpasses, in this respect, every other in Derbyshire.



G. A. M. delt. J. Whimper, lignt.

LIGN. 270. SECTION ACROSS THE VALLEY OF THE DERWENT, AT TH

Fig. 1.— The HIGH TOR, composed of strata of Mountain Limestone.

2.— Capping of MILLSTONE GRIT and DRIFT.

2.— Supposed position of an intrusion of TRAP.

2.— Cliff of limestone on the opposite side of the valley.

a. Entrance to the
— High Tor Cavern.

b.— Trap seen at the bottom of tile Cave.

c.— Trap beneath the limestone on the opposite bank of the Derwent.

Within a few hundred yards of the cavern, a gallery has been driven into the cliff, and a vein of lead (*galena*) discovered, and worked with some success. Tine masses of blue fluor (provincially termed *blue John*) and double refracting calcareous spar were also obtained. On the opposite bank of the Derwent, beneath the limestone, and extending along the road-side for two or three hundred yards, a bed of *toadstone*, evidently the continuation of that at the

base of the High Tor, is distinctly exposed.

Proceeding northwards, the line of mural precipices, of which the High Tor is the most elevated point, gradually descends; but there is a bold and bare rock, called the Church Tor, from the church of the village of Matlock being situated near its summit, that requires particular remark; for on the face of this cliff the strata present a series of curves, or rather arches, nowhere broken, but having such an appearance as would result from an expansive force from beneath uplifting a group of horizontal strata, while yet in a soft or plastic state. The upper beds of limestone at the Church Tor abound in marine shells (*Spirifer*, see p. 390, particularly the large species, *S. giganteus*). Such are the appearances presented by the strata in this locality, on the right bank of the Derwent. On the opposite side of the valley are beds of limestone, many of them varying in mineral constitution from those we have examined, being of a light yellowish dun or cream colour (hence called *Dun-stone*), and containing magnesia; in these strata traces of fossil plants are occasionally found. These magnesian limestones are of a granular texture and extremely hard; they are said to be very rich in lead and calamine, and have been extensively worked. The prevailing rocks on this (the western) side of the valley belong to this group.

FORMATIONS OF DERBYSHIRE.

GEOLOGICAL FORMATIONS OF DERBYSHIRE.—Before we proceed on our walk, let us sit down awhile on this mossy bank, beneath the magnificent knoll of trees that here overshadows the river, and, by a reference to the geological table (p. 31) and the

geological map, obtain a clear idea of the nature and succession of the strata around us; in other words, the order of superposition of the deposits of Derbyshire.

1. *Lowermost.* A bed of compact BASALT or TRAP (in Derbyshire called *Toadstone*), of uncertain thickness and extent. This rock consists of mineral matter that has undergone complete fusion, and been erupted from the profound depths of some internal source of intense heat (see *Wond.* pp. 684, 848). The upheaving force thus put in action having been unequally exerted in different places, the superincumbent beds of limestone have been protruded in dome-shaped masses through the upper strata; and are now seen bent and curved, forming what is termed arched stratification.[802]

[802] My excellent friend, the late Robert Bakewell, Esq., was the first geologist who correctly explained the phenomena here described. See his Introduction to Geology, 5th edit. p. 147.

Vesicular or *amygdaloidal* Toadstone. This partakes more of the character of scoriæ, being full of little cells or cavities formed by air bubbles; when these cavities are filled with other mineral matter, as is often the case, the rock is termed amygdaloidal. This bed of Trap was formerly considered to be distinct from the lowermost; but it is now supposed, and with much probability, that all the masses of igneous rock that pierce, or are intercalated with, the sedimentary strata, have sprung from one common source, and are but lateral protrusions from some grand mass of erupted materials.[803]

[803] See an analogous example, *Wond.* p.

857.

2. LIMESTONES with intervening layers of clay, and Magnesian limestones, or Dunstones.

3. Alternation of LIMESTONE and SHALE. Many of these limestones abound in organic remains; and it is in this group that the ornamental marbles of Derbyshire are comprised. The upper beds are generally of a slaty texture, and contain layers and nodules of chert, which often afford exquisite siliceous casts of the stems of *Crinoidea* (pulley-stones, see p. 284; and *Wond.* p. 650), and shells; white chert or porcelain-stone, and black jasper or flinty slate also occur in these beds.

4. MILLSTONE GRIT and SHALE, and coarse sandstones; these form the subsoil of the principal heights of the mountain ranges, their sterile soil supporting only a covering of ling and heath.

5. COAL MEASURES; consisting of beds of Coal, with intervening layers of shale, clay, and ironstone (see p. 80).

6. PERMIAN and TRIASSIC strata (see pp. 29, 30).

The mineral substances found in the above strata in Derbyshire are very numerous, and the organic remains equally so, and of a highly interesting character.[804]

[804] A good, catalogue of the principal varieties will be found in Mr. Adams's pamphlet previously recommended; and specimens may be obtained at his museum in Matlock, and from Mr. Tennant (Professor of Mineralogy to King's College), 149, Strand, London.

This enumeration of the geological formations of which the country around Matlock is composed will enable us to proceed on our rambles without further digression, and should the reader be at a loss to comprehend the nature of any of the rocks or strata we may meet with on our way, he can refer to the above description.

Mr. Bakewell, with his wonted penetration, first detected the true character of the stratification of the High Tor, previous writers having described this cliff as being composed of nearly horizontal layers. But this is a deceptive appearance; for, although, when viewed in front, or in the direction of their planes, the strata appear to be horizontal, yet they are in reality highly inclined, as may be seen in the line of dip, and enfold or envelope the back of the cliff; and they are continued into the hill (Masson) on the opposite side of the valley, where they present a similar arrangement. The continuity of the strata is broken by the vale of the Derwent, which has evidently originated in a fissure extending along the axis of elevation, in a direction from north to south; thus forming the water channel for the drainage of the country on the north, and the bed of the present river. We have already pointed out the curved position of the strata on the face of the *Church Tor*.

EXCURSION TO CRICH HILL.

EXCURSION TO CRICH HILL.—The appearances observable at the High Tor are of so striking a character, and involve the consideration of so many interesting phenomena relating to the physical mutations which this district has undergone, that it is desirable, while they are strongly impressed upon the mind, to take an excursion to Crich, a few miles to

the south-east of Matlock. Here there is an entire mountain of limestone, formed by a protrusion of numerous strata, many hundred feet in thickness, through the once superincumbent beds of millstone grit and sandstone, into a dome-shaped mass, upwards of 800 feet high. And there it stands, a stupendous monument of one of the past revolutions of the globe, with its arches of rifted rock, supported by a central mound of erupted mineral matter, now cooled down into an amorphous mass of compact basalt! Were there no other object of interest near Matlock, Crich Hill would alone render it worthy of resort.

