THE MUSIC OF THE SPHERES

A Nature Lover's Astronomy

BY

FLORENCE ARMSTRONG GRONDAL

New York

THE MACMILLAN COMPANY

1926

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FLORENCE ARMSTRONG GRONDAL

NEW YORK
THE MACMILLAN COMPANY
1926

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IN
GRATEFUL APPRECIATION
OF HIS KINDLY AND
HELPFUL INTEREST
THIS BOOK IS
DEDICATED TO
SAMUEL L. BOOTHROYD
PROFESSOR IN CHARGE OF
THE FUERTES OBSERVATORY
CORNELL UNIVERSITY
ITHACA, N. Y.

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THE MUSIC OF THE SPHERES



A TREASURE-TROVE OF 50,000 STARS.

Photograph of the star cluster in Hercules by Mount Wilson Observatory through the 60-inch reflector.

THE MUSIC OF THE SPHERES

CHAPTER I

BEHOLD,—THE STARS!

HOW thrilling to read of great hunts for treasure! Yet the pirates who dug their spades into the earthy loam never cached such jewels as are hidden along the dark slopes of the sky. Armed with a chart of the heavens, the fledgling astronomer prods about in the depths of the gloom, shovels the dark with the aid of his telescope, and discovers,—even more surely than the pirate his chest,—some wonderful treasure. Sometimes the find is a star-like diamond, a twinkling emerald, a fire-filled ruby or a cluster of star gems of colorful hues, but it may be, too, a profusion of riches, heaped in a magnificence that leaves one breathless.

One must know, however, before adventuring along the skyways, just where to look for these starry jewels. The air must also be clear and the eye color-true. In the tropics where the atmosphere is more transparent, the colors seem deeper and more beautiful. This is also true on deserts, on

the ocean or on mountain tops.

To those who do not know that stars, even as jewels, have individuality, the various colorings will come as a special surprise. *Vega*, for instance, is large and most *wonderfully blue*, rising in the far northeast during the first of May; *Arcturus*, appearing at the same time near the zenith, is tinted like a *King Midas' rose*. On the first of June, *Antares* glows like a scarlet-shaded lamp hung low in the southeast, while in the northeast, *creamy-hued Capella* scintillates like the electrified cross-section of a rainbow. In the case of a double star where the colors are sharply contrasted—gold and blue or scarlet and green—the effect is startling and very beautiful. Weird looking purple stars and wan lavender ones may also be found, but all these lovely tints and shades are hidden among the hosts of more common yellow and white stars, and if one does not know just where to find them it is like hunting for treasure without a chart.

When the world was young, people gazed in never-ending wonder as the darkness of the heavens filled up with the lights of stars. According to an old Malayan story the stars were the children of the Moon-mother, who brought her children out only at night when the jealous sun, who had no children, was far away on the other side of the earth. The ancient Greeks believed that night came because the God of the Sun drove his sun-chariot along the invisible edge of the western ocean when he returned from the west to the east. All the natural laws of Nature were explained in some such naïve manner by the ancient peoples; the imagery of the Greeks is especially interesting, for they impressed shadowy figures on the very stars. These figures have given names to the constellations, or groups of stars, and to the student of Nature, the legends of these heroes traced in the sky add to the charm of the stars in the same manner that the delicate aroma of the rose

enhances its loveliness.

Later, these remarkable people, in trying to account for the fixed and orderly movement of the stars as they slowly passed from east to west, adduced that they must be fastened in crystal spheres which whirled, one within the other, over and under the motionless disk of the earth. They noted that a few of these luminaries followed a wandering course, and so called them "planets"—which means "wandering stars." Since some of these wandering stars moved swiftly and others moved more slowly, they fancied, in their beautiful way of explaining things, that these different rates of speed must cause a musical tone as each star rolled upon its crystal, a deep note for the slow bodies and a high note for the swift bodies, and that with the infinite swelling harmony of all the myriad stars, one vast sweeping tone of heavenly music swirled around the spheres. But this music was for the gods and no mortal could hear it.

Our modern music of the spheres is no more audible to our dulled ears than the music of those ancient days, yet its silent song of light and color, its mystic setting of ancient tales, and its wonder background of scientific fact, descends in the same sweet way to all hearts lifted to receive it. Yet many people miss all this and only know that the stars are there.

It is easy to become acquainted with the more conspicuous of the star-designs which are formed by the brightest stars in a constellation for these seem to hang down from the dome of heaven like electrically lighted frames. Some of these, such as the "W" of Cassiopeia, the "Square" of Pegasus, the "parallelogram" of Orion, the Northern Cross and the Big Dipper, are not only ornaments in the sky, but serve also as guides to point the way to other constellations.

An endeavor has been made to arrange the constellations

in this volume in the most easily-learned-without-effort way that could possibly be devised, and to present them in such a manner that the student will go out of doors with a picture of the position of the stars in his mind so that in more advanced study sky maps will acquire a new significance.

First the stars in the vicinity of the North Star are discussed—the two starry Bears and *Draco*, the Dragon; then the great sky drama of Perseus and Andromeda, with *Cepheus*, the King of Ethiopia, *Cassiopeia*, the Queen, *Pegasus*, the Flying Horse and *Cetus*, the terrible Sea-monster; the "parade of the zenith constellations" led by *Leo*, the fierce Nemean Lion; the constellations on either side of this interesting spectacle; the four great southern stars, each noted enough to have the stage by itself, and the gorgeous winter program with the brilliant stars of the Giant *Orion*, *Taurus*, the Bull, and *Castor* and *Pollux*, the Heavenly Twins.

Whirling about the sun in the same plane as the earth are seven other planets. These planets resemble stars to the unaided eye but show a definite disk through the telescope. With but the expenditure of an idle moment now and then, who would not like to learn a few facts about Jupiter, a world with nine moons and a thousand times larger than the earth; Saturn, a globe surrounded by a magnificent ring and composed of such diaphanous material that it would float on water; Mars, with its mysterious surface markings; Venus, shrouded in the secret of its impenetrable atmosphere; the hundreds of tiny worlds, some but a few miles across, and even the raging sun itself with its hydrogen flames, spots, moving belts and other idiosyncrasies?

These are only suggestions of what may be anticipated in our treasure hunt along the slopes of the sky, but every star that has once been found and called by name will

stand forth from the multitude with a magnetic radiance that forever after thrills the discoverer with the pride of achievement.

CHAPTER II

AN INTRODUCTION TO THE STARS

> "*He who knows what sweets and virtues are in the ground, the waters—the planets, the heavens, and how to come at these enchantments, is the rich and royal man.*"
>
> —*Emerson.*

THE dome of the heavens with its constellations of stars turns westward at the rate of about 15 degrees an hour.

Thus the stars, in unchanging order, rise majestically above the horizon in the east, wend their way across the great expanse of sky above our heads, and disappear below the horizon in the west. It is only necessary to note the position of a particularly bright star or a conspicuous constellation lying near the horizon and then return after several hours have elapsed and again note its position in the sky to prove this general movement toward the west. This is an interesting experiment for it is often a surprise to people to hear that the stars of the heaven are constantly shifting their position throughout the hours.

Each star has an individual pathway which describes an

arc across the heavens, the exception to this being the circum polar stars which describe complete circles around a point north of the zenith.

The center indicated by the curved pathways of the stars is called the Pole of the Heavens, and in the northern hemisphere this important location is marked by the North Star. The North Star, also called *Polaris* or the Pole Star, lies almost directly above the north pole of the earth, and is located in the sky by the "pointers" on the bowl of the Big Dipper.



Since we cannot realize the whirling of the earth on its axis which causes the heavenly bodies to appear to pass in the opposite direction, it is the same to us as if the axis of the earth continued upward to Polaris, thus causing this star to seem to stand still, while all the other stars in the course of twenty-four hours seem to whirl in fixed orbits around it.

"The earth in circling round the moving sun,

Seems to give motion to the nearer stars,

Bending the tracks they trace across the sky."

This remarkable performance may be photographed on a clear, moonless night if a camera is properly focused on the North Star and left exposed in that position for two or three hours. The photograph thus obtained will consist of a series of circular trails around the central star. These are produced by the stars moving slowly over the plate in consequence of their changing positions,—just as if the stars instead of our own little world had really moved. This is what the ancient peoples believed and in the words of Aratus

> "the axis shifts not a whit, but unchanging is forever fixed, and in the midst of it holds the earth in equipoise, and wheels the heavens itself around."

Since the stars were always in the same order with reference to one another, it was thought that perhaps these luminaries were the heads of golden nails which made the heavenly dome secure. Thus through their apparent immovability, they acquired the name of "fixed" stars, although this fixity has long since been disproved.

The stars nearest to the North Star complete their circles above the horizon and are called circumpolar stars. The Big Dipper, the Little Dipper, Draco and the "W" of Cassiopeia are star groups which do this for an observer in the north temperate latitudes. If watched throughout the night any one of these star groups may be seen to complete half of its circle around the North Star, although the other half of the journey would be invisible on account of the daylight.

Although the circumpolar stars may be seen to complete their pathways above the horizon, the pathways of all the other stars are completed on the other side of the earth,—the greater the distance from the North Star, the larger their arcs above the horizon, until the distance of 90 degrees is reached. This greatest curve is shown by the stars which rise almost directly in the east. The stars which rise south of east have only a small portion of their pathways visible.

It would seem that since the stars move as a complete unit, the aspect of the star dome would appear the same at the same hour of the night throughout the year. But this is known not to be the case for in consequence of the earth's motion around the sun, or the apparent advance of the sun among the stars, the same position of the stars re-occurs four minutes earlier each day, and the star groups appear a little farther west at a given hour each evening. They appear at the same time only after the lapse of a year. This is the reason that the dates and hours for the appearance of the different stars are given in the star maps. Since four minutes a day total up to two hours a month, a star seen to rise at ten o'clock in one month will be seen to rise at eight o'clock the next month, and at six o'clock the following month, and so on through the daylight at the rate of two hours a month, until it has again worked back to a place in the darkness of the evening sky.

The number of the stars is beyond determination, but those visible to the unaided eye amount to only a few thousands.

Many stars on the border-line of invisibility send us flickering glints of light although seldom can we clearly see more than two thousand at one time and usually many of these are blotted out by the thick veil of atmosphere which surrounds the earth.

Among the exceptionally bright stars which may be seen from the northern hemisphere are:

Arcturus (in Boötes)	Regulus (in Leo)
Aldebaran (in Taurus)	Vega (in Lyra)
Altair (in Aquila)	Antares (in Scorpio)
Betelgeuse (in Orion)	Rigel (in Orion)
Capella (in Auriga)	Sirius (in Canis Major)
Procyon (in Canis Minor)	Spica (in Virgo)
Deneb (in Cygnus)	Formalhaut (in Piscis Au

Yet even these cannot be seen at the same time but must be viewed from different parts of the earth's journey around the sun.

These brightest stars, which are called first magnitude stars, should be among one's first star acquaintances, for they serve conveniently as guides to locate the other stars, which are also classified according to magnitudes. The second, third, fourth and lesser magnitudes are each progressively two and a half times lower in the scale of brightness. The smallest stars discernible to the unaided eye of ordinary vision are stars of the fifth magnitude, although a sharp eye can discern those of the sixth and even of the seventh magnitude. All below this are telescopic stars. With a 60-inch reflector 219,000,000 stars are visible. The Mount Wilson 101-inch telescope brings the number up to 319,000,000. Stars are most dense in the region of the heavens called the Milky Way. Sir William Herschel observed 116,000 go past the field of his telescope in a quarter of an hour while directed at the densest part of the Milky Way.

This vast collection of stars differ not only in brightness but also in color.

The colors of the stars are brought out most vividly in the telescope if the observer knows just where to look for those which are the most pronounced. Some of the large stars are characterized by the most exquisite coloring,—which is sometimes further enhanced, as a glass will reveal, by a charming companion of a flamboyant or a delicate hue. Some of these "companions" are green, blue, orange, purple, gray, maroon and other colors, but such gayety is the exception rather than the rule. About three-fourths of the stars are white or bluish-white and nearly one-fourth of them are varying shades of yellow. The star Arcturus is of the deepest shade of yellow while the star Spica is so exceedingly white that poets and writers from the earliest times have spoken of the "purity" of its rays.

Although every star visible to the unaided eye may be identified by a Greek letter or a number, most of the brightest stars have individual names.

These individual names were given by the Arabian astronomers who nurtured astronomy through the Dark Ages when this science was almost forgotten by the rest of the world. These odd names have a certain appeal and many of them possess rippling musical qualities which add to the plain word as twinkles add to the star. It is a pleasure to say 'Capella,' or 'Antares,' when we see the gleam of the "Shepherd's Star," or the glow on the "Heart of the Scorpion"; or to call such jewels as shine on "Orion's Belt," 'Mintaka,' 'Alnilam' and 'Alnitak.' After the introduction one naturally takes a particular interest in 'Capella,' or 'Antares,' or 'Mintaka,' or 'Alnilam,' and continues to refer to it familiarly by name.

Each star not only attains a certain charm and individuality by having its own particular name, number, magnitude, color and pathway, but it also forms a part of a highly interesting group called a constellation.

On a clear night points of starlight seem to fairly fill the sky, yet it will be found, on careful examination, that the brightest of them often seem to be assembled together in a very picturesque manner, forming the outlines of figures such as the Dippers, the Crown, the Cross, the Sickle or the Lyre. Since these designs unfailingly deck the heaven's dome at the same place, hour and season each year, there is not the hopeless confusion among the stars that the novice might think from his occasional glances at the sky.

These star groups, or constellations, were probably first noted and named in Chaldea where the ancient shepherds amused themselves by tracing their heroes among the stars. One can well imagine the hold that these dream-pictures would have on a lonely shepherd as he wandered about the solitudes of the hills and gazed through the quietness of the night at the distant stars. For long ages these stories were told by one shepherd to another and so vivid were their fancies and so keenly were they enjoyed that they made an indelible impress upon the folk-lore of other nations and in this manner have been carried down to the present day.

The stars are self-luminous, like our sun,—indeed, the stars are distant suns, and the sun is a nearby star.

With the exception of the star or sun around which the earth and the other planets of our solar system whirl, all the other suns are so immensely remote from the earth that their huge diameters dwindle to a mere twinkle of light. The diameters of some of the stars have been measured and have been found to vary from a few thousand miles to many million miles. Our sun, a most medium sized star,

has also been measured and has a diameter of 866,000 miles; this diameter, as seen from any other system of planets, would also dwindle to a twinkle, and our great sun would thus be lost among the other stars.