From the heights above our hotel, looking towards the south-east, a mountain remarkable for its elevation and obtusely conical configuration, and distinguished by a tower on the summit, forms a striking object on the horizon, at an apparent distance of three or four miles—this is CRICH HILL; and on the same range, to the right, is seen the church-spire of Crich village (see *Lign.* 272).

A long summer's day is not too long to visit this mountain, and examine all its interesting details. A good pedestrian should proceed with his hammer and haversack, for every step of the road is replete with interest; and as numerous specimens will be obtained, bags, paper, and boxes should be taken. If an invalid or ladies be of the party, it will be desirable to have a carriage for the day, and dine at the little village of Crich;[805] and, if time permit, the interesting ruins of South Wingfield Manor-House (once the prison of Mary of Scotland), about two miles from Crich, may also be visited.

[805] A good, guide will be a great acquisition, and save much, time and trouble;

> and BENJAMIN FROGGATT, who has conducted Dr. Buckland and other geologists to the principal localities in the neighbourhood, will be found an obliging and intelligent attendant, perfectly conversant with the richest geological and botanical sites around Matlock.

The shortest drive from Matlock to Crich Hill is over Cromford-bridge; but a far more picturesque route is by the Derby-road to Whatstandwell-bridge (see *Lign.* 273), and from thence ascending the hill to Crich, and returning home by Holloway; making the entire distance about twelve miles. As our immediate object is to examine the geological features of the mountain, we shall proceed by the nearest road; and upon reaching Scarthing Rock, turn to the left, by Wellersley Castle grounds, having on the right a bold escarpment of mountain limestone, with layers of chert in nodules and amorphous masses. At Cromford Canal, the limestone suddenly terminates, and sinks beneath the surrounding alluvial silt of the river valley, and the millstone grit. We will chip off a few specimens of the chert, to examine at leisure. Crossing the bridge, the road winds round the foot of the hills of sandstone, which lie on our left, while on the right is the valley of the Derwent, and the river is seen here and there through openings in the copses and hedge-rows, meandering through the rich meadow-lands of the valley, which are flanked on the west by a magnificent range of lofty hills, clothed with the luxuriant woods of Alderwasley. The character of the scenery from this point of the road, till we ascend the high ground, is faithfully and graphically portrayed by Mr. Rhodes.[806]

[806] Derbyshire Tourist's Guide, p. 48.

"The road lies through a beautiful valley by the side of the Derwent; sloping meadows, crowned high above with a long range

of magnificent woods, skirt the road-side on the left: on the right the river, pursuing its winding way beneath the umbrageous branches of oak, ash, alder, hazel, and sycamore, and bubbling as it passes along, is a beautiful object. About two miles below Cromford-bridge, the road leaves the more open part of the valley, and plunges into the thick woods that environ the little hamlet of LEA; a lovely spot, romantically situated by the side of a sparkling stream, in a deep hollow, amongst steep hills covered with foliage, and fields of the freshest verdure. The houses of this secluded village, with the exception of here and there a comfortable cottage, are handsome residences, nestling among orchards and parterres of flowers. Everything was flourishing most luxuriantly; and when we passed through the place, the hollyhocks, dahlias, and roses were in full blossom, and gave an extremely bright and cheerful aspect to the scene. The road continues through *Lea Wood* to *Holloway* by a very steep ascent, and from the toll-gate at the top of the hill it traverses the side of a mountainous ridge, covered with wood and intervening rock. The prospect is now magnificent: on the right a scene of great extent opens to the view, rich in all that constitutes the highest beauty in landscape. The summits of the two ranges of hills that form the eastern and western boundaries of the fertile valley at our feet are here from three to four miles apart; and the extent from north to south is from ten to twelve. Many minor eminences, rich with wood and intervening verdure, adorn this enchanting scene, through which the Derwent, sometimes hidden by overhanging trees, and sometimes sparkling with light, flows with busy speed and uninterrupted current by Belper, Milford, and Duffield, to Derby; the whole presenting an assemblage of splendid scenery finely diversified and rich in picturesque beauty. The woods of Alderwasley, that cover the hills from below Whatstandwell-bridge, to the dark pine-crowned eminence of STONNIS, are peculiarly imposing and magnificent."

Near the village of Holloway there are several quarries opened on the side of the hill, which enable us to ascertain that this range is composed of strata of millstone grit and sandstone, highly inclined and dipping from the hill. The beds are so split and shattered in every direction, that no large blocks can be procured, and the stone, although a good building material, is therefore only employed in the construction of the cottages and houses in the immediate vicinity. The *vignette* of this volume

represents a mass of the inclined sandstone strata near this place. The reader will recollect that the hills on the opposite side of the valley, on our right, are also composed of similar strata; and that the ridge, covered with fir-trees, marks the bold escarpment of the millstone grit at STONNIS, over Cromford; so that the geological horizon of the valley, as seen from this spot, is wholly formed by the millstone grits and sandstones. A mile beyond Holloway toll-gate, the road turns to the left, and the bare dome of mountain limestone of CRICH HILL is before us. We soon arrive at a limestone quarry, in which the strata are seen to be distinctly arched (see *Lign.* 271, p. 886), as in the cliff at Matlock *Church Tor*.

We will alight here to examine the rock more closely, and obtain specimens. Here we see that the strata are inclined both to the right and to the left, and also lean towards the central axis of the hill in front of us; presenting such an appearance as would be afforded by an excavation made in an onion, or other spheroidal body, formed of a series of concentric layers. The limestone in this quarry is of the usual subcrystalline character, abounding in shells, principally *Spirifer*. There are numerous vertical and oblique fissures in the rock, and these are more or less incrusted with minerals and spars, which have evidently been deposited by electro-chemical action, and admirably exemplify the manner in which the rich veins of lead, &c. are distributed in the strata of the interior of the mountain. In a crevice of the rock, in which the mineral contents were undisturbed, the arrangement of the prevailing minerals of this part of Derbyshire, namely, galena (*sulphuret of lead*), sulphate of barytes (here termed *cawk*), and fluor spar, was beautifully

displayed. A layer of the blue sulphuret of lead, or galena, was spread over the surface of limestone forming the walls of the fissure: upon this was a thick stratum of white sulphate of barytes; and on the latter, fluor spar, of a light blue colour, forming cubic crystals on the surface nearest the cavity of the fissure, which therefore appeared to be lined with crystals of fluor.[807]

[807] The workmen at this and the other quarries generally have specimens of the fossils and minerals for sale, at moderate prices.

TRAP OF CRICH HILL.

About half a mile beyond, we arrive at Wakebridge, near which there are several very productive lead mines. The "*Glory-mine*," one of the richest in Derbyshire, is said, some ten years since, to have been worth from thirty to forty thousand pounds a-year.[808] A mining establishment, on the left hand, where a powerful steam-engine is constantly at work, affords numerous specimens of the usual I Derbyshire spars and minerals; and from among the heaps of refuse thrown by the visitor may make an interesting collection. Near this spot, a vertical shaft was sunk in the side of the hill, in search for lead ore, and at the depth of twenty fathoms, a rock of *compact Trap* was reached; the work was continued for a few yards deeper, but ultimately abandoned as fruitless. A gallery was subsequently driven into the side of the hill, lower down, and here, too, the trap was found; thus proving the existence of a central protrusion of igneous rock, over which the bent strata of mountain limestone are now disposed in consecutive layers. Numerous blocks of this compact trap or basalt, some of which are veined with red jasper, lie

scattered about the site of the old shaft, and an interesting suite of specimens may be collected. Pursuing our way, the limestone strata are seen in openings on the hill side, having the same remarkable arrangement as those before described.

[808] Derbyshire Tourist, p. 50.

Upon arriving where the road divides,[809] we must proceed on foot and visit the quarries, and examine the exposed masses of rock, that we may clearly comprehend the structure of the mountain. We will now ascend by the pathway that leads to the summit, and on the left several good sections of the strata are displayed. On reaching the tower on the crest of the mountain (*Lign.* 272, p. 887), a magnificent panorama bursts upon our sight; but which no language can adequately describe. Here and there bare pinnacles of rifted rock protrude through the green sward; and masses of white, yellowish, and pink sulphate of barytes, pyrites, fluor, and other minerals lie strewn upon the surface. [810]

[809] The carriage should here be sent on to the village, and orders given for refreshments.

[810] Good specimens may often be obtained from the piles of stones, and from the walls on the side of the hill.

Having reposed for some time at the foot of the tower to enjoy the glorious prospect spread around us, correct our notes, look over, trim, and wrap up our specimens, we will now descend to the north-eastern side of the hill, that the appearance of the strata on that aspect may also be examined. But ere we leave the summit, again let me call your attention

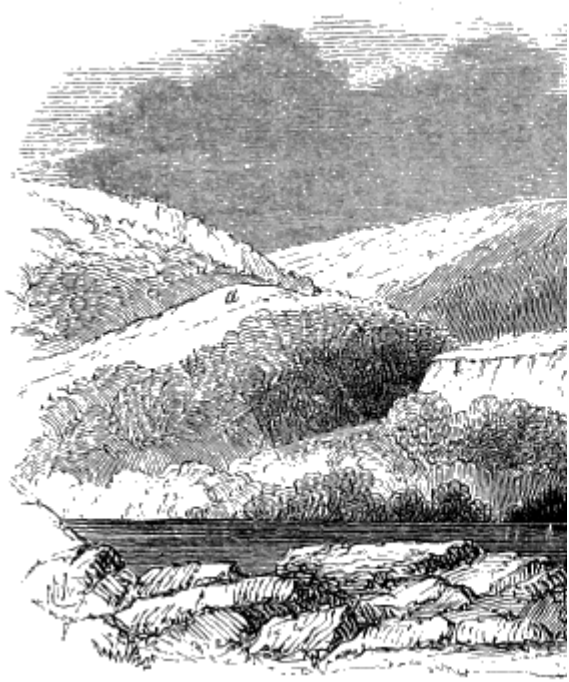
to its external configuration. Were it not on too extended a scale, we might suppose that we were standing on an ancient earth-work, or encampment, formed of limestone, surrounded by a deep fosse or ditch, and flanked by precipitous embankments of millstone grit and sandstone, so strongly defined are the physical features of this remarkable mountain.

We will now visit a large quarry on the eastern side, which presents a fine section of the limestone strata, above 100 feet thick (see *Lign.* 271), and which, like those we have previously observed, are disposed in curves, and enfold, as it were, the central axis of the hill; and the rock is shivered and fissured in every direction. A thick bed of drift, or alluvial debris, covers the limestone strata, as shown in *Lign.* 271; and in it, partially rolled blocks of sandstone, some of them of great size, are imbedded. The direction of the dip of the strata in this quarry is indicated by the arrows.



Drawn by Henry Carr, Es
LIGN. 271. QUARRY OF MO

VIEW OF CRICH HILL.



Drawn by Henry Car

LIGN. 272. VIEW OF CRICH

Let us now take a retrospect of the facts investigate during this morning's ramble, and consider how far Mr. Bakewell's interpretation of these phenomena (see p. 879) is in accordance with the data we have obtained. The outline of Crich Hill, as seen from a moderate distance, is that of an insulated oblong dome, encircled by precipitous escarpments, or angular eminences of less elevation. The annexed sketch (*Lign.* 272), by my friend, Henry Carr, Esq. C.E., of Duffield, to whom I am also indebted for a survey of Crich Hill, and admeasurements of the dip of the strata, will render this feature in the physical geography of the country more apparent.

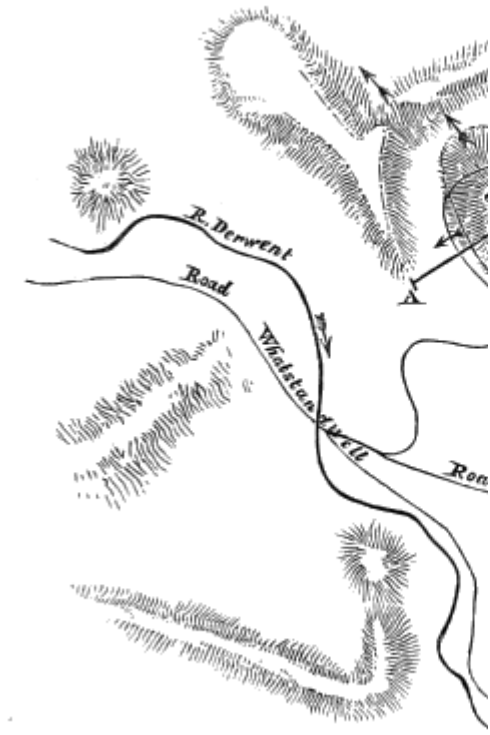
In *Lign.* 272, the protruded elongated cone of mountain limestone is denoted by the tower, or *Stand*, on the summit; and the other heights, and the foreground, are composed of millstone grit and sandstone. The highest point of limestone is 716 feet above the level of the Derwent in the adjacent valley; and was estimated by Mr. Bakewell at about 900 feet above the level of the sea. The hill of sandstone on the right, on which the mill stands, is 402 feet high, and conceals Crich village in this view; that in the middle distance, on the left, marked *a*, is 400 feet high.