Throughout the sky are young stars, adult stars, and stars whose light has almost flickered out, for stars, we find, even as all other things in Nature, have a limited span of life. This life may last for untold ages but as surely as stars are formed, so do they die.

The nucleus of a star is formed by gas under high pressure. This gas is gathered together by the force of gravity and gradually condensed into a glowing ball. In contracting the stars at first rise in temperature but when too advanced condensation retards this contraction, then the star gradually cools.

Recent studies have revealed the fact that stars when young are huge and red. This early stage is called the giant stage. Antares, Betelgeuse, Arcturus and Aldebaran are examples of stars at the beginning of their careers. The giant red stars are gaseous throughout and of enormous volume—Antares, the youngest and by far the largest of the four named above, being 400,000,000 miles in diameter. The bluish stars are the hottest stars; a red tinge indicates comparative coolness whether the star is young or old. The blue stars are in the prime of life, intensely hot and brilliant, and glow with a temperature of perhaps 10,000 degrees at their luminous surfaces. With a gradual rise and fall of temperature, stars burn, even as earthly flames, through a continuous series of colors,—generally speaking, red, yellow, blue, yellow, red,—all of which bear a special meaning to an astronomer. The yellow stars, like our sun, are middle-aged; the dwarf red stars, old, like a dying ember. After a star has expended its heat, if it does not in the meantime meet with some accident, it becomes a

darkened, lifeless and cold-surfaced globe.



AN IRREGULAR NEBULA IN SCUTUM SOBIESKI.

Photograph by Mount Wilson Observatory through 60-inch reflecting telescope.

The material believed to condense into great hot stars is scattered about in various sections of the sky. This material has somewhat the appearance of a summer-day cloud or an

illuminated daub of paint, occasionally as shapeless as a pinch of cotton; however, these objects, called nebulæ, have, as a rule, a definite form, the most common being the 'spiral,' the 'ring' and the 'planetary,' these terms also being the descriptive names of such nebulæ. But most of the nebulæ are not for ordinary folks to see for they lie at such vast distances that they are only visible in a large telescope. Sometimes stars are disclosed enmeshed in nebulous folds or again the nebula is seemingly sprinkled with the gold of stars, and there is one object of this kind that every amateur may locate. This is the Great Nebula of Orion which stretches over the whole of the huge constellation of Orion but is concentrated at the star at the center of the Sword which swings from the Giant's Belt.

"I never gazed upon it but I dreamt

Of some vast charm concluded in that star

To make fame nothing."

—Tennyson.

The Nebula of Orion may be seen in the south in the wintertime with a comparatively small telescope. With a large telescope it is one of the most beautiful and awe-inspiring sights in all the sky.

One theory of the life cycle of a star has it born "of nebulous vapor and dead as a tiny, shrunken old sun" and thus the order of evolution would be from nebulæ to extinct stars, but some astronomers believe that stars may change back to nebulæ, "thus forming a universe having no beginning and no end".

The earth travels in a long journey around the sun. This

was surmised by Copernicus in 1530 and proved by Kepler and Galileo about 1610. Before this the earth was supposed to be the center about which the universe moved.



The star scenes along this tremendous journey, which covers 576,000,000 miles and requires a year to complete, vary with the seasons of the year—yet year after year as we retrace the same path, the same familiar stars shine in the same familiar groups, each appearing in its set position in the east and at the same time each season.

Viewed through the window of the earth's cold and icy atmosphere, the stars seen during the winter part of the journey seem to scintillate with particular brilliancy. Since we are then passing by the most colorful stars and the most spectacular star groups the gorgeousness of these scenes is unequaled. During the summer the stars are more demure and tranquil in their light but their soft fires gleam with the gold of romance which the ancient people cast about them in journeys of the past. After once recognizing a few of these constellations or beholding through a telescope the glories of a double star or the face of a distant world, one will never again fail through indifference to raise his eyes to the heavens. There is one thing certain—if all the wondrous phenomena of visible stars could be seen on but one of the nights of our long ride about the sun, the civilized world would spend its last cent on glasses and sit up until dawn to feast its eyes on the sublimity of the spectacle.

CHAPTER III

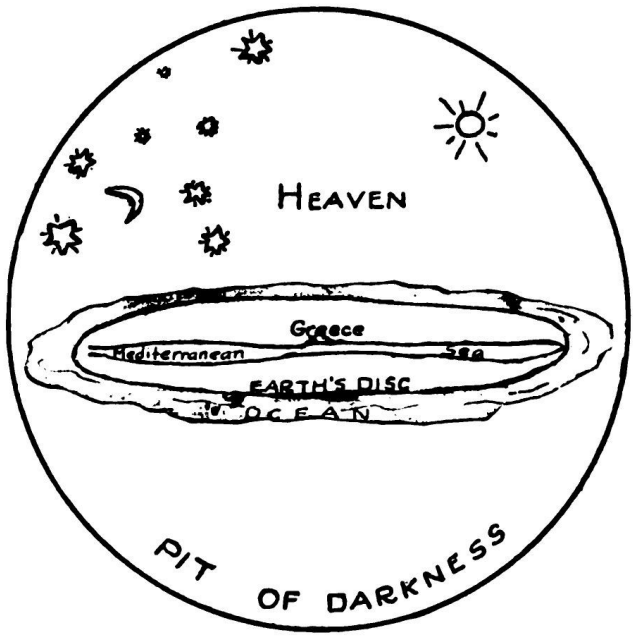
THE ROMANCE OF THE STARS

IN the vividness of their fancy, intensified by glorious scenery and sunny skies, the ancient Greeks believed that the gods dwelt on the summit of Mount Olympus and that queer and lovely beings roamed about the land. They heard the raging of the Wind-gods, the dancing feet of wood nymphs, the trip, trip, trip of satyrs and the music of Pandean pipes as this merry god went skipping over hill and lea. They knew that naiads peeped from the mist in fountains and dryads lived in the hearts of trees, while down in the sea, Neptune tossed up the billows with his trident and the little sea-maids sat in them and rocked and sang. Heroes, semi-divine, swept the earth of its monsters, while gods in golden chariots attended to the welfare of mankind. So deeply sincere was this mythological faith that great temples and beautiful shrines were built in honor of the gods, and one can scarce find a spot in all of Greece, or in all the sky that hangs over Greece, that is not hallowed by some wonderful legend.

This beloved country was thought to lie on the center of the earth, which was marked by the oracle of Apollo, at Delphi. In those days, the earth was supposed to hang like a disk in the great hollow globe of the world, its land divided into two parts by the Mediterranean Sea and its edges washed by the turbulent river of the ocean. The upper part of this globe was illuminated by the sun, moon

and stars and was called Heaven, but the lower part extended below the earth-disk and formed a terrifying pit of utter darkness. The Milky Way was a road which led to the home of the gods, but this pit was a place of dire punishment.

One of the many duties of the gods was to see that the earth was properly lighted by the sun and the moon, and that the stars were "penned in" at dawn and "unpenned" nightly. The sun, moon and stars rose and sank in the stream of the ocean, but the sun, instead of being submerged, was carried around the stream from west to east in a winged cup or golden boat made by the god Vulcan.



It was at first thought that Vulcan, with a mighty heave, threw the hot sun-ball over the Caucasus mountains in the

east to the Atlantic ocean in the west, and then hastily paddled around the world stream to catch it as it fell, but later it was believed that Apollo, the Sun-god, drove it across the sky in a chariot, the return journey to the country of the sunrise being accomplished by placing both chariot and sun in Vulcan's remarkable boat. Centuries later (about 336 B. C.) Eudoxus evolved the theory of the concentric crystalline spheres which brought the tracks of the heavenly bodies under and above the motionless disk of the earth with the stars rolling round in long-drawn notes of celestial sweetness audible only to the gods.

The ancient people imagined that before the earth was smoothed out flat in its present attractive form, the whole world was tumbled together in great confusion,—land, air, sea, sky, hot, cold, soft, hard, light and heavy all mixed and melting in a desolate mass presided over by the god Chaos. Chaos was dethroned by the God of Darkness, who in turn was dethroned by Light and Day. Light and Day, being orderly, industriously sorted the earth from the sea and extracted the heavens from both. The fiery part was cast into the sky where it splintered into stars, while the earth, "a lifeless lump, unfashion'd and unfram'd," was heaped in a big, broad mound with a deep and terrifying stream of waters flowing around it. Then Uranus, the Heavens, noting his superior position, took the scepter away from Light and Day and became the first ruler of the created world. Love was then born and the Earth, entranced, hemmed in her valleys and extended her plains, made paths for the rivers and beds for the lakes. The seeds, relieved of weight, burst their coverings, and the hills became green with foliage and the meadows brilliant with flowers. The world was now beautiful, and Heaven looked down on the colorful earth, and Earth looked up into the starry eyes of Heaven, and love grew, and the Earth became the Heaven's bride.

In the course of time, Uranus began to seriously consider his numerous and somewhat fearful progeny, for the huge Titans, the one-eyed Cyclops and the hundred-handed giants were here and there and everywhere about the land. Foreseeing that his sovereignty might eventually become imperiled, he picked up the Cyclops and Hecatoncheires and thrust them out of sight into the Pit of Darkness.

Such heartless conduct on the part of her husband aroused the wrath of Mother Earth, who urged the Titans to revolt against their father and release their brothers from the Pit. But the Titans looked at the great Sky and were afraid, all except one huge giant named Saturn who picked up a keen-edged scythe and frightened his father into submission. Saturn then appropriated the throne and made Rhea his Queen,—although he prudently swallowed all of the children that were born to him lest they in turn might take the throne. By the time Jupiter, her sixth child, was born, Saturn's wife was aroused to such a point of opposition that she concealed a stone in the infant's clothes and hid the 'mighty babe.' Jupiter, however, expressed himself so vigorously and so continuously that Rhea, in desperation, sent him away from Mount Olympus, the home of the gods, to an island named Crete, lying to the south of Greece. Here he was fed on honey, milk and ambrosia while his attendants danced and clattered and kept up a perpetual din. This concealment was quite necessary, for his uncles, the Titans, had now become a powerful race of giants and had decreed that not one of Saturn's heirs, but one of themselves would succeed to the throne. His nurses, by the way, and the goat with which he played, were afterwards placed in the sky as a reward for their kindness, the nurses, according to one legend, being accorded a position on the "V" of stars in the constellation of Taurus, while the goat was placed in the arms of the shepherd in Auriga.

When the Titans discovered that they had been deceived and that a child of Saturn's was among them, they rushed with furious war-cries upon Olympus. Hearing the commotion from the island of Crete, Jupiter rushed to the aid of his father, and so confident and strenuous was this powerful child, that the surprised Titans turned and fled. The young god then displayed an inherited trait and helped himself to his father's kingdom and the golden palace on the top of the mountain.

After establishing his sovereignty over the world and rescuing his brothers and sisters through the aid of a powerful potion, he called Neptune and Pluto into his presence and made Neptune God of the Sea, and Pluto God of the Underworld. These three deities were then armed with powerful weapons for Jupiter could hurl his thunderbolts and flash his lightnings, Pluto walk about in the security of a hat of darkness, and Neptune stir up the sea, or calm it, by means of a three-pronged spear. The Titans, now thoroughly cowed, were punished in various ways, some being imprisoned in the Pit of Darkness with their brothers, the sons of Uranus, while others were doomed to work without ceasing on servile tasks for the gods. Atlas, the tallest, was commanded to stand on the western extremity of the earth and bear the vault of heaven on his head and shoulders. His station was later said to be in the Atlas mountains in Africa. Aeschylus, an ancient writer, claims that the daughters of Atlas and their mother, the nymph Pleone, fled to the sky in sorrow when Atlas was forced to undergo this terrible punishment. The seven daughters, now styled the Pleiades, represent one of our most beautiful star groups.

Now when Mother Earth heard of the high-handed ways of her grandson, Jupiter, she decided that she would give him a much needed lesson, so gathering together the most terrible of the giants among Uranus' sons, she incited them

to start another great war. This war lasted ten years, the giants proving so formidable that Jupiter summoned the one-eyed Cyclops and the hundred-handed sons of grandfather Uranus to come to his aid. The Hecatoncheires gave immediate assistance by flinging rocks with all their three-hundred hands at once while the Cyclops forged thunderbolts as fast as Jupiter could handle them. In the thick of this bombardment, which left debris and bowlders strewn all over Thessaly, the giants balanced Mount Pelion on the summit of Mount Ossa, which lay between Pelion and Olympus, in a final effort to storm the home of the Gods, but Jupiter, hurling his thunderbolts, struck Ossa from under Pelion and buried the giants beneath the ponderous mass. The violence of this battle shook the foundations of the world:

"the immeasurable sea

Roared: earth resounded: the wide heaven throughout

Groaned shattering: from its base Olympus vast

Reeled to the violence of the Gods: the shock

Of deep concussion rocked the dark abyss

Remote of Tartarus:"

—The Theogony—Hesiod.

(*Trans. by* ELTON.)

Only one giant escaped, a terrible monster named Typhon, who picked up a whole mountain in a paroxysm of supernatural rage and hurled it at his adversaries. He was finally subdued, after a terrible struggle, by a

thunderbolt from Olympus, which knocked him into the sea. There the gods lashed him with the Lightnings of Jupiter and heaped the vast three-cornered island of Sicily upon his limbs, two of the corners weighing down his arms and the third one crushing his feet, while his head was entombed beneath Mount Etna which hurled off its crown to let out his fiery breath. The lame god Vulcan took advantage of this situation and henceforth used the location for his workshop where he forged many wonderful works of art within its fires.

This last war left Jupiter reigning in peace. He was the greatest of the deities, the king of gods and men; he watched over the state and family; his hand wielded the lightnings and guided the stars; and, in short, he regulated the whole course of Nature. Since the world soon became far enough advanced to understand natural phenomena, he was also the last of the Olympian rulers. He is probably the best known of any of the gods and one finds many of the stories of his loves and adventures immortalized in the skies. His daughter Urania was the Muse of Astronomy, and is represented with a celestial globe, to which she points with a little staff.