This disposition of the millstone escarpments around the central cone of elevated limestone is shown more in detail in the ground-plan, *Lign.* 273.

Thus we perceive that the strata of mountain-limestone dip from the centre of the hill in every direction, as indicated by the arrows, at various angles, from 20° to 50°; and those of the sandstone hills, which form an irregular zone around Crich, are also highly inclined, and in like manner dip from the central axis, as is shown by the direction of the arrows. Now we know, by observations made in places where the relative position of the Millstone and Limestone has suffered no disturbance, that these two series of strata were originally disposed horizontally and conformably upon each other, thus —

1. *Uppermost*— MILLSTONE GRIT AND SANDSTONE.
2. *Lowermost*— MOUNTAIN LIMESTONE.

GROUND PLAN OF CRICH HILL.



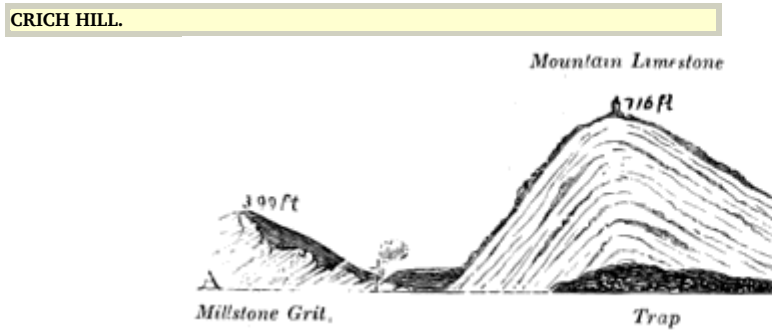
LIGN. 273. GROUND PLAN OF C
(*Scale, one inch to*
By HENRY CARR, Esq. C. E. f

The area, enclosed within a line, and marked *Stand, Crich H* surrounding country is composed of *millstone grit* and *sa*

The arrows on the boundary line of Crich Hill denote the positions measured and determined by Mr. Carr. The di the south-east of the tower.

The arrows on the surrounding millstone escarpments mar stations, to convey a general idea of the position of the

[811] At Whatstandwell, abridge crosses the Der where good accommodation and sleeping apartments



LIGN. 274. SECTION OF CRICH HILL;
(*Natura*
By REGINALD NE

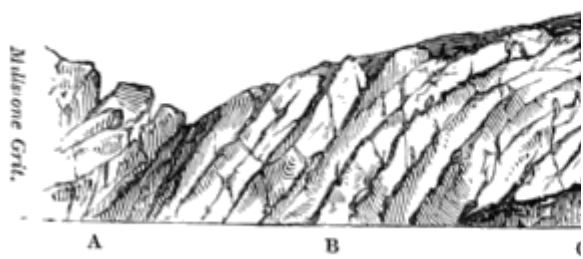
A, B. — Strata of *Millstone Grit*, highly inclined, and dipping from the ce
Protrusion of the Mountain Limestone, on the summit of which
Central mass of TRAP, reached by a vertical shaft from above, a

It is therefore evident, that at Crich the strata No. 2 must have been forced up, and protruded through the strata No. 1, or they could not occupy their present position. We remarked, on ascending Holloway Hill, the great disturbance which the Millstone beds had sustained (see the vignette of this volume); and the shaft and gallery near Wakebridge (p. 884) disclosed the existence of a mass of basalt, or *trap*, of unknown extent, beneath the limestone, in the centre of the mountain; while the fissures and crevices, filled with metallic ores and spars, attest the action of intense heat, under great pressure. According to a survey made by my son, a section in the line marked A—B on the plan, *Lign.* 273, presents the arrangement of the strata seen in *Lign.* 274: the heights are from actual admeasurements.

From the data thus obtained, we may construct an ideal section in illustration of these phenomena, as in the following diagram (*Lign.* 275).

Here then, as Mr. Bakewell forcibly observed, "we have cause and effect in conjunction." Here is the cooled and consolidated molten rock, whose expansive force elevated the horizontal strata of limestone, and forced them through the superincumbent beds of grit and sandstone. But this eruption must have taken place under great pressure, and at the bottom of the sea; for, had the phenomena been sub-aërial, the result would have been altogether of a different nature; and we should have had cooled lava streams, and not masses of basalt.

We have seen that the strata rise round and enfold this central nucleus of volcanic rock, displaying nearly hemispherical segments and curves. Now if we suppose a vertical transverse fissure across such a hill as that represented in the diagram (*Lign.* 275), the face of the remaining strata would be in every respect similar to that of the HIGH TOR (see *Lign.* 270, p. 876); namely, a mass of *Trap*, or *toadstone*, at the base, and a series of arched strata of limestone above; with fissures containing ores of lead, zinc, barytes, &c. and various kinds of spar.



LIGN. 275. IDEAL TRANSV

A, A.— Highly inclined strata of *Millstone Grit.*

B, B.— Arched strata of *Mountain Limestone*.
C.— A central nucleus of *Trap* or *Toadstone*.

To a mind accustomed to investigations of this nature, a slight examination of the phenomena under review will, I apprehend, suffice to demonstrate the correctness of these deductions; but I may have failed to place the subject before the general reader in an intelligible and lucid point of view; should this be the case, still, if the attempt to present a familiar exposition of the physical structure of this remarkable district shall induce him to visit the scenes I have so imperfectly portrayed, and interrogate Nature in a right spirit, the hours we have passed together in our excursion to Crich Hill will not have been spent in vain; for in the beautiful language of the noble bard:—

"To sit on rocks, to muse o'er
flood and fell,
To slowly trace the forest's
shady scene,
Where things that own not
man's dominion
dwell,
And mortal foot hath ne'er
or rarely been;
To climb the trackless
mountain all unseen,
With the wild flock that
never needs a fold;
Alone o'er steeps and
foaming falls to lean;
This is not solitude; 'tis but
to hold
Converse with Nature's

charms, and view her
stores
unroll'd."—CHILDE
HAROLD, Canto II.
XXV.