During the reign of Jupiter's father, Saturn, the God of Time, there was so much happiness in the world that it was called the "Golden Age." Hesiod mentions five ages—the Golden, simple and patriarchal; the Silver, voluptuous and godless; the Brazen, warlike, wild and violent; the Heroic, an aspiration toward the better; and the Iron, in which justice, piety, and faithfulness had vanished from the earth. Ovid omits the Heroic Age. The Golden Age was said to be governed by Saturn; the Silver, by Jupiter; the Brazen, by Neptune; and the Iron, by Pluto. An "Age" was regarded as a division of the great world year, which would be completed when the stars and planets had performed a revolution around the heavens, after which

destiny would repeat itself in the same series of events. Thus mythology was brought into connection with astronomy. It was believed that successive conflagrations and deluges were designed by the gods to purify the earth from guilt, and that after each of these judgments man was again so regenerated as to live for a time in a state of virtue and happiness. During the Golden Age, the year was one continued springtime, and the earth, "as yet unwounded by the plowshare," produced of its own accord. This was followed by the Silver Age where spring was "but a season of the year" and the "wings of wind were clogged with ice and snow" driving shivering mortals into houses. Next came the Brazen Age, a "warlike offspring, prompt to bloody rage," and last of all the Iron Age when again—according to Dryden's translation of Ovid's Metamorphoses—landmarks were set up "limiting to each his right," and not satisfied with the blessings of earth men greedily rummaged beneath the soil for the precious ore the gods had wisely hidden next to Tartarus. This ungrateful race was then destroyed by Jupiter, who sank their country and formed a new people to take their place. In the meantime, all the gods and goddesses had left the earth, Astræa, Goddess of Justice and Purity, remaining to the last. When man finally became so inferior that he engaged in strife and discord, this goddess hid her face in sorrow and flew upward to the sky where she took her place among the stars of the constellation of the Virgin.

Ovid describes the Milky Way as being the great road which led to the palaces of the gods which were clustered about the lofty, cloud-hidden summit of Mount Olympus. In these golden homes with their ivory halls and furniture which possessed self-motion, dwelt Jupiter, Supreme Ruler of Heaven and Earth; Juno, his wife; Mars, the God of War; Venus, Minerva, Mercury and all the other gods and goddesses and many lesser deities. They drank nectar, poured by Hebe or Ganymede, and ate ambrosia, which

gave immortal life. Their statures were immense, for when Jupiter shook the locks of his hair the stars trembled, but they often disguised themselves as earthly beings and mingled with mankind. At times they issued commands through the voice of an oracle, or displayed anger through some exhibition of nature, such as when Jupiter threw his thunderbolts.

Although Apollo, Neptune and Pluto sometimes met in council at Olympus, these three gods had their principal palaces in quite a different part of the earth, Apollo's being beyond the "Land of the Sunrise," Neptune's under the sea and Pluto's under the ground.

Around Neptune's palace waved his lawns of seaweed and his trees of coral while the currents were the breezes which fanned and cooled his brow. His scepter was a trident with which he raised and stilled storms while his chariot was a shell drawn by brazen-hoofed sea-horses. Dolphins, tritons and sea-monsters made sportive homage about his watery path and sea-nymphs played among his rocks and grottoes or sat on the shore in the moonlight drying their long, bright hair. Neptune married one of these, a lovely dark-eyed nymph named Amphitrite and made her Goddess of the Sea. The dolphin which carried him during his courtship was rewarded by being placed on a diamond-shaped group of stars which have ever since been called "Delphinus, the Dolphin."

The kingdom of Pluto, the Ruler of the Shades, was a level, cloudy country under the ground and was inhabited by pale, fleeting shadows, the spirits of those who had died in the country on top of the ground. Across the meadows of this dreary land wandered the river of Sighs and the river of Forgetfulness,—but the flaming river of Phlegethon, with its sulphurous smoke and its waves of fire, flowed in an endless circle about the walls of Tartarus where the wicked groaned and clanked their chains. If a

soul was not condemned by the three judges, who weighed the good and evil deeds in their scales, it was led to a place of happiness called the Elysian Fields, which was supposed by some writers to be next to Tartarus, but by others, to be above the earth on the Isles of the Blest in the western ocean. The gates to Pluto's regions were guarded by a fiendish dog with three heads but there were supposed to be a number of pathways which led to the upper world for strange vapors drifted out of an unexplored cave in southern Italy and both Hercules and Orpheus went down through caves in Greece to

"Pluto, the grisly god, who never spares,

Who feels no mercy, who hears no prayers."

—Homer.

Hercules went down as one of his Twelve Labors,—some of which have constellations named after them,—while Orpheus descended to find his Eurydice, playing so beautifully on his harp that this little instrument was afterwards placed among the stars and called the constellation Lyra.

Pluto rarely appeared above the ground but when he did he made himself invisible by wearing his Hat of Darkness or was drawn in a sooty chariot by fierce black horses whose reins were covered with rust. One day when Typhon was causing trouble around Mount Etna by his incessant grumbling and turning about, Pluto came up to ascertain just how much his roof under the Sicilian land was endangered. This proved a sorry day for the earth, for while the gloomy-faced god was looking about for cracks, Venus saw him from a distant hilltop, and calling Cupid, told him to shoot the dour fellow with a gold-tipped arrow,

for this was the only kingdom over which she had no control. The first person whom Pluto saw was Proserpine, the beautiful daughter of Ceres, the tutelary Goddess of Sicily, and falling immediately in love with her, he carried her off to his kingdom under the ground. Although for many days Proserpine wept bitterly, she gradually became reconciled, and once ate six pomegranate seeds from a tree in Pluto's sunless garden. This proved her undoing, for when Ceres discovered that Proserpine was Queen of the Kingdom of Shades, she inquired of the Fates if there was any chance of her daughter's release and they informed her that since Proserpine had tasted of the seeds, the food of death, she must spend six months of every year with Pluto. Thus, through six long months Ceres, the Goddess of the Harvests, sits and weeps and no fresh crops are planted and no fruits appear on trees or vines; in the meantime poor mortals do the best they can throughout the winter and wait eagerly for the springtime when Proserpine again appears above the land and Ceres, in happiness, sows the grain and covers the orchards with masses of blossoms.

Apollo, a son of Jupiter, was dazzling and life-giving—a direct contrast to Pluto, dark-visaged King of the Dead. Apollo's sun-palace, which had been built by Vulcan in the country beyond the east, was crusted thick with gold and embedded with large and wonderful jewels. His sun-chariot was also of gold, but of so great a radiance that it blinded the eyes of any one but the gods. Every morning Apollo put the sun in this chariot and drove to the eastern gates where Aurora, Goddess of the Dawn, flung down the bars for her Sun-god, who penned up the stars, collected his Hours about him and drove out along the pathway of the Heaven with the brilliant light of the sun.

Phæthon, an ambitious son of Apollo, watched his father day after day, and wished that he, too, might ride in such radiant splendor above the clouds. At last he made his way

to the sun-palace and begged his father that he might show his comrades in Greece that he was truly the child of so glorious a god by being privileged to drive the sun. Apollo was horrified, but Phæthon persisted and at last he gave his reluctant consent. The headstrong youth then jumped into the chariot, grasped the reins of the celestial steeds and started along the zodiac. Ancient poets assert that the Earth looked up and trembled as she watched the snow-white horses of the Sun-god tear wildly up the steep slope in the east. The constellations shook with terror as they swerved from the beaten pathway, the Serpent twined about the icy Pole grew warm and began to writhe, and the Bear's stars fluttered and "wished to dip in the forbidden sea." Half dead with fear, Phæthon saw the shadowy star-decked forms of wild beasts scattered about the heavens and shuddered as the fierce Scorpion moved his claws and brandished his sting. Now beyond all control, the horses veered aside from the "heat vex't creatures" and rushed straight toward the earth, but, just in time, Jupiter hurled a tremendous thunderbolt and knocked Phæthon out of his chariot into a nearby river. The horses now turned toward the horizon which rested beyond the waters in the west, but the burning sun-ball had been drawn so close to the earth that the Nile had fled in fright and hid its head, which still remains hidden, and over a great area now known as the African desert, the moisture had risen like a cloud of steam leaving a drear, unfertile waste of land good for naught. The poor African people fared even worse, for while gazing bewildered at the wild antics of the sun, their faces were scorched and their bodies were scorched and they transmitted forever after to all succeeding generations the scourge of being hopelessly black! As a memorial of this famous adventure, the name of the river Eridanus, into which Phæthon had fallen, was given to one of the star groups in the sky. This was also supposed to be a consolation to Apollo, who grieved so deeply at the death

of his son and all the unfortunate consequences of his adventure that he offered to allow any other god on Olympus the privilege of driving the sun on its daily course from east to west, but no other god could do this, nor were any willing to try.

Apollo had a twin sister named Diana who owned a chariot as wonderful as his own, only it was wrought of pure silver and made to carry the earth's night light, called the moon. But Diana did not spend all of her time in the sky, for she loved to hunt and would often leave her chariot at home, take out her bow and arrow and spend whole nights upon the mountains with her nymphs. She was wondrously fair and full of grace but not as faithful as her brother, and at such times as she chooses to enjoy herself, earth-beings must do without a moon.

Besides the gods and the goddesses who dwelt in ancient Greece, there were many heroes who were semi-divine. One recalls Perseus, Hercules, the twins Castor and Pollux and others. Perseus was a son of Jupiter and a very noted hero. One of his adventures was so thrilling that the early people of this little country impressed its story on six constellations!

Hercules, the hero famed for his wonderful strength, patience and endurance, was a grandson of Perseus. He was also rewarded with a constellation. So was Orion, the giant, who has the most conspicuous figure of stars in all the sky. The twins, Castor and Pollux, were given twin stars and were much beloved by seamen for it was thought that if both stars were visible, fine weather was sure to follow.

Not only were gods and heroes placed in the sky, but also objects and creatures connected with their adventures.

"monstrous shadows of prodigious size,

That deck'd with stars, lie scatter'd o'er the skies."

—*Ovid's Metamorphoses.*

(ADDISON'S *Trans.*)

Thus we find among the constellations Draco, the Dragon; Cygnus, the Swan; Ursa Major, the Great Bear; Ursa Minor, the Little Bear;



The Constellation of Cygnus, the Swan.

Lyra, the Harp; Pegasus, the Flying Horse; Cancer, the Crab; Delphinus, the Dolphin; Pisces, the Fishes; Sagitta, the Arrow; Argo, the Ship; Corona, the Crown; Leo, the Lion; Scorpius, the Scorpion; Hydra, the Watersnake; Aries, the Ram; Taurus, the Bull; Eridanus, the River, and others.

Mapmakers later drew fanciful pictures of these objects and animals and heroes which had been transposed to the sky and united them up with the positions of the stars. This imaginative tapestry of figures is believed to be an attempt on the part of the ancient people to weave a record of their history in the dusk among the stars. That this most original method was successful is attested by the fact that although several thousand years have elapsed these ancient figures still stand and the names that they gave to the constellations are used by astronomers today.

Many of the Grecian characters which are mentioned in the stories of the gods and heroes are personified in groups of three—the three Fates, daughters of Chaos, appointed to watch over the thread of human life—

"Spin, Spin, Clotho spin!

Lachesis twist!

Atropos sever!"

—*Lowell.*

the three Furies, daughters of Night, who represent the remorse which torments and pursues the wicked; the three Sirens, who lived on an enchanted Isle in the Mediterranean Sea and lured mariners on the rocks with their bewitching songs; the three Graces, who presided over feast and dance; the nine Muses, daughters of Jupiter, who dwelt on Mount Helicon and presided over arts and sciences—

> "Fortunate is he whomsoever the Muses love, and sweet blows his voice from his lips."

Mount Helicon was also the home of the great Flying Horse which is sought by poets and is now represented in the sky by a large square of stars called the Square of Pegasus. In one of the adventures of the hero Perseus he snatched the solitary eye away from the three Grey Sisters and thus forced them to tell where he might find the three terrible Gorgons. Transcribed to stars, he still holds the snaky ringlets of the Gorgon Medusa which he had been forced to obtain at the command of the king of the Island of Seriphus. This head now has the added attraction of a mysterious star called Algol, which every few days indulges in a slow, deliberate "wink," a performance most unusual among the wide-eyed stars.

The names of the gods and goddesses were bestowed upon the five planets then known—Saturn, Jupiter, Mars, Venus and Mercury. This plan was also followed when the two outer planets, Uranus and Neptune, were discovered in modern days. These names are Roman names but the mythology of the Greeks and Romans is so intermingled that the names of their characters are, as a general rule, used interchangeably, although the Roman names seem more popular and are used by astronomers. Many writers of mythology use the Grecian names entirely because much of the material of the Roman legends was brought into their literature by Greek poetry.

Roman	***Greek***
Jupiter	Zeus
Juno	Hera
Neptune	Poseidon
Ceres	Demeter
Diana	Artemis
Vulcan	Hephaestus
Minerva	Pallas Athene

Mars	Ares
Venus	Aphrodite
Mercury	Hermes
Apollo	Apollo
Vesta	Hestia

The symbols of the gods were used as signs for their planets. These signs are very familiar objects in almanacs. Thus, Uranus (Heaven) and Earth are respectively represented by ♅ and ♁; Saturn, their son, has a sign which suggests his ancient scythe ♄; Jupiter has a hieroglyph for the eagle ♃, a bird which carried his thunderbolts; his brother Neptune is pictured with a trident ♆, the pronged fork he used when issuing commands; Mercury, son of Jupiter, is represented by his Caduceus, a miraculous staff intertwined with serpents ☿; Mars, God of War and also a son of Jupiter, a conventionalized arrangement of his shield and spear ♂; while Venus, Goddess of Love and born from the foam of the sea, has a sign somewhat like Mercury's ♀, resembling a hand mirror.

A word as to Mars, Mercury and Venus might not be amiss. Mars was worshiped as a warrior in splendid armor, his name being quite appropriate for the red tinged planet which shines as such a brilliant, fiery star. Discord was visioned as running before him in tattered garments while Anger and Clamor follow in his train. Deimos and Phobos, children of Venus and Mars, were given as names to the two satellites of his planet, although these satellites (or moons), were not discovered until modern times. (The ten satellites of Saturn were named after his brothers and sisters, while those of Jupiter, who possessed nine, were named after various favorites.)

Mercury, also a son of Jupiter, was a somewhat mischievous but charming young man with wings fixed to

his helmet and sandals, and his hand held a rod which quieted all disputes. He was messenger, herald and ambassador for Jupiter, just as Iris, who flew along the rainbow in her tinted robes, was a messenger for Juno, Jupiter's wife. It was afterwards discovered by astronomers that the tiny orb which had been given the name of Mercury in honor of this god, not only resembled a drop of "quick-silver" but also possessed the "wing-shoe" characteristic of its namesake, for it speeds at the rate of more miles per second than any other planet in the solar system.

Venus, the beautiful Goddess of Love, has been the inspiration for painters, poets and sculptors in every corner of the world.

"But light as any wind that blows,

So fleetly did she stir,

The flower she touched on dipt and rose,

And turned to look at her."

—Tennyson.

One of the most famous statues extant is the Venus de' Medici preserved in the Uffizi Gallery at Florence. This statue, which was dug up in several fragments during the 17th century, is the work of Cleomenes, an Athenian who "flourished" in 150 B. C.

Venus was called Aphrodite by the Greeks, from *aphros*, meaning foam. Some poets have told how the foam itself suddenly turned iridescent, trembled, and from its center rose the lovely Venus. Others tell how a closed shell tinted like a rose floated to the top of a billow where it opened

and disclosed the pearly daintiness of the goddess. The god Zephyrus, the west wind, then wafted her to the shores of Cyprus where she was adorned by the Hours and later carried to the home of the gods on Mount Olympus where the most beautiful star in the sky, the planet Venus, was named after her.

Owing to the slanting motion of the stars when in the east or west, the figures of these star groups show marked changes. The "Great Square," for instance, stands on a corner star when seen in the east and west although it is a perfect square when seen in the south, while the "Twins" appear above the eastern horizon standing on their heads, slowly right themselves as they travel across the sky and sink feet first when they disappear below the horizon in the west.

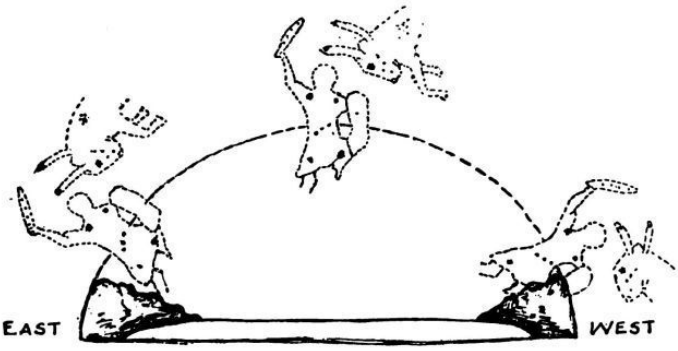
To illustrate more clearly one might imagine the "Giant Orion" to be a tiny toy fastened by his waist to a wire bent in the shape of an arc.



As he slides from east to west it is easy to see how his position changes in relation to an eye directly in front of him. This varying orientation is easily understood and should give the reader but little trouble.

Often a part of a constellation, such as the Big Dipper, is

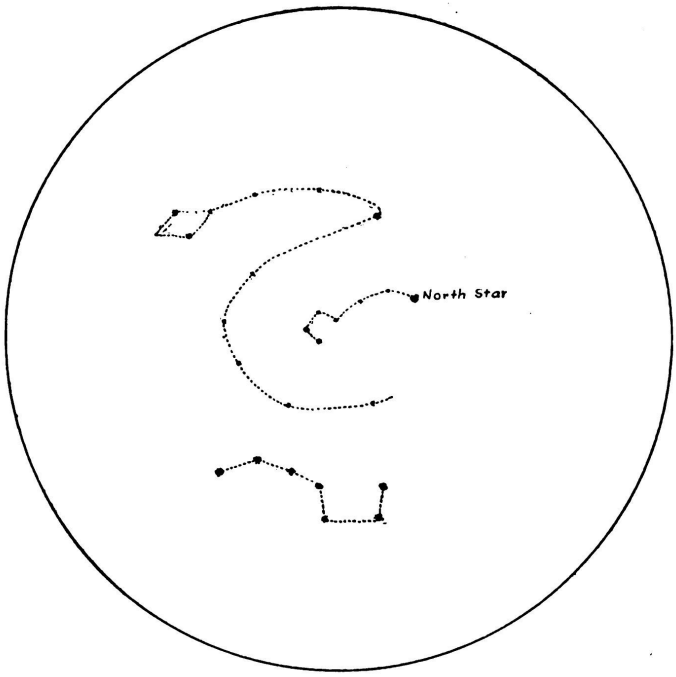
more familiar to the majority of people than the whole constellation, which is called "Ursa Major" or the "Great Bear,"—the handle of the Dipper is only the tail of the Bear.



"Constellations come and climb the heavens and go."—*Bryant*.

In all cases these prominent features will be used as index names.

Romance is said to gain when tinctured with realism just as realism gains when tinctured with romance. So, with a heart filled with beauty and a mind filled with facts, let us go forth on starry nights and seek, with eyes that are friendly, our acquaintances among the stars.



THE TWO DIPPERS AND DRACO, THE DRAGON.

These stars circle about Polaris, the North Star, and are visible at any hour during the night throughout the year.

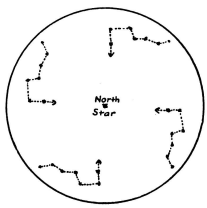
CHAPTER IV

THE TWO SKY DIPPERS AND DRACO, THE DRAGON

THE BIG DIPPER



A BROKEN handled duplicate of the old fashioned tin dipper that used to hang by the well, lies twinkling in the northern half of the sky. This Dipper is ornamented with seven bright stars although a telescope or a field-glass will disclose dozens more encrusted on its handle and a starry phosphorescence in its bowl.



This Dipper may be found near the zenith, almost overhead, during the early evening hours in April and May; it is west of the North Star in July and August, near the northern horizon in October and November and in the east during January and February.

Although every twenty-four hours this Sky Dipper swings completely around the North Star, half of the journey is invisible because the strong light of the sun prevents us from seeing the stars in the daytime.

"The fiery sun, when wheeling up heaven's height,

Obscures the stars and the moon's holy light."

—Leonidas.

The stars, however, rise two hours earlier every month and this brings the Dipper, when observed during the early hours of darkness, to different positions in the sky during the different seasons.

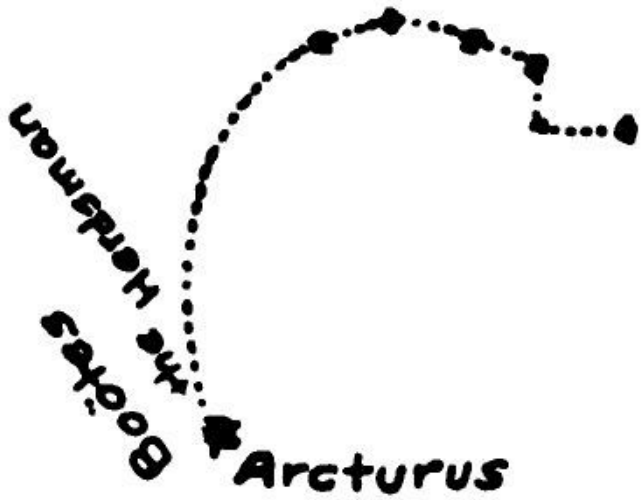
Since this conspicuous star figure travels completely around the arctic circle of the heavens in twenty-four hours, the space within this circle has been likened to a great star clock, the two outer stars on the bowl—called "The Pointers"—forming the hour hand which always points toward the center of the clock marked by the North Star. With a little attention anyone may learn to judge the time by this timepiece and wager as much on it as the Carrier in Shakespeare's King Henry IV who looks up as he enters the Inn Yard with his lantern and remarks:

> "Heigh-ho! An't be not four by the day,
> I'll be hanged, Charles' Wain is over the
> new chimney, and yet our horse is not
> packed."

The Big Dipper is called "Charles' Wain" in England, the bowl being the wagon or wain, and the stars on the handle, the horses. It is also called "David's chariot" and the "Plowshare." In Rome these seven bright stars were called "Septentriones" or "The Seven Plowing Oxen"; in Greece, simply the "Triones."

> "'Twas the time when all things are silent, and Boötes had turned his wain with the pole obliquely directed among the Triones."
>
> —*Ovid's Metamorphoses*.

Boötes, so the story runs, being of an ingenious turn of mind, tilled his land in fine order by inventing the plow which he hitched to two oxen.



For this he was given the title of the "Herdsman" or the

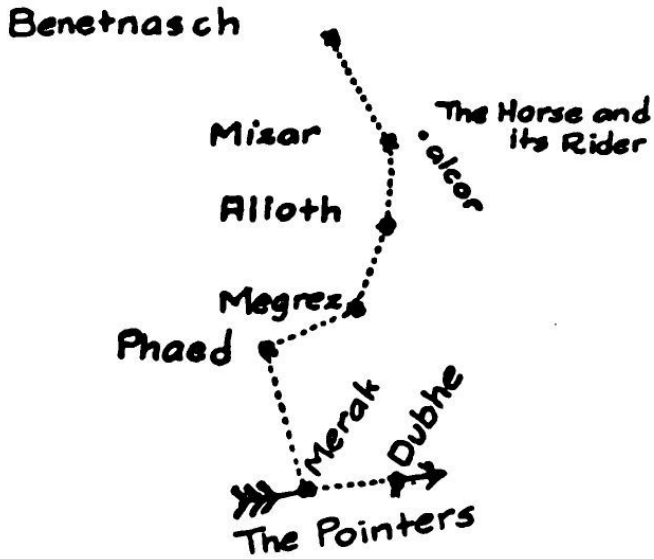
"Ox-driver" and placed in the heavens to follow the stars of the Big Dipper which resembles a "wain" or a plow. Boötes' constellation, though very large, is formed of faint stars,—with the exception of one brilliant golden-yellow star which may be located by drawing a curve from the end of the Big Dipper's handle.

The little star just above the star in the crook of the handle of the Dipper is sometimes spoken of as a 'rider.' The Arabs call these two stars a "Horse and its Rider," the English call the rider "Jack-on-the-Middle-Horse," while the Germans call him "Hans-on-the-Middle Horse." Hans chose this position in preference to any other on the face of the earth or in the kingdom of Heaven.

Astronomers have still another name for the Horse and its Rider. To them it is a "naked-eye double," the tiny star being called "Alcor," and the one on the Dipper's handle just below it, "Mizar." A 3-inch telescope discloses a still closer companion to Mizar which has a decided greenish tinge in its light. Of the two stars composing Mizar, each one is itself composed of two, which revolve around a common center of gravity in a period to be counted in thousands of years. This wonderful law of gravitation which holds not only planets in their orbits, but also stars, was discovered by Sir Isaac Newton, an English philosopher and mathematician. Two stars revolving around a common center of gravity in this manner are called a "binary"; in the case of Mizar and its companion, each of the two visual components is called a "spectroscopic binary." The brighter component was discovered to be a binary in 1889 by E. C. Pickering with the aid of a spectroscope and the fainter component was found to be a spectroscopic binary in 1908 by Frost and Lee. Alcor is also a spectroscopic binary.

The stars are such an exceedingly great distance from the earth that even though they are in constant motion, they

do not seem to change their relations to other stars through long periods of time. The whole configuration of the Big Dipper will some day be changed because its stars are traveling in various directions. Through the skill of various scientists this infinitesimal difference in motion is detected and recorded,—not only that a star is moving, but which way and how fast! Thus the spectroscope exploded the old idea that the stars were "fixed." The facts, however, are amazing and one must immediately readjust his ideas of what constitutes big and little, fast and slow, for in studying astronomy the small distances on our earth and the vast distances in space, and man-made speed and God-made speed, can hardly even be compared.



The stars of the Big Dipper are an exceptional group for they are all bright stars of the second magnitude, with the exception of Megrez at the junction of the handle to the bowl. These seven stars, and the "Rider," were given

names by the Arabian astronomers, and although modern astronomers prefer for the most part a Greek letter prefixed to the genitive case of the Latin name of the constellation —such as β Ursae Majoris—these names are rather interesting to know. Starting from the top of the Big Dipper's handle, the Arabian names are as follows: Benetnasch, Mizar, Alioth, Megrez, Phaed, Merak, and Dubhe.

THE LITTLE DIPPER



The "Little Dipper" hangs on the Pole of the Heavens, swinging swiftly around night after night, century after century.



It hangs stiffly, as a dipper should, from the bright golden nail of the North Star. From its appearance, it would seem that the rapid motion near the pivot of the starry dome had caused its handle to bend forward at a most precarious angle—surely nothing less than the immortality conferred upon it as a part of Ursa Minor could prevent it from flinging its bowl through the depths of space and whirling henceforth an uninteresting stub of a handle.

The Little Dipper is rather faintly outlined, the only bright stars being those which mark the extremities. The two more conspicuous stars were named "The Guards" for it was thought that they protected the "hole in which the axle of the earth is borne." This "hole," which was imagined as keeping in place the north pole of the heavens, is marked by the North Star.



To be exact, the North Star does not mark its precise location but is about twice the diameter of the moon away from it. Such a small distance, however, is scarcely discernible to the eye.

As mentioned before, all the stars travel in unchanged order along their arcs from east to west except this one star which marks the north pole of the heavens. There is no star directly above the pole of the southern hemisphere of our earth. The North Star, or "Polaris," is therefore the only star which remains in an apparently fixed position in the sky, and all the other stars visible to us whirl around it as a center, although in most cases only a portion of their arcs may be seen. If the earth should falter or halt in its rotation, so would the whirl of the stars, and this remarkable exhibition, which is only a delusion dependent on the motion of the earth, would immediately cease to be.

Polaris has a minute blue companion star which may be viewed in a 2- or 3-inch telescope.

The most reliable method of establishing a true meridian in surveying is to take observations on Polaris. "Amid the blue ice and rose-petal night of the pole" this star is, of course, in the very dome of the sky, and Admiral Peary

once had the unique distinction of having it shine directly over his head. But in any other location, this star burns like the light of a signal fire marking the north, and its steady, never-failing presence has always heartened and given a feeling of security to travelers, as well as being useful to surveyors.

THE TWO BEARS AND THEIR STORIES

The two sky Dippers are only the flanks and the tails of the whole constellations which are called the "Great Bear" and the "Little Bear." Their names are usually written in Latin—"Ursa Major" and "Ursa Minor."

The tail of the Great Bear, outlined by the bright stars of the Big Dipper's handle, is the most clearly marked portion of his anatomy. So inordinately proud is he of this huge appendage, (which is also, the most clearly marked figure in the sky), that, so old legends assert, he gazes jealously at the lone bright star on the end of the Little Bear's tail in hopes that some day he may gain possession of it and add it to his own. This is another reason why the "Guards" have been placed to watch the North Star.