SPECIMENS OF FOSSILS AND MINERALS.—On our return, our first care must be to look over all the specimens we have gathered, arrange them, and select those which are the most illustrative of the phenomena we have examined; and ticket every specimen, as recommended in the Instructions. The fossils, consisting of several species of *spirifer* and other brachiopoda, and of portions of encrinital stems, require no particular care. The rocks should comprise specimens of the different varieties of limestone and sandstone; and of the green limestone, altered by contact with the toadstone; and examples of the compact trap, and of the variety veined with red jasper,—of the amygdaloidal toadstone,—and the vesicular, or that in which the cavities are empty. The minerals should comprise the ores of lead, zinc, barytes, fluor, and calcareous spar; of the last some good clear pieces should be selected, that will exhibit its double refracting property. Of the common metal, *Pyrites*, a few specimens should be preserved; this mineral, from its splendid yellow appearance, is often mistaken for gold; but a mere blow of the hammer will immediately detect it, for *Pyrites* is brittle, and readily cracks to pieces, while gold, as is well known, is remarkably ductile. If the collector be not satisfied with the fruits of his day's researches, he should look over the catalogue of Mr. Adams, and purchase such specimens as will render his collection sufficiently extensive to present a full illustration of the geological character of the scenes he has this day visited.

There is a variety of sulphate of barytes from near Youlgreave exhibited in the shops at Matlock, of which one or two examples should be obtained. The surface of the polished specimens much resembles the rich variegated appearance of dark tortoise-shell. This mineral has been formed, like the common calcareous stalactite, by infiltration through some porous rock; transverse sections exhibit concentric layers of various shades; while the longitudinal have the varied colours disposed like those in tortoise-shell.

BONSAL VALLEY.

NOTES FOR A GEOLOGICAL EXCURSION BY CROMFORD, UP BONSAL VALLEY, BY VIA GELLIA, TO MIDDLETON MOOR; RETURNING BY STONNIS.

This excursion will present many objects of interest, and one day at least should be devoted to the examination of the different localities pointed out in the following notes.[812] To Cromford, and then take the road that leads through BONSAL vale. A fine range of limestone on the right, and a sparkling stream (Bonsal-brook) on the left. On the banks of this brook there is a manufactory of mineral colours (Pooley's) well worthy a visit. But before we reach this establishment, there is an opening on the hill side where the strata are exposed, and a bed of Trap is seen beneath the limestone; near this place specimens of fluor, calc-spar, &c., that have been thrown out in forming the excavation, may be collected. From beneath the trap a warm spring issues and flows into the neighbouring brook.

[812] Benjamin Froggatt should be engaged to conduct the pedestrian; and a carriage party would also do well to place themselves under his guidance.

Proceed up the road leading to *Via Gellia*, and through a valley flanked with high ranges of limestone and dun-stone. On the right, is the beautiful cascade previously mentioned, near *Dunsley*. This valley is a celebrated botanical region, for several species of plants which are of great rarity or unknown elsewhere are here met with. At the direction post, turn to the left up the steep hill that

leads to Middleton Moor. On each side numerous fossils of the mountain limestone may be collected from the blocks lying on the flanks of the hill. Views splendid in picturesque scenery and of a highly interesting geological character are obtained as we ascend. On the summit of Middleton Moor, which is from 1,300 to 1,400 feet above the level of the sea, a most extensive panoramic view of the surrounding country may be obtained. The geological map will enable the observer to identify the crags of Charnwood Forest, the High Peak, &c. &c. Almost every part of the Moor is studded with the disused shafts of exhausted mines, and which are so carelessly covered over as to be extremely dangerous, and the visitor must bear this caution in mind; for the heaps of stone placed at irregular intervals on the hill, and which tempt the geologist to seek for specimens, are for the most part piled over the openings of deep shafts.[813]

> [813] My son narrowly escaped being drawn in by a heap of stones which gave way under his feet, and suddenly disappeared in the chasm below. In rambles of this kind in a mining country, the young geologist must, therefore, be upon his guard, or he may be engulphed with masses of limestone in some deep chasm, and his bones, incrusted with stalactite, form an ossiferous breccia, that in future ages may perplex some collector of organic remains to determine its relative antiquity!

Pass on by Worksworth, to the quarries of mountain limestone, where the encrinital marble, so largely employed for side-boards, chimney-pieces, &c. is procured. Near the approach to the entrance of the quarry, an instructive example of curved strata of

limestone is seen on the left; and on the right, a fine vertical artificial section. On the weathered surface of the left side of this entrance, and on the face nearest the quarry, good specimens of the stems I and ossicula of the usual Derbyshire crinoidea may be extracted (p. 284) from the layers of reddish limestone; and good blocks of the marble may be selected. Large spirifers can be procured from the limestone in these quarries; the quarry-men often have specimens. On the right hand of the entrance, layers of flinty slate (called partings of *black bind* by the miners) occur between the beds of limestone. In a field near this quarry, on the left of the road leading to Cromford, where some mining operations are going on, blocks of the stone called *chert* have been thrown up, and often contain beautiful examples of the pulley-stones (p. 285), or siliceous casts of the stems of the crinoidea. A large collection of fossils may be gathered in the localities above mentioned.

We now drive to the escarpment of millstone grit at STONNIS, called *Black-rock*, whose pine-clad summit forms so conspicuous an object in the view from Crich Hill; it is about a mile from Cromford, and overlooks Matlock Dale.

On the right of the road, the refuse workings of a mine cover the side of the hill; among which some specimens of spars or minerals may perhaps be found.

VIEW FROM STONNIS.

But the grand attraction of Stonnis is the view of Matlock Dale and the surrounding mountains, obtained from the verge of the precipitous escarpment of sandstone rocks, under the knoll of

pines. It is, indeed, a scene of transcendent beauty and magnificence, and is said, by one who has ascended every mountain top and traversed every ravine and valley in this district, to be unrivalled.

"In that species of beauty which in landscape scenery approaches to grandeur, it is unequalled in Derbyshire. The parts of which it is composed are of the first order of fine things, and they are combined with a felicity that but rarely occurs in nature. Scarthing Rock, the woods of Willersley Castle, Matlock High Tor, the hills of Masson, Crich, and Riber are all noble objects; and the rude masses that constitute the foreground of the picture are thrown together, and grouped and coloured in a manner strikingly picturesque. I have scaled the highest eminences in the mountainous districts of Derbyshire—seen from their summits the lovely dales that repose in H tranquil beauty at their base—marked the multitude of hills included within the wide horizon they command, and my heart has thrilled with emotion at the sight; but not an eminence that I ever before ascended—not a prospect, however rich, and varied, which I thence beheld—is at all comparable with the view from Stonnis."[814]

[814] Derbyshire Tourist's Guide, p. 42.