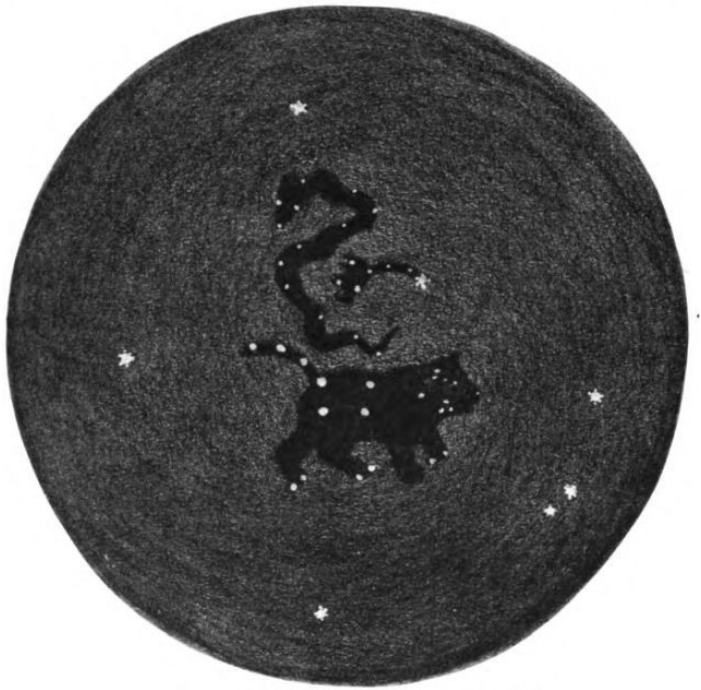
The feet of this Bear extend to three pairs of stars set nearly equidistant, although there are no stars for one of his forefeet.



The "Does Leaps" or the Feet of the Great Bear.

The Arabs call these the "Doe's Leaps." The Bear's head is sprinkled with a scattered group of faint stars on a line with the bowl of the Dipper.

This interesting creature is most impressive when in the springtime his shadowy, star-decked form crosses the sky near the zenith. He seems closest then and we cramp back our necks to get a better view of this ancient Bear about whom is twined so many legends.



"The Bear that prowled all night about the fold

Of the North Star."

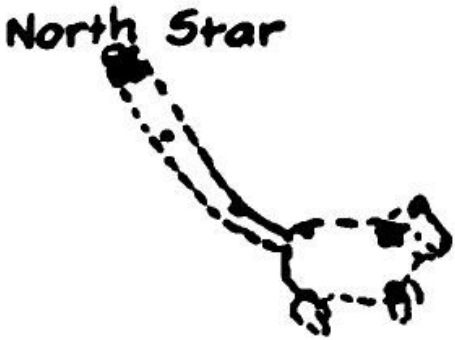
—*Lowell.*

Later, during the autumn months, he walks along the rim of the horizon in the north, but there too often, sad to relate, he is more than half obscured by the mists and fogs which hover about near the surface of the earth.

Many attempts have been made to account for the ridiculous length of the brightly-jeweled tails of the star-bears. Richard A. Proctor in "Easy Star Lessons" suggests that as the star maps were arranged by astronomers who being aware of the many legends but who had themselves

never seen a bear, naturally supposed the three bright stars in the handle of the Big Dipper to be Ursa Major's tail and so drew it. Since the Big Dipper was made part of Ursa Major or the Great Bear, the Little Dipper, whose seven principal stars resemble those of Ursa Major, was made part of Ursa Minor, the Little Bear.

Howe remarks in his "Descriptive Astronomy" that the "length of the little fellow's tail might be ascribed to environment."



The "Little Bear"

'Tis reasonable indeed. With the tip of it fastened to the North Star for a pivot it might stretch after being swung round for a few centuries. Perhaps, to go still further, this is the reason it is now so thin and therefore faint, and also why it is broken. The quaint theory of Dr. Thomas Hood, who wrote early in the 17th century, is also quoted as a possible reason for the length of the Great Bear's tail:

> "Imagine that Jupiter, fearing to come nigh unto her teeth layde hold on her tayle, and thereby drew her up into heaven, so shee of herself, being very weightie, and the distance from the earth to the heavens very great, there was great likelihood that her tayle must stretch.
>
> "Other reason know I none."

Ursa Major was not a real bear, however, but a beautiful and most unfortunate Arcadian nymph, named Callisto, who had been transformed by Juno, Queen of the Immortals, into this great shaggy creature. Years afterward, Callisto's son Arcas, then a boy half-grown, met the bear on a lonely pathway on the mountains and shot an arrow at the creature. Happily, as was often the way with the gods, Jupiter looked down just then, stopped the arrow in its flight and changed the young boy also into a bear. The bears were then raised to the sky and placed among the stars, for Jupiter straightway:

"Snatched them through the air

In whirlwinds up to heaven and fixed them there."

—*Ovid's Metamorphoses*. (ADDISON'S *Trans*.)

The place is even yet easily located on account of the clearly marked outlines of the Dippers.

This sympathy on the part of Jupiter aroused Juno to such a jealous rage that she immediately sought a way to bring discomfort to the Bears, particularly to the Bear which was Callisto. It seems that the Greeks believed that

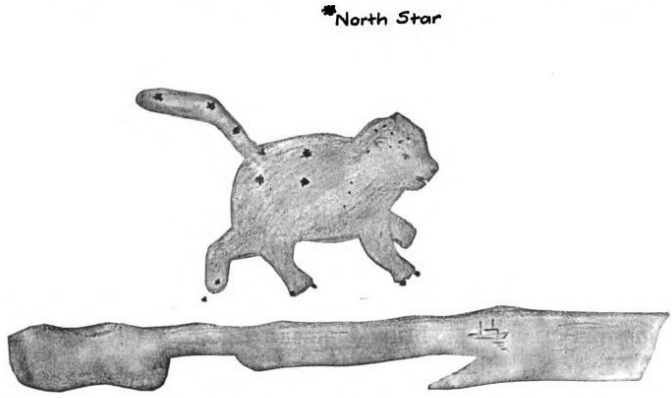
the stars enjoyed a dip in the western waves of the ocean before disappearing to the darkness below the horizon, and seeing in this a chance for revenge, Juno harnessed up her peacocks and drove to the palace of Oceanus, the ancient God of the Ocean Stream. Here the goddess found the Ocean God (who was one of the Titans and ruled before Neptune's time), and calling him up from the briny depths inveigled that deity to swear by the river Styx that he would drive the "seven Triones" away from his "azure waters" every time these stars appeared and never, under any circumstances, would he share his hospitality with the Bears. After the long journey from the east across the dimly lighted heavens, this was a hardship difficult to endure, yet to this day, since a god's decree may never be changed, the two Bears turn as they approach the ocean and dare not even linger to sniff the spray. While all the other constellations immerse their stars beneath the waves, these poor creatures again ascend the steep slope of the sky and repeat the big circle about the pole of the heavens with never a rest—nor a bath.

But travelers have quietly observed these stars in a latitude south of 40 degrees, and have noticed, as they approached the equator, that the Bears slip their feet into the sea and still farther south

"despite of Juno, lave

Their tardy bodies in the boreal wave."

Allen, in "Star Names and Their Meanings," comments on the singularity that peoples separated by an impassable ocean had like ideas concerning the resemblance of Ursa Major to a bear.



He Dare Not Linger—

"Whence came the same idea into the minds of our North American Indians? Was it by accident? The conformation in no way resembles the animal,—indeed the contrary; yet they called them Okuari and Paukunawa, words for bear, long before they were visited by white men. In justice, however, to their familiarity with a bear's anatomy, it should be said that the impossible tail of our Ursa was to them either Three Hunters or a Hunter and two dogs in pursuit of the creature, the star Alcor being the pot in which to cook her. They thus avoided the incongruousness of the present astronomical ideas of Bruin's makeup, although their cooking utensil was inadequate."

According to this legend, which is related from a monograph on "The Celestial Bear" by Stansbury Hagar, the whole bear is represented by the stars of the Big Dipper. The first hunter, who is the first star in the handle

of the Dipper, was called the robin and carried the bow with which to kill the bear. The chicadee, the second star in the handle of the Dipper, carried the pot, the little star Alcor, in which to cook the bear. The third hunter, the moosebird, carried the sticks with which to build the fire. Four other hunters followed besides the three represented by the stars in the Dipper's handle.

The chase continues throughout the summer until part of the hunters disappear below the horizon. About mid-autumn the Bear rises up to defend herself but is pierced by an arrow of the robin, and the autumn leaves are stained scarlet from his wounds. The spirit of the dead Bear enters into another Bear and the chase begins again and so keeps up eternally. In the Indian version the group of stars above the hunters (which is the Bear's head in the Ursa Major of the Greeks), is the Bear's den. This den is picturesquely situated on the northern horizon early in the spring and, to the mind of the Indian, the great Bear seems as if it were just emerging after a long winter's hibernation.

There is also an old Iroquois Indian tale which claims that at one time in the distant past the bear had a fine bushy tail but that this tail was frozen off one cold winter when the foolish animal endeavored to catch a fish by letting the long appendage hang through a hole in the ice. In those days, perhaps, the bears were vain creatures,—which might explain, in part, why the star-jeweled tails on the shadowy forms of Ursa Major and Ursa Minor are held with the upright pride of a cat with nine kittens as these mammoth plantigrades nightly promenade on their circular path around the Pole.

DRACO, THE DRAGON

A sinuous line of stars divides the figures of the Great

and Little Bears. These stars lie on the huge body of Draco, the Sky Dragon, whose length coils halfway around the axis of the world.



Draco is sometimes called the "Guardian of the Stars," the stars being the golden apples which hang from the pole-tree in the Garden of Darkness. This is rather a pretty conceit as the Dragon's Eyes, represented by the stars Alwaid and Etanin, never rest, that is, never set below the northern horizon of Greece.

The above title was probably suggested by the legend which tells of Laden, the sleepless dragon, that guarded the tree of golden fruit in the Garden of the Hesperides. This garden lay near the feet of Atlas, the giant Titan, who sat

on a mountain in northern Africa supporting the dome of the heavens. The bright eyes of this snake were at that time aided in their wakefulness by the silvery, lilting voices of the Hesperides, daughters of Hesperus, whose name was given to the beautiful Evening Star so often seen in this direction. According to one legend, Hercules slew this dragon in order to pick the gleaming fruit and bring it to his cousin Eurystheus as his eleventh Labor, but that this Dragon could be identical with the sky dragon, Draco, whose head lies just beyond the heel of Hercules, is somewhat discounted by other legends which claim that Hercules temporarily supported the weight of heaven while Atlas went down to the garden and got the apples from his nieces. In return for this favor, Atlas gained a little rest.

It has also been suggested that perhaps Draco was the monster "with a body more huge than any mountain pine" and "a roar like a fire among the woodlands," which was entwined around a beech tree in the Grove of Mars, the War-god, at the eastern end of the Euxine (which we now call the Black Sea). On this beech tree was nailed the golden fleece of the wondrous ram which flew into the sky and aided two persecuted children to escape. To obtain this fleece, Orpheus drugged the snake with music while Jason stepped across the mighty coils and tore the golden wool from the tree. After the Argonautic expedition, both the ram and the dragon were placed among the stars.

Still another legend relates that when the gods and the earth-born giants waged their mighty war to gain possession of Olympus, a huge crawling monster had the audacity to anger the Goddess Minerva who seized it and hurled it far into the heavens where it caught on the axis of the world, and froze into immobility before it had time to unwind its contortions. The only time on record that this dragon ever revived from its stupid torpor was when Phæthon, son of Apollo, lost control of the steeds of his

sun-chariot and the heated vehicle swerved northward from the beaten path.

"Then the folded Serpent next the frozen pole,

Stiff and benumb'd before, began to roll,

And rag'd with inward heat, and threatened war."

—*Ovid's Metamorphoses*.

Although there are a number of opinions as to just which dragon in legend is represented by Draco, the constellation is a very important one, for one of its stars, a star named Thuban, was at one time our Pole Star. Indeed, in 2300 B. C. the Pharaohs of Egypt looked up at Thuban as their Pole Star. As their *Pole Star*! But where was our faithful North Star during 2300 B. C., and how could our earth's pole swing from this point in the heavens to one half the way between the "Guards" on the tiny bowl of the Little Dipper, and Mizar on the crook of the handle of the Big Dipper? This strange phenomenon not only happened but happens regularly, for the earth "reels like a top" as well as "whirls," although the reeling motion is so much slower than the whirling motion that while it whirls once on its axis in a day, it reels around only once in 25,000 years. During this time the earth's axis describes a circle from Thuban, through the present Pole Star, around through Vega and back again. Vega may be easily located for it crosses the zenith in the late evenings of summer, a beautiful bluish-white star of the first magnitude. It will be about 11,500 years or about 13,500 A. D. before this blue star will again shine above the northern pole of our earth.

It was not an uncommon thing in olden times to build temples dedicated to the observation of certain stars. It is

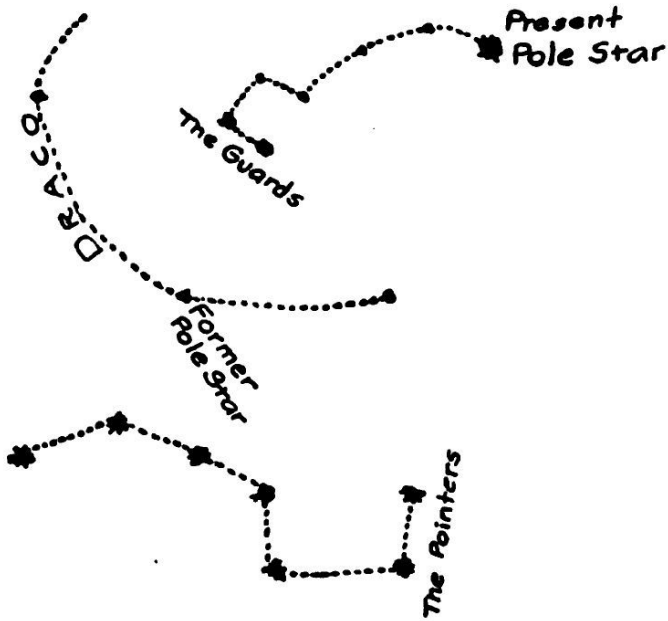
believed that the great pyramid of Cheops, built 4600 years ago, was so constructed that the light of Thuban, then the Pole Star, would shine down its great stone tube at the time the star was at its lower culmination. Olcott in "Starlore of All Ages" tells us that the idea was to conduct the ray of light from Thuban through the passage opening high up in the side of the pyramid, to the eye of a god hidden far down beneath its foundations. When viewed from the bottom of the tunnel, which ends in a room hollowed out of solid stone, it is said that the mouth appears but little larger than the moon's diameter. It is interesting to note that the pyramid of Cheops is the mightiest structure the world has ever seen. According to Herodotus, 100,000 men were employed constantly on this work for 20 years. But the rays of Thuban can no longer shine down the 380 feet of stone tube to light the eye of the god hidden in its depths, for the reeling of the earth has caused the tube to be out of the star's line of light. It may happen again in 21,000 years, however—if the pyramid is still there.

In China there is an observatory 4000 years old which Samuel G. Bayne in his little book the "Pith of Astronomy" speaks of visiting. Here is a slanting granite wall in which two eyeholes had been bored for the sole purpose of sighting Thuban.

Changes in the universe are very gradual and although 4000 years seems a long time to the limited mind of a human being, it is but little in comparison to the vast periods of time which must pass before a visible change can be noticed in the heavens. We speak of these years nonchalantly, but astronomers have had to work hard and patiently in order to make such assertions and to back them up with sufficient proof.

Traveling backward in imagination on the circle that our pole has taken 25,000 years to describe in the sky, and again imagining the star which we now see as our Pole

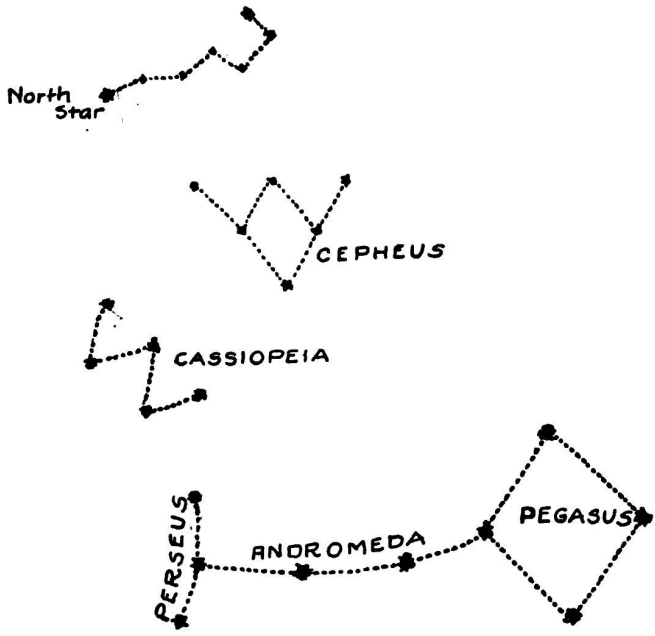
Star as the Pole Star of that by-gone era, what a difference we find in the appearance of the earth! Herds of strange and savage animals are scattered here instead of thriving villages and cities, and man, in equally savage state, wanders about the hills and plains alone or in straggling bands.



In traveling forward 21,000 years again to the time only 4000 years ago when Thuban, on the coils of the Dragon, shone as our Pole Star, we come to comparatively recent times; civilization on our earth has made great advances, not the least of them being that it has raised its head and has noted that there are not only stars but that the stars differ from one another. Probably during this era the Chinese chose the Dragon for their national emblem.

The principal interest in the constellation of Draco is, of

course, the star Thuban. It is interesting to locate this ancient Pole Star which lies on the tail of Draco, just above the handle of the Big Dipper, and reflect that this star was once the hub of the starry universe, with the Big Dipper whirling round and round it in a close circle.



A SUMMER DRAMA.

The Stars of this ancient Royal Family shine conspicuously in the Northeast during the late summer evenings.

CHAPTER V

THE STORY OF ANDROMEDA IN STARS

Characters

CEPHEUS, *the King*.	ANDROMEDA, *the Pri*
CASSIOPEIA, *the Queen*.	PEGASUS, *the Flying H*
PERSEUS, *the Hero*.	CETUS, *the Sea-monste*

LIKE the shadow of a dream among the summer stars of the northern sky is a wonderful story of romance and adventure. This story has been mentioned in all Greek literature of the 5th century before Christ, in incidents portrayed on early vases and in wall-paintings found in Pompeii, and its characters have been immortalized on brilliant groups of stars.

The tale that I am about to recount has lived since the time when great fabled sea-monsters were wont to appear and frighten the people along the coasts of the Mediterranean. Wild with terror, the king and his subjects would fly to the temples for protection and would even sacrifice their loved ones if an oracle so decreed.

In an age long past, scientists tell us, strange beasts actually inhabited the waters of the ocean. This they know for they have found the fossilized skeletons. For the sake of the romance let us imagine that some of these still

survived in Andromeda's time; that one such monster had wandered in through the straits to the blue waters of the Mediterranean during the reign of her father King Cepheus, and that this king, following the advice of an oracle, actually chained his daughter to a rock upon the sea-shore believing that by this supreme sacrifice the wrath of Neptune might be appeased. Storms, wrecks and other disasters relating to the sea were thought to be the handiwork of the Sea-god seeking revenge for some fancied insult. Seeing the strange sea-beast appear along their coast, the Ethiopians probably considered all their sins and decided the cause was the excessive vanity of their Queen. Thus, from a bare thread, a beautiful story was elaborated and woven about Andromeda, the Princess; Perseus, the Hero; Cassiopeia, the Queen; Cepheus, the King; and Cetus, the terrible Sea-monster.

Not only was Cassiopeia proud and beautiful, but she wished others to be envious of her beauty, and to prove her superiority sent challengers throughout the country so that none might question it. In the excess of her vanity, she deliberately took her throne and sat in state by the shore, loudly repeating her boasts to show that she did not fear even the peerless sea-nymphs.

When the news of this audacious performance reached the ears of the Nereids who inhabited the depths of the Mediterranean, there was great excitement, but particularly was it resented by the sea-beauty Atergatis who straightway swam to the palace of Neptune, under the Ægean Sea, and begged him to avenge the insult offered to his nymphs. Neptune, furious at the effrontery of the Ethiopian Queen, shook the land of King Cepheus until the hills cracked and sent his waves to flood the country and wash away the coast. With the onrushing waters came the ferocious sea-monster which loitered near the shores and the mouths of the rivers and destroyed every man and

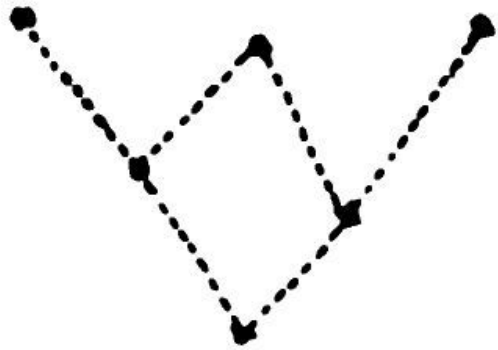
animal that came within its reach.

Terrified by such a combination of calamities, Cepheus and Cassiopeia fled to the oracle of Jupiter, but they found no peace here, for the oracle informed them that the only way to make amends and ward off the evil that had befallen them, lay in the sacrifice of their innocent daughter Andromeda. There being no alternative, Cepheus was compelled by his subjects to submit to these terms, and taking poor Andromeda to the sea-beach, chained her wrists and ankles and fastened them to staples driven in a rock upon the shore. In the meantime the population of the entire city had gathered weeping upon a cliff, while in the distance Neptune's monster, sensing the commotion, swam steadily nearer, with his wicked, gloating eyes staring fixedly on the dainty morsel baited on the rocks.

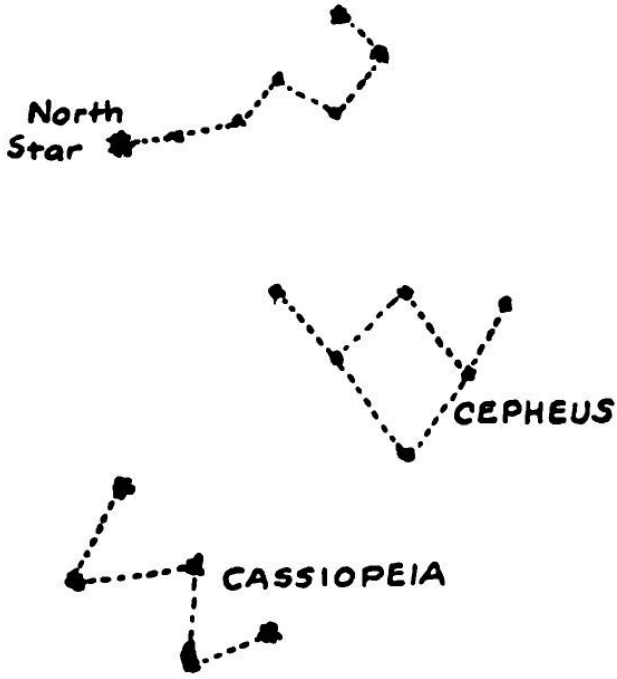
Andromeda, in utter despair, bowed her head,—then looked up quickly on hearing the cheers of the people, for the hero Perseus had appeared, bounding and skimming along the sky and slanting downward toward the foaming waves. The hero gave one glance at the awful monster, then drew his sword and drove it deep into the sea-beast's scaly neck. With his other hand he pulled the Medusa's head from his wallet,—and the sea-beast slowly hardened into a beast of stone. With its glassy eyes protruding like balls of obsidian, the creature then sank in a petrified mass to the bottom of the sea.

The heroic youth, amazed at the effectiveness of the terrifying head, flew quickly to Andromeda and struck away the fetters which bound her to the shore. The King and his subjects then swarmed around them and amid great rejoicing carried them to the palace. Not long after, the Princess became the bride of the hero, who put away his fluttering shoes and set sail in a ship to the island of Seriphus.

CEPHEUS, THE KING



This is Cepheus as he is traced among the stars, a king done in shorthand. He claims no star above the 3rd magnitude, but since his constellation is near the North Star and just above the Chair of his Queen, a large and conspicuous "W," it is easy to find and may be seen any clear night the year around. Cepheus may be seen at his best during the summer evenings when his stars are nearly overhead in the dome of the sky.



The other characters in this drama were placed among bright stars and are therefore more easily found, although to less romantic moderns these stars merely indicate the part of the sky-field where the ancients claim the royal family were lifted to the stars.



Below Cepheus, on a "Chair" of bright stars, sits Cassiopeia, his Queen, her arms upraised and her face pensive through long ages of humiliating sorrow; below Cassiopeia stands Perseus transfixed in a heroic attitude, the segment of three stars shining against his armor-clad body, his diamond-bladed sword thrust among the fainter gleams above his head.



The snaky-locked Gorgon Medusa hangs downward from his shield, while among its fearful tresses blinks Algol, the Demon Star. On the line of stars that twinkle at the hero's feet, lies the fair maid Andromeda, her hands outstretched and bound, and her long, dark hair caught with a star on the Square of Pegasus.



The silvery-winged Horse was, oddly enough, placed upside down upon his constellation with his head extending earthward from a corner of the "Square" and his feet pawing upward into the darkness. Far below in the south glitters Cetus, Neptune's wicked monster, although Cetus does not appear until September and is not completely visible until January. The ancient royal family from Ethiopia, now famous for all time, and the immortal Perseus, from whom proud kings claim their ancestry, are conspicuous figures in the northeast during the late summer evenings, and are at their best here rather than in the dome of the sky or in the west.

A small meteor shower radiates from the vicinity of Cepheus during the latter part of June. Remember that Cepheus lies up near the North Star near the Pole of the Heavens and these meteors will not be difficult to locate.

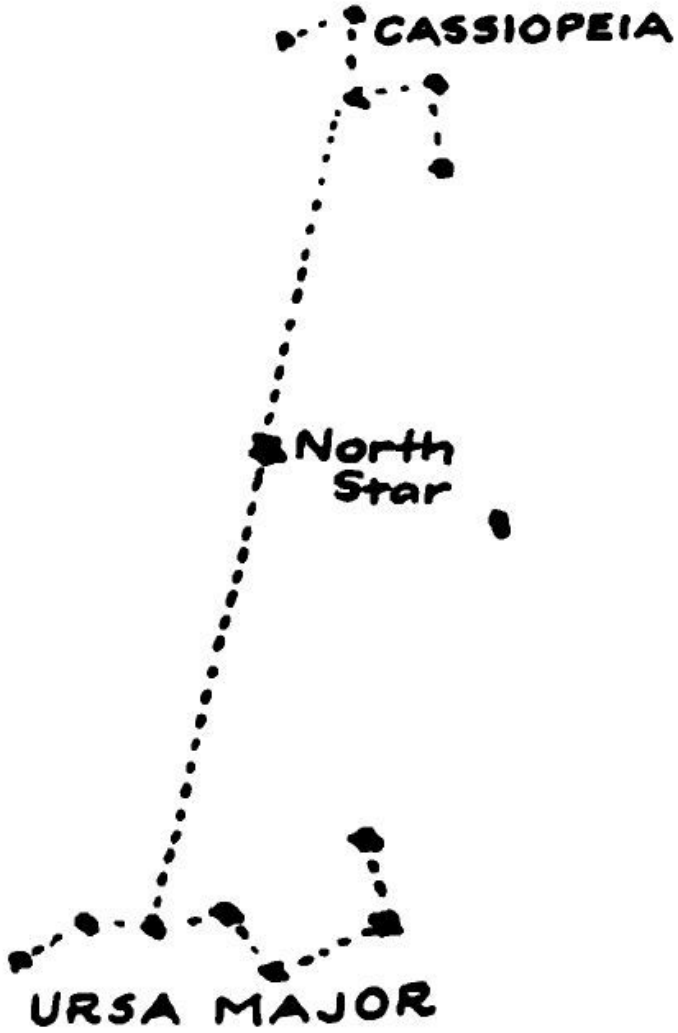
It is also interesting to note that in the constellation of Cepheus may be found the north polar star of the planet Mars.

CASSIOPEIA, THE QUEEN



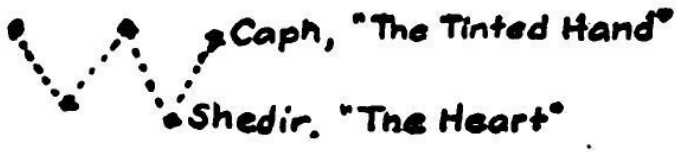
The "Chair of Cassiopeia" rests upon the path of the Milky Way in the northern part of the heavens. It consists of five bright stars which suggest the outlines of an "M" or "W," and may be easily located by projecting a line drawn from the Big Dipper through the North Star and on again for an equal distance. Thus the Dipper and the "W" in beautiful balance, teeter, now high and now low, about the pole. The "W," however, is most impressive when near the horizon.

Poets tell of the silvery currents of the Milky Way that wind in and out among the stars of this "Chair," but with the telescope one may see more clearly and perceive that the "silvery currents" are a magnificent wilderness of suns.



When the nymphs of the Mediterranean discovered that Cassiopeia had been honored with a choice position among the stars, they were perfectly furious, and even the sympathy of Juno did not console them as she recalled the time that Callisto was transposed as Ursa Major to the

stars. Odd fate that forced an Arcadian maid and an Ethiopian Queen to follow each other forever around the Arctic circle of the heavens! The Nereids, however, protested violently to Jupiter that such a reward for Cassiopeia's boasting was unfair and their influence so far prevailed that the Queen was set in a tilted fashion and forced to swing half of every night with her head hanging downward, and both her arms upraised. Furthermore, her "Chair" was strongly outlined while her queenly person was quite ignored. Thus the petty spite of the sea-nymphs was much worse than Cassiopeia's boasting.