Every one possessed of taste and feeling who gazes upon this glorious landscape will partake, in a greater or lesser degree, of the emotions thus finely expressed by the ardent lover of the sublime and beautiful in nature; but to the natural philosopher the physical characters of this enchanting region are fraught with a deeper interest, and present subjects for the most profound contemplation. To him the rocks and the mountains are the grand monuments of nature, on which are inscribed the history of the physical revolutions of the globe which took place in periods incalculably remote and long antecedent to the creation of the human race. They present to his mind a succession of events, each so vast as to be beyond his finite comprehension; ages of tranquillity, with lands and seas teeming with life and happiness, succeeded by periods in which the earthquake and

the volcano spread universal ruin and destruction—and they teach him that all these awful changes bear the impress of the ALMIGHTY'S hand, and were subservient to the eternal purpose of rendering this planet the fit abode of MAN, during his mortal pilgrimage.

CHAPTER XXV.

NOTES FOR A GEOLOGICAL EXCURSION TO CHARNWOOD FOREST, TO EXAMINE THE CENTRAL GROUP OF PLUTONIC ROCKS OF ENGLAND; AND THE CARBONIFEROUS AND CAMBRIAN STRATA, THROUGH WHICH THEY HAVE BEEN ERUPTED.

In the central county of our Island, within a hundred miles of the Tertiary deposits of the South-east of England, a group of plutonic rocks emerges from beneath the strata of limestone, coal, and red marl which constitute the principal geological features of the midland provinces, and rises up into the bold and picturesque range of hills of CHARNWOOD FOREST. Almost the entire series of British rocks is now brought by the railroads within a few hours distance of the metropolis; and the geological inquirer may, in the course of a fortnight, examine in their natural situations the Eocene

deposits of the London and Hampshire basins—the Cretaceous and Wealden strata of Sussex, Kent, and Surrey—the Oolitic, Liassic, Triassic, Permian, and Carboniferous systems—the Mountain limestone and its metalliferous treasures—Traps, or ancient lavas, and their effects—strata of the Silurian and Cambrian systems—and, lastly, Granite, Syenite, Porphyry, and other modifications of the plutonic or igneous rocks. The present notes refer to two or three days spent in exploring the country around Leicester, and in examining the granite of Mount Sorel[815]—the slate quarries of Swithland—the syenitic crags of Bardon Hill—the porphyritic masses of Markfield and Grooby—and the coal-mines of Whitwick. On our previous excursion by railway to Leicester (see Excursion to Matlock, p. 867), the order of the succession of the strata from the metropolis to that town was described; on this occasion it will only be requisite to direct the traveller's attention to the abrupt isolated hills, by Hinckley, Grooby, and the craggy peaks of Charnwood Forest, in the distance, on the left of the railroad, before reaching Leicester. If a pedestrian excursion be resolved upon, three or four days at least will be required to follow the route presently pointed out; in a carriage and pair, it may be accomplished in a long summer s day, by starting from Leicester at six, and returning by ten or eleven. [816]

[815] SOREL, a corruption of *Soar Hill*, or hill on the river Soar.

[816] It maybe well to remind the visitor that at Leicester the following objects are worthy of notice:—the Roman Milestone, now placed in the High-street; the remains of the Roman Wall; and the Blue Boar Hotel, where Richard III. slept the night before the battle of

Bosworth.

EXCURSION TO CHARNWOOD FOREST

The geological localities to be visited in this excursion are the following—

I. BARROW-ON-SOAR.[817] *Lias limestone.*—The quarries at this locality are celebrated for the organic remains that have from time to time been obtained from the limestone. Bones of Ichthyosauri and Plesiosauri (see p. 669), fishes (*Dapedius*, p. 603), leaves of cycadeæ, and fossil wood, together with ammonites, terebratulæ, &c. may generally be obtained.

[817] There is a station at Barrow, and the pedestrian may be put down within a short distance, by the railway.

Although at the very foot of the plutonic rocks, and on the verge of the grand focus of volcanic action which erupted the syenitic masses of Charnwood Forest, the strata in this spot appear to have suffered but little disturbance. But this phenomenon is in accordance with what occurs in other volcanic districts. For, as M. Constant Prevost remarks, volcanoes may open across all the strata, without occasioning great derangements; thus, at Limagne, Aurillac, and Puy (see *Wond.* p. 269), the tertiary strata have preserved their horizontality, even around the vents through which issued the volcanic matter that covered those countries with numerous cones of eruption.

II. MOUNT SOREL. *Granite and Syenite.*—The road from Leicester ascends a ridge of Triassic or New Red strata, called Birstal Hill, from whence there is a fine view of the town. In the meadows on the left, some

ruined walls, covered with ivy, mark the site, and are the only remains of the Abbey in which Cardinal Wolsey expired. Approaching MOUNT SOREL, an abrupt hill, with a mill on the summit, denotes, from a considerable distance, the geological character of the spot. There is a small Inn in the village, where accommodation may be procured. Visit the quarries, and also the establishment of Mr. Jackson, where the granite is worked into pillars, side-boards, &c.[818]

[818] An interesting account of this manufactory will be found in Sir Richard Phillips's "PERSONAL TOUR."

The hill is about 120 feet in height, and 1,400 yards long; and is estimated to contain about two hundred millions of cubic feet of workable granite, above the general level of the district.[819]

[819] The granite resembles that of Aberdeen, but contains a larger proportion of felspar.

III. SWITHLAND. *Slate-rocks.*—From Mount Sorel proceed to Swithland: as we approach the quarries, the employment of slate for every available purpose, in the footpaths, walls of cottages, &c., indicates the abundance of this material in the neighbourhood. At Swithland, the quarries are very extensive, and expose magnificent sections, from 100 to 120 feet thick, of strata of Slate, highly inclined; and forming one side of an anticlinal axis, the summit of which will be passed over in our route by Woodhouse. In one quarry, at the time of my visit, a series of nearly horizontal strata of red marl was exposed, lying unconformably upon the edges of the highly inclined beds of Slate. The Slate-rocks of Charnwood Forest have a single anticlinal axis, which strikes from

NN.W. to SS.E.; and the axis of the adjacent coal-field of Nuneaton has a similar direction.[820]

[820] Murch. Sil. Syst. p. 569.

WOODHOUSE. BARDON HILL.

IV. WOODHOUSE. *Slate-rocks.*—From Swithland to Woodhouse, is a continuation of the highly inclined Slate strata. The village is romantically situated on the ridge or crest of the anticlinal axis of Charnwood Forest. On the sides of the road, there are occasional openings where the strata are exposed. There is, in particular, a fine section on the sides of the elevated point on which the church and school are built, lying to the left of the road in the approach from Swithland. A day might be well spent in this place, and at Swithland.