There was a slight compensation, when, for all this humiliation, two of the stars in the "W" were named after the Queen's 'heart' and 'hand' by the Arabian astronomers, —Alpha, the lower star of the five bright ones, being called Shedir, "the heart," and Beta, in the back of the chair, Caph, "the tinted hand."

About six centuries ago, a phenomenon happened among the stars in Cassiopeia's constellation, where, suddenly, in a position which had previously been blank, a new star shone forth. This star glowed as brightly as the planet Venus, which outshines every star in the sky. It was so bright that it was even visible in the daytime! This brilliancy then commenced to diminish, the star growing fainter and fainter until in about a year and a half it had completely disappeared.

While new stars have been noted during the course of centuries, the appearance of one is always so unusual that

it stands out against the background of the sky with almost a disquieting effect. The presence of an additional bright star, strange as it may seem, is immediately noticeable to one who is familiar with the constellations. Astronomers record its history with as much interest as the appearance of a new island or volcano would occasion on earth.

Two theories for temporary stars are given in Moulton's "Introduction to Astronomy." Professor Moulton tells us that these theories are surrounded by serious objections—but they are interesting nevertheless.

One is "that there is invisible nebulous or meteoric matter lying in various parts of space, particularly in the region occupied by the Milky Way (there is confirmatory evidence of this hypothesis); that there are also dark or very faint stars"—(that is stars which are in the last stages of cooling, a phenomenon also confirmed)—"that the dark stars, rushing through the nebulæ, blaze into incandescence as meteors glow when they enter the earth's atmosphere; that the heating is superficial and quickly dies away." Another hypothesis is that temporary stars "are produced by collisions of stars with stars."

Still another hypothesis among astronomers which has lately gained considerable support is that at the time of an outbreak in a typical nova (new star), a shell of incandescent gas is actually ejected at an enormous rate of speed. Such a phenomenon has been witnessed in the case of one very recent nova.

A 3-inch telescope will show two interesting double stars on the second part of the "W" of Cassiopeia, although the lower of these double stars may also be seen through a 2-inch telescope.



The lower star (α) is a lovely double, one of its components being a rose and the other a clear-hued blue; the yellow star above it has a purple companion which with the larger star whirls around a common center of gravity in a period of about 200 years. Since these stars are suns, as all stars are suns, it is often speculated what effect such combinations of colors would have on a family of planets,—but only a mathematical astronomer would be privileged to figure this out, with such complicated days and nights and seasons. Perhaps there would be no nights —only purple days and yellow days, or blue days and rose days, while peculiar combinations of life—inducing light rays and heat rays might produce strange and awesome forms and eerie vegetation!

Cassiopeia, as well as the Big Dipper, has been called a "celestial clock" for one may read the sidereal time from this configuration of stars with an error not exceeding 15 or 20 minutes. When the star Caph, or β Cassiopeiæ, is vertically above the Pole Star it is sidereal noon; 6 hours when it is on the great circle drawn from the Pole Star to the west point of the horizon; 12 hours when vertically below it; and 18 hours when due east. Caph, or β Cassiopeiæ, leads the other stars of the constellation in their journey westward.

PERSEUS, THE HERO



This is the hero Perseus, easily recognized by the three bright stars which lie in a curved row. These stars hang just below the W-shaped Chair of the unfortunate Queen Cassiopeia who sits in the Milky Way. Aratus, the Greek poet, claims that the sparkles of light which twinkle in this vicinity are particles of dust which the hero stirred up in his haste to rescue Andromeda.

"His giant strides the blue vault climb and move

A cloud of dust in heaven."

What a charming picture to impress upon the sky!

But now in the twentieth century we analyze this dust which the ancients claim their Perseus raised—and what do we find? Every particle in that misty path is a mighty sun, suspended amidst multitudes of other mighty suns, massed in one long strip of splendor across the sky. For (calmly speaking) the Milky Way is a zone of innumerable stars so very distant that the individual lights are blended in one continuous band of silvery haze.

Against this glorious path stands Perseus, sword

upraised among its stars, while entangled in the fearful locks of the Gorgon Medusa glows Algol, the "Blinking Demon." This so-called demon-star actually winks, that is, it indulges in one long, slow wink at intervals of exactly 2 days, 20 hours and 49 minutes. Such a phenomenon used to be a source of terror to the Arabs who feared it might be predictive of some disaster.

Although Perseus and the Gorgon are figments of fancy the wink of this amazing star is not imaginary by any means, for its light actually drops from the 2nd magnitude to the 4th magnitude and stays thus, half darkened, for about 20 minutes. Then it begins to slowly brighten and in the course of the next three hours regains its former brilliancy. In the clear air of the desert where the large stars burn like fire-brands, this change in brightness is very noticeable. Since it was not understood, it seemed terrifying and the superstitious Arabs imagined it to be the eye of a demon. It seemed a fitting star for the ancient Greeks to place on the grewsome head of the Gorgon Medusa where ever after it has flashed and faded in the most eerie fashion.

The mystery of this winking star was not discovered until 1889. Then Vogel found that the periodical change of brightness in Algol is caused by a huge dimly lighted sun, —relatively dark compared with Algol,—which revolves around the major sun at a distance of only 3,000,000 miles. (The earth revolves at a distance of 93,000,000 miles from our sun.) Every time this darker body passes between Algol and the earth, five-sixths of the light from Algol is cut off, thus making it appear to blink. Vogel also found, through the aid of the spectroscope, the diameter and mass of these stars. Algol was found to be about one million miles in diameter with a mass less than half that of the sun while its companion was found to be about 800,000 miles in diameter with a mass about one fourth that of our sun.

Thirty stars are now known to be of the Algol type. One of the most remarkable of these, V. Puppis, was found to be in the southern hemisphere and was carefully examined by Dr. A. W. Roberts. This star has a light variation of only 1½ days and is believed to whirl so closely to its companion that it is in actual contact.

The most favorable seasons for seeing Algol during the early evening are in the autumn, winter and early spring; in the autumn, low in the northeast, when it rises at sunset in the middle of September; in the winter, high up in the north, not far from the zenith; and in the spring, low down in the northwest. At the correct time it is possible for anyone to see its change in brilliancy although the best time to watch for this is during September and October. Algol rises at sunset in the middle of September and consumes 9 hours and 12 minutes in reaching the meridian. To best appreciate the change in this star compare it with the stars near by, especially to the 4th magnitude star that lies quite near to it.

Thus Perseus holds Algol on the Gorgon's head which flashes with "fiery snakes,"—his right hand brandishes a glittering sword, his armor is decked with stars, while the 'dust' he raised swirls in a milky path from the zenith to the trees on the horizon.

In the Sword Hand of Perseus the ancient Greeks saw the gleam of the sword borrowed from Mercury, a diamond-bladed, diamond-hilted sword, carved from a single diamond, but modern astronomers searching in the same spot discovered a more wonderful object for, through the eye of a telescope, the two nebulous patches of hazy light on the Sword Hand were resolved into countless stars! These star clusters are interesting even in a field-glass although higher powers disclose them as veritable sun-bursts of diamond-like stars. The two clusters may be located about half-way between Mirfak, the brightest star

in the Segment of Perseus, and the "W" of Cassiopeia.

One might at first glance take these crowded masses of stars as an example where the great force of gravity had worked not wisely but too well; but it is only the unbelievable distance that our earth lies from these stars which makes them look so closely clustered together. Would the brighter naked-eye stars which bespangle our sky look like this—a glimmering spot—from so vast a distance? To know that our solar cluster of stars is not the only cluster in the heavens is enough to take a little of the conceit out of man's colossal opinion of himself.

A good meteor shower appears in the vicinity of the constellation of Perseus about the 10th of August. These meteors are best seen around three o'clock in the morning and have been recorded as appearing as far back as 811 A.D. This would seem to reasonably assure the annual reappearance of the spectacle but since the number of meteors is steadily decreasing there is a time in the future when it will cease to be. These meteors are popularly known as the "Tears of Saint Lawrence," mentioned as the "fiery tears" in ancient legends because Saint Lawrence was burned at the stake upon the 10th of August in the "sad old days" of religious intolerance. Every year, like ghosts, his tears return and rain down from the sky in drops of fire. They fall at the rate of about one a minute. Miss Proctor, in "Half Hours with the Summer Stars," mentions a quaint old oriental legend in which the meteors are supposed to be darts which are thrown by the angels at the evil ones who are barred from heaven and eavesdrop at its gates.

The myth which is woven about the hero Perseus is a very beautiful one and a few words as to why the Greeks so loved this gallant lad might be well appreciated by those who are not familiar with the story.

Acrisius, King of Argos, was so selfish and quarrelsome

that finally Jupiter, who watched over the affairs of mankind, determined to give him something real to worry about, so Acrisius was informed through an oracle that he would lose his crown and die by the hand of his own grandson. Soon after this Perseus was born, and the King was indeed terrified. His fear increased daily, finally bringing him to such a state of madness that he placed the Princess Danae, his own daughter, and her little son in a large chest and threw it into the sea.

The gods, however, watched the chest and held it steady among the roughest waves, finally stranding it in the sea-weed on the little Island of Seriphus where the wanderers were rescued and given a home.

Years passed, and the King of Seriphus grew to love Danae, but he feared Perseus who looked like a golden-haired god. One day this king planned a great feast and informed his guests that each must bring a gift as proof of his loyalty, and the gift must be either costly or rare. Since Perseus had no wealth, the king suggested that he bring to court the head of the Gorgon Medusa who lived across the sea in the wilds of a strange and distant land.

With his heart filled with sorrow at the thought of this wellnigh impossible task, Perseus went out into the fields and walked about alone. What chance had he against this fearful creature that had the wings of an eagle and hair that writhed in living snakes about her shoulders, and coiled and hissed and darted on her head? More than this, her eyes were filled with horror and turned all who gazed upon her into stone! Walking along thus enwrapped in dreary thoughts, the youth felt himself suddenly grow buoyant, and looking down on his sandals saw that living wings had grown upon their heels; then a polished shield reflecting like a mirror was hung upon his arm, and a sword carved from a diamond, which must have once equaled the size of a bowlder, was thrust into his hand. The gods had again

taken care of their own! Holding himself proudly, our hero walked to the end of the island where a high cliff jutted above the rocky shore below. He stood on the edge and looked down at the rocks beneath him; then he raised his head and looked at the high white clouds in the sunny sky. He thought of the gods and his mother—and bravely stepped over—then laughed joyously as he skimmed like a bird in the warm rays of the sun.

It is a long tale to tell how he journeyed northward to the land of snow and ice, then southward again, and across the Mediterranean.

"He saw the southern, and the northern pole:

And eastward thrice, and westward thrice, was whirl'd."

After finding the Three Gray Sisters who had but one eye between them, Perseus forced them to tell him where to find the country where the Gorgons dwelt. After many hardships, he found this country on the western shore of Africa and knew it immediately, for all around stood the images of men and beasts whose flesh and blood the Medusa's eyes had hardened into stone:

"Beasts to the rocks were fix'd and all around

Were tribes of stone and marble nations found."

—Lucan's Pharsalia.

There, amid the rocks, lay the Medusa asleep, with half of the snakes awake and squirming restlessly. With his eyes on the reflection in the shield, the son of Danae swooped quickly downward, cut off the monster's head and grasped its clammy, lifeless locks in his hand.

Winging his way over northern Africa, Perseus came to the mountain on which the Titan Atlas sat, hunched up on a peak with his shoulders sagging under the weight of the heavens. Somewhat weary after his long flight, the youth landed in the Garden of the Hesperides, which lay at the foot of the mountain, and watched the maidens, daughters of Hesperus, the silver Evening Star, as they danced around a shining tree of golden apples. But he dared not touch or even go near the apples, for around the trunk was coiled old Laden, a monstrous dragon whose watchful eyes were never closed. He then climbed up to the top of the mountain to talk to Atlas, but Atlas did not receive him hospitably for an oracle had declared that the day would come when a son of Jupiter would take his golden fruit, and he had therefore forbidden strangers to come into his land. Perseus begged for just one night of rest, but Atlas roared in anger and would not even listen to him. "Have a rest yourself, then!" shouted our hero, and held up the Gorgon's head. The great giant gave one startled look, which was plenty, for the features of his face grew stiff as weather-beaten ledges, his bones congealed like a mass of Tock, and his beard stuck out like a forest of naked trees! Perseus hurriedly swung the head behind him and, a trifle panic-stricken perhaps, flew away over the African desert with the blood falling drip, drip, drip on the hot, gray sands.

"The gory drops distilled, as swift he flew,

And from each drop envenomed serpents grew."

Thus from this monster Nature produced the first snakes, which bred and multiplied on the desert until the region was infested with the miserable creatures.

The great dark splash which the sea had caught when first he rose in the air after beheading the Gorgon, had

formed the silvery winged Pegasus, the world's first horse. This splendid animal, however, did not stay with Perseus, but spread its beautiful feathered wings in the air and flew directly to Greece, where it was presented to the Muses on Mount Helicon and afterwards given a constellation.

Flying over mountains and deserts and the narrow green valley of the Nile, Perseus came to the shore of Palestine, the home of the Ethiopians, which he found inundated with floods and strewn with the wreckage of towns and villages. Traveling slowly above the sea-coast of this unfortunate country, he spied something white at the water's edge, and coming closer saw that it was a maiden chained by her wrists and ankles to a rock, while not far distant and ever approaching closer, was the most terrifying monster that he had ever seen. On the star maps this creature is labeled a "whale." It may have been a whale, and it may not, who knows? Sixty or seventy feet of whale lashing a tail big enough to destroy a large boat would certainly seem a terrible sea-monster to people who had never seen a whale. How could they know that its fifteen or sixteen feet of gaping mouth had never tasted anything but tiny crustaceans and acalephæ strained from sea-water! Hero indeed was Perseus, for he skimmed swiftly down to a nearby wave, and poising upon its frothy peak, thrust the monster deep below the jaw. A brave, brave deed was this, and the people shouted their vast amazement and delight. As the great sea-creature leaped and lunged and fell, Perseus again snatched the blood-freezing head of the Medusa from his wallet—and the cliffs trembled as the monster hit the bottom of the sea!



THE STORY OF ANDROMEDA IMMORTALIZED IN STARS.

"She still in heaven her captive form retains,

And on her wrists still hang the galling chains."

—Aratus.