V. BARDON HILL. *Syenite.*—We next proceed to Bardon Hill, ascending to the highest ridge of the protruded mass of igneous rock, of which this mountain-range is composed. The craggy and bare pinnacles which are every where presenting themselves, shooting up, as it were, from the green sward, cannot fail, from their novel and striking character, strongly to impress the mind of the young geologist, who now, for the first time, visits a region of plutonic rocks. The view from the summit of the hill is grand and imposing; it should be studied with a geological map of the country before us, that the position of this central mass of volcanic rocks, and its relation to the surrounding sedimentary strata, may be fully comprehended.

VI. WHITWICK AND SNIBSTONE. *Coal-measures.*—Spread around the foot of the Syenitic mountain which we are descending are the coal-bearing strata

of the Carboniferous system; and in the works at *Whitwick* and *Snibstone* the geological inquirer can examine the nature of these deposits in the coal-mines, which he should descend, and obtain specimens of the strata and fossils from the beds in situ.[821]

> [821] Should he be so fortunate as to see the resident engineer of Snibstone Colliery, Mr. George Vaughan, he will be certain of meeting with a courteous reception, and every facility for pursuing his inquiries, descending the shaft, and obtaining fossils. Mountain limestone is brought to this place to be converted into lime; and good specimens of shells, encrinites, &c. may sometimes be extracted from the blocks of stone.

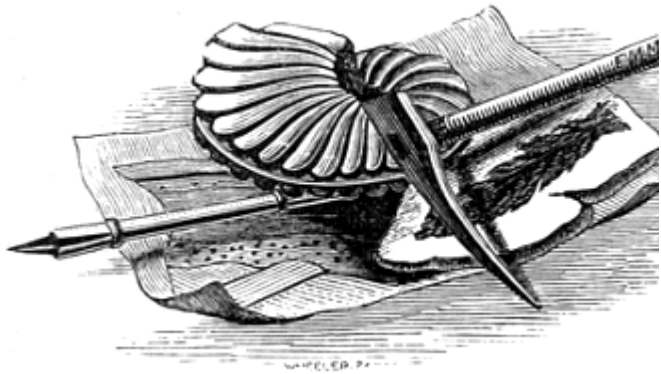
Among the refuse of the workings thrown up from the various shafts, search should be made for stems of *calamites* (p. 108), *seed-vessels* (p. 149), *fern-leaves* (p. 109), &c.

A section from Whitwick, through Charnwood Forest, to Barrow-on-Soar, in the direction of the route we have traversed, would give the following succession of rocks:—1. Whitwick; *Coal-strata*, highly inclined. 2. *Slate-rocks* of Woodhouse, highly inclined. 3. Protrusions of *Syenite*. 4. *Slate-rocks* of Swithland, highly inclined, with unconformable strata of red marl. 5. *Granite* and *Syenite* of Mount Sorel. 6. *Red marl* and *sandstone*, supporting the *Lias*, at Barrow-on-Soar.

The pedestrian should spend one or two days at Snibstone, where there is humble, but comfortable accommodation.

MARKFIELD AND GROOBY,

VII. MARKfiELD AND GROOBY. *Syenite and Porphyry*, &c.—These places may be visited on our way back to Leicester.



MISCELLANEOUS.

List of Dealers in Fossils, Minerals, &c.

BRITISH NATURAL HISTORY SOCIETY, for the distribution of Fossils and Recent Shells, London Agent for the, 30, Tavistock-street, Covent Garden.

CHARLTON, Mr., at the Geological Society's apartments, Somerset House. For boards and tablets for fossils; prepared and backed paper for diagrams; cabinets for specimens, &c. An excellent and intelligent workman, and moderate in his charges.

CUTTELL, Mr., 52, New Compton-street, Lapidary. Prepares fossil teeth, &c. for the microscope.

DARKER, Mr., Lapidary, 9, Paradise-street, Lambeth. Fossil and recent objects for the microscope. Specimens of the infusorial earths, teeth of fishes and reptiles, marbles, &c.

EDWARDS, 40, High-street, Camden Town. For boards for cabinets, to affix fossils, shells, &c. instead of trays.

MCLELLAN, 107, Great Russell-street, Bloomsbury. Manufactures the trays for the British Museum. Wooden trays with black sides, 2 inches by 2, to 6 inches by 2, price 7*s.* per dozen. This price is much too high, except for public collections. Common card or pasteboard trays answer every purpose.

SIMMONS, Mr., 6, Francis-street, Newington Butts. Collector of fossils; especially of choice Chalk fossils and fossil Foraminifera.

SOWERBY, Mr. G. B. (the eminent naturalist), 50, Great Russell-street, Bloomsbury. All kinds of minerals, fossils, and recent shells.

TENNANT, Mr. J. Professor of Mineralogy and Geology to King's College, 149, Strand. Every purchasable species of fossil, mineral, or shell may be obtained; as well as the various microscopic fossils, infusorial earths, slices of teeth, wood, marble, &c. The collections formed by Mr. Tennant for the student in Geology, Palæontology, and Mineralogy are admirably calculated to afford that practical acquaintance with specimens, so indispensable to the acquisition of a knowledge of

Geology. A series may be obtained, illustrative of the system of instruction suggested in these volumes, and arranged in a sequence corresponding to the order in which the fossils are described. The price of a mahogany cabinet with five trays, containing 200 specimens, illustrative of the elementary works on Geology, is five guineas: cabinets with fewer and less valuable specimens from two to three guineas. The following is an outline of the contents of the five guinea cabinet—

MINERALS which are either the components of Rocks, or occasionally imbedded in them:—Quartz, Agate, Chalcedony, Jasper, Garnet, Zeolite, Hornblende, Augite, Asbestus, Felspar, Mica, Talc, Tourmaline, Calcareous Spar, Fluor, Selenite, Baryta, Strontia, Salt, Sulphur, Plumbago, Bitumen, &c.

NATIVE METALS, OR METALLIFEROUS MINERALS; these are found in masses or beds, in veins, and occasionally in the beds of rivers. Specimens of the following Metallic Ores are put in the Cabinet:—Iron, Manganese, Lead, Tin, Zinc, Copper, Antimony, Silver, Gold, Platina, &c.

ROCKS; Granite, Gneiss, Mica-slate, Clay-slate, Porphyry, Serpentine, Sandstones, Limestones, Basalt, Lavas, &c.

SILURIAN FOSSILS from the Llandeilo, Wenlock, and Ludlow Rocks.

SECONDARY FOSSILS from the Devonian, Carboniferous, Permian, Triassic, Lias, Oolite, Purbeck, Wealden, and Cretaceous Groups.

TERTIARY FOSSILS from the Thanet Sands, Woolwich and Reading beds, Bracklesham, Barton, and London Clays, Isle of Wight fresh-water series, Crag, &c.

Mr. Tennant has also models of many unique and rare fossils; as for example, teeth, horn, claw-bones, &c. of the Iguanodon; lily encrinite; small models of the upright coal-trees, near Bolton; of the magnificent Plesiosaurus of Mr. Hawkins's collection, now in the British Museum (price 4*l.* 4*s.*); Mr. Sopwith's models of stratification, &c.

TOPPING, Mr. 1, York-place, Pentonville-hill; supplies boards and cases, and every kind of fossil infusoria, &c.; polished slices of

fossil wood and teeth; and all kinds of microscopical objects, admirably prepared, and at moderate prices.

BRITISH MUSEUM.—Models of some of the most remarkable fossils in the National Collection (a list of which is published in the "Synopsis of the British Museum ") may be purchased of the *Formatore*.

MICROSCOPES.—A microscope is now an indispensable instrument for the collector of fossil remains; and, in fact, for the cultivator of any natural science. A microscope sufficient for every useful purpose may be obtained, at the price of from seven to twenty guineas, of—

POULTON, Mr. C., Wooburn, near Marlow, Bucks; beautiful preparations of minute fossil animal and vegetable structures for the microscope at 1*s.* 3*d.* per slide. Infusorial earths admirably prepared. Specimens of foraminifera, recent and fossil. Grignon sand with, foraminifera, &c.

POWELL, Mr., 24, Clarendon-street, Clarendon-square.

PRITCHARD, Mr. Andrew, Fleet-street; the author of various useful works on microscopical subjects. Mr. Pritchard's microscope, of from seven to ten guineas, has been purchased by several of my geological friends, and admirably answers the purpose of investigation.

ROSS, Mr. 21, Featherstone-buildings, Holborn; justly celebrated for the perfection of his instruments.

Smith and Beck, Messrs. 6, Coleman-street, City.

BRIGHTON.

NIGHTINGALE, Mr. 52, Frederick-street, near the railway station Brighton A large assortment of Sussex chalk and other fossils. Mr. Nightingale is a first-rate artist in clearing chalk fishes and crustaceans.

THATCHER, Mr., West Cliff, King's-road, has often very choice chalk fossils, admirably cleared, and at fair prices.

Most of the pebbles cut and set in brooches, and sold by the lapidaries and jewellers in this town, as Brighton common German moss-agates. The green brooches called *Brighton aqua marines!* are rolled fragments of bottle-glass. Occasionally good sections of the *Choanites* (see p. 234) may be obtained: inquire for "*petrified sea-anemones*."

CHIPPENHAM, WILTS.

BUY, WILLIAM; for Oxford Clay fossils of the greatest variety and in the highest perfection. Especially celebrated for his discovery and admirable development of the soft parts of Belemnoteuthides, Belemnites with phragmocones, &c.

DOVER.

GRIFFITHS, Paradise-street.

MOSES, Stroud-street; has generally a large collection of Chalk and Galt fossils.

HASTINGS.

BISSENDEN, THOMAS, West-street; OLIVER, ELIZABETH, 7, Parade; of whom Wealden fossils from the neighbouring cliffs may often be obtained.

RYDE, ISLE OF WIGHT

FOWLSTONE, Mr., 4, Victoria Arcade.

SHEERNESS.

HAYES, PATRICK, Sheppey-street, Blue Town. The usual Sheppey fossils. According to his own list, he has for sale,—petrified whelk-shells, cockles, clams, screws, Nautilus. Fruits, various; as beans, coffee, figs nuts. Crabs, lobsters, turtles. Fishes' heads, teeth, and spine-bones. His charge for perfect specimens is high; a Nautilus, cut in half and polished, presenting two perfect sections, 25*s.*; if imperfect, 1*s.* or 2*s.* A fish's head, or lobster, 10*s.* to 15*s.*; imperfect examples, 6*d.* to 2*s.*; see p. 840.

VENTNOR, ISLE OF WIGHT.

WHEELER, CHARLES, Holder's Sea-side Cottage. An excellent guide to the most interesting localities along the southern shore of the island. Collects and sells specimens.

WARMINSTER.

BAKER, Mr.; dealer in fossils. The Warminster Greensand, and Chalk fossils.

WEYMOUTH.

DAMON Mr. Robert, dealer in fossils; has always on sale a large and excellent collection of the organic remains from the neighbourhood of Weymouth, the Isle of Portland, and Lyme Regis, &c. A series of recent British shells, from 200 to 400 species, correctly named.

YORK.

BRITISH NATURAL HISTORY SOCIETY, for the distribution of Fossils and recent shells; conductor, &c. Mr. Charlesworth, Curator of the York Museum.

NOTES ON THE PRICES OF FOSSILS.—A Short communication by the Author to Charlesworth's London Geological Journal, No. I. p. 13, contains a list of the prices of several interesting fossils and collections of fossils.

MINERALS.—A complete series of the minerals of Cumberland comprising specimens of great beauty and interest, can be obtained of JOHN COWPER, Alston, Cumberland; he may be relied upon for his knowledge and attention, and his prices are moderate.

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[822] We have here refrained from making many references to the very numerous passages in the text in which our great palæontologist's investigations and opinion, in almost every branch of vertebrate and invertebrate zoology, have been freely and of necessity quoted by the Author and Editor,—always, however with due and grateful acknowledgment.

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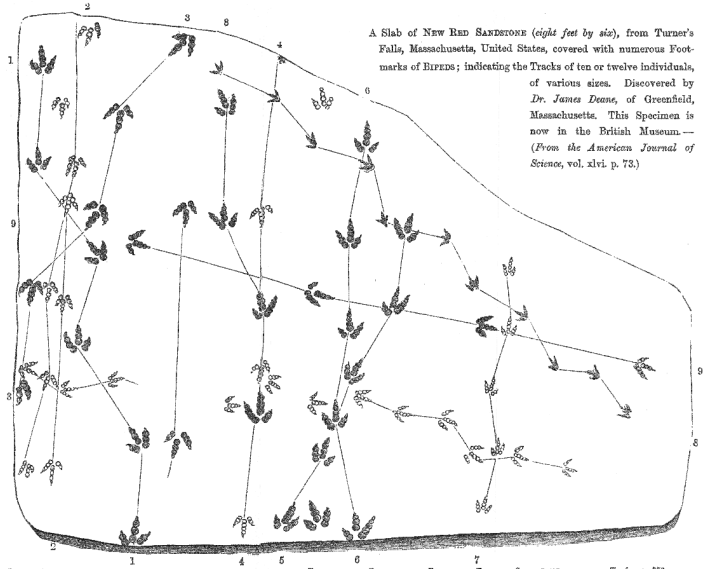
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