According to some of the poets, Jupiter was so inordinately proud of the youth's achievements, that he caused all the principal characters in his adventures to be immortalized in stars, the sea-monster sharing the honor in a dim constellation far to the south. He, as well as the horse, has been given a name and even grave astronomers call him "Cetus."

For a thousand years the famous rock was shown at Joppa and the slaying of the Medusa and the rescue of Andromeda were favorite subjects in ancient art. Artists thrilled to their theme as they made it glow in colors on their canvases, and poets made the story live again and again. If anyone wonders what became of the awful Medusa's head after Perseus had won Andromeda for his bride, it might be well to add that after reducing two courts of cowardly nobles to statues of stone, Perseus gave the head to the goddess Minerva who placed it on her shield. This goddess is very chaste and with the fearful head has since succeeded in freezing all beholders.

ANDROMEDA, THE PRINCESS

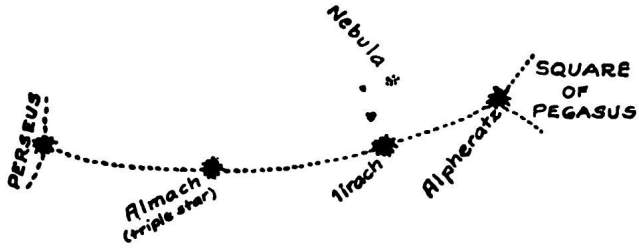


The charming Princess Andromeda wears her chains in

the sky just as she did upon the sea-shore of the earth, only as a constellation she has a line of pretty yellow stars on which to rest, one of the stars lighting her dark hair, one adorning her girdle and one sparkling like a jewel upon her sandal. The head of the Princess lies against the Square of Pegasus, the Winged Horse, and her feet reach out almost to Perseus, who with a ready sword watches her protectingly.

The orange star on Andromeda's sandal is the radiant point of the Biela meteors. These appear every year on the 27th of November. This star is a delight to the eye when viewed through a large telescope, for not only one star is disclosed but three—a sea-green and a blue beside the one of orange-gold!

Just above Mirach, the star on the girdle, are two fainter stars and a small misty object. A large telescope will show that this misty object is a long shuttle-shaped nebula of the most colossal size. This is the famous nebula of Andromeda, the only spiral nebula in the heavens which may be located without a telescope. The nebula of Andromeda is not a gaseous nebula but an outside universe, an aggregation of millions of suns comparable to the Galaxy. (The Galaxy is our Milky Way.)



This in itself is astounding, but it is also astounding that we have been privileged to gaze over a chasm so wide that an aggregation of millions of suns looks no more to our eyes

than a misty spot of light. Dr. Edwin Hubble, of the Mount Wilson observatory in California, has recently made the discovery that the more distant spiral nebulæ may also be resolved into stars. Dr. Hubble made his investigations photographically with the 60-inch and 100-inch telescopes. Although most of the spiral nebulæ appear very small because they are at least a million light years distant, the nebula of Andromeda is comparatively close, its apparent diameter being about six times the diameter of the moon.

This famous nebula may be most easily located when near the zenith during the latter part of October. Watch for it just after the star Alpheratz, on the head of Andromeda, has passed the meridian and started toward the west.



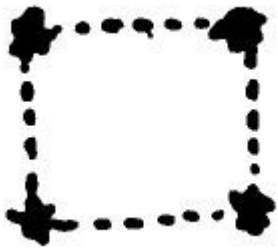
THE GREAT NEBULA OF ANDROMEDA.

Photograph by Yerkes Observatory through the 40-inch refracting telescope.

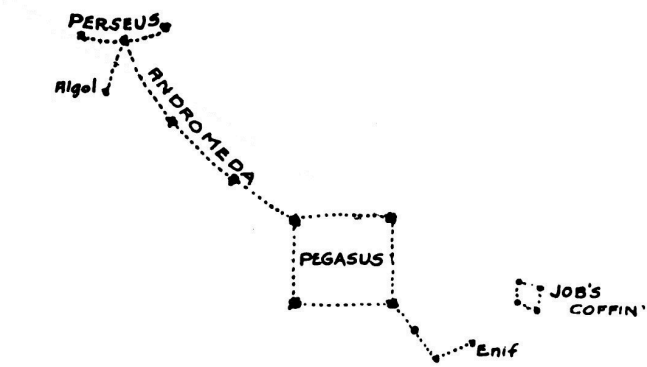
To the unaided eye, it appears as a small mass of faint light and inexperienced observers often mistake it for a comet. Although this mass of light may be considered as being comparatively close compared to other spiral nebula, it is scarcely like sighting a ship at sea, for so far away does the

spiral of Andromeda lie, that a ray of light must travel at least 36,000 years in order to reach the earth—36,000 years with light traveling 186,000 miles a second!

PEGASUS, THE FLYING HORSE



The constellation of Pegasus, the Winged Horse of the Muses, is marked by a great square formed by four bright stars. This "square" lies against the horse's neck and wings, while his head, adorned by the star Enif, hangs downward from one corner and stretches toward the west.



Enif lies about 10 degrees west of a small but conspicuous

diamond-shaped constellation called The Dolphin, or Job's Coffin.

Although Pegasus is close to Perseus in the sky, this winged horse was not with the hero either at the time he met Andromeda or at any other period of his life. Since only half of his body is represented on his star square it is sometimes said that the remainder is hidden behind the rocks to which Andromeda is chained. The reason that artists so often draw Pegasus beside the hero Perseus must be that they take the astronomical picture instead of the mythological version of the story as a basis for their theme, although his unnatural position of being upside down is studiously ignored;—even the ancient poets refrained from comment upon this point.

Mr. Clark, in "Astronomy from a Dipper," aptly remarks that "the square suggests a box-stall in which a horse could be kept rather than a portion of a great flying horse." There is certainly "more truth than poetry" in this idea and just about all of the constellations look most like "what they are not." Not possessing the vivid imagery of the Greeks, most of us must be content with looking at the bright Square which marks the place of the great Winged Horse in the darkness.

It will be recalled that when Perseus swooped down and cut the head off the Gorgon, its life-blood crimsoned the foam on the sea. Neptune, seeing this, spun it into silver with the wind and waves, and formed, in a moment, the wondrous horse.

Born full-grown, gifted with immortal life and blessed with incredible speed, Pegasus lifted his silvery wings and sprang toward the clouds. He then rushed headlong toward Mount Helicon where he flew about the mountain, alighted in its sacred groves, and was petted by the Muses.

According to all accounts the hoofs of this beautiful

creature must have possessed not only miraculous strength but also some of the properties of a divining-rod, for, when thirsty, all that he needs must do was to strike his magic hoof upon the ground and up would spout a fountain or a spring—crystal clear and delightfully cool.

"He it was, men say, that brought down from lofty

Helicon the bright waters of bounteous Hippocrene."

The Fountain of Hippocrene was the result of an almost unbelievable exhibition of strength which occurred, as the story goes, at the time that the nine Muses and the nine daughters of Pierus engaged in a musical contest on Mount Helicon. When the nine daughters of Pierus began to sing, the heavens scowled and grew dark, but when the nine Muses lifted their voices in song, the skies grew gold with sunlight, the rivers stopped spellbound in their courses and Mount Helicon rose skyward in sheer delight. Neptune, observing the mountain, advised Pegasus to stop its ascension by kicking it with his hoof. The winged steed kicked and not only quenched the rising enthusiasm of Helicon, but caused the waters of Hippocrene to burst forth from the very crest of a vast rock. Poets were not long in discovering that a draught of these sparkling waters fired their minds with divine inspiration, and the beauty in their souls grew like flowers into poems which stayed fresh and fair through all succeeding centuries. No wonder modern poets sigh

"for a beaker full of the warm south

Full of the true, the blushful Hippocrene,

With beaded bubbles winking on the brim."

—Longfellow.

Twenty "stadia" below the Fountain lay the Grove of the Muses, situated in a pleasant hollow, while below this Grove, at the foot of Helicon, was the village of Ascra, the residence of Hesiod, and the earliest seat of poetry in Greece. One can imagine that the poets made frequent trips up the two miles or so that brought them to the Fountain of the Horse. In modern times, Hippocrene has been identified with a fine spring at Makariotissa.

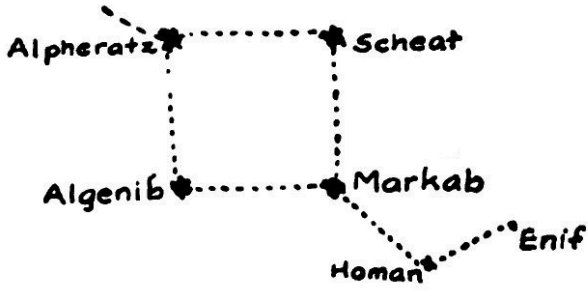
The limpid spring of Pirene on the citadel of Corinth was also opened by a blow from the winged horse's foot. The water from Pirene was in later days conveyed down the hill by subterranean conduits into a marble basin made especially to hold it Pegasus was not given credit for having opened these springs, however, until the days of the Alexandrian poets. In lovely fancies, these "Spring-inspired" poets not only extolled the wondrous strength in the hoof of Pegasus as he cleft a chasm in the earth, but they also sang of so light a foot that he no more than shook the sweetness from the flowers.

For a long time Pegasus flew about Mount Helicon, adored by the Muses and admired by the gods, but finally one day, while drinking at a spring, he was captured by a Grecian youth named Bellerophon. After making him fast with a golden bridle loaned to him by Minerva, Bellerophon mounted the broad back, slipped his feet between the wings and soared to the sky. As might have been expected, Bellerophon henceforth spent a good part of his time along the dizzying heights above and around the clouds and one day accomplished the praiseworthy deed of swooping down and slaying a triple-headed monster which had been terrorizing all the surrounding land.

After this famous ride, Bellerophon seized what he

considered a good opportunity and tried to ascend to the top of the broad summit of Mount Olympus which towered almost twice as high as the summit of Mount Helicon. But Mount Olympus was the abode of the gods and this presumptuous act so angered Jupiter that he sent an insect to torment the steed which reared backward and threw its rider to the earth. Being now quite accustomed to a rider, Pegasus was presented to Aurora, Goddess of the Dawn, whose duty it was to lift the curtain of night with her rosy tinted fingers and open the eastern gates for Apollo, the Sun-god. In art Aurora is often pictured as a spirited maiden in dazzling robes riding swiftly on the winged Pegasus, although she is also represented as rising out of the ocean in the east in a car drawn by four white horses. Perhaps she decided to employ the latter exclusively to usher in the dawn, for Pegasus was later transposed to the stars and never again permitted to stray earthward. His great dark sky square with a star on each corner is exceedingly easy to find especially during September when it is on the sky slope in the east, although if there is any difficulty in locating it, let the eye travel from Cassiopeia to the Segment of Perseus—which resembles a rod bent in the middle and swayed by the weight of this big chained Square.

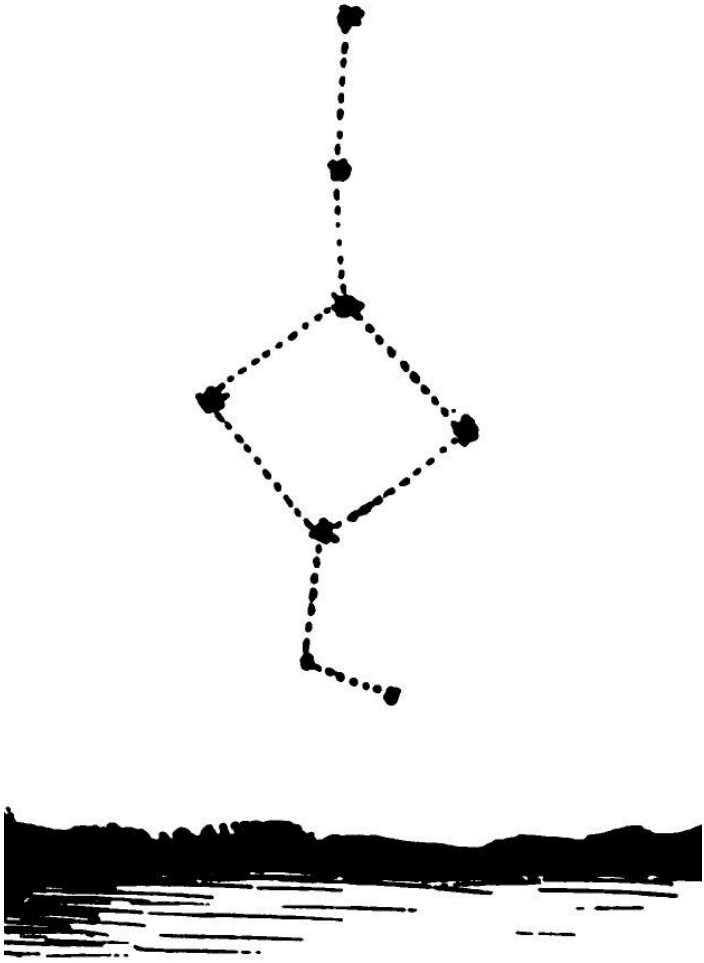
The Square rises and sets in a tilted fashion with its corner star, Scheat, on the horse's knee, almost above Algenib, which lies on his wing.



"as if by art at equal distance placed."

This causes the Square to resemble a distorted diamond-shaped figure when seen in the east or west but when the figure travels along the south about nine o'clock during the latter part of October or the first of November, its sides are horizontal and vertical.

The Winged Horse first makes his appearance in the northeast near midnight in the middle of June but is better seen in the east between nine and ten o'clock a little later in the summer. Any time during the Autumn he may be seen flying inverted across the dome of the heavens and by November is high in the west. Evening after evening his silvery wings fly lower and lower; the star Enif flutters as it nears the thickened atmosphere about the horizon and Andromeda probably trembles as he draws her near Cetus, head downward through the western sky.



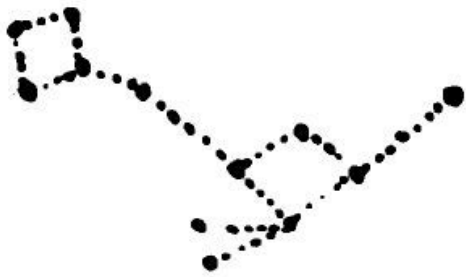
The Winged Horse flies head downward in the west.

"The head of Andromeda is setting and against her is brought by the Misty South the mighty terror, Cetus, but over in the North Cepheus with his mighty hand upraised warns him back."

—Aratus.

By the first of the year the starry "Square" of the beautiful Pegasus has entirely disappeared. Andromeda and Perseus soon follow but Cassiopeia continues around the horizon in the north. Throughout the spring and early summer Pegasus remains in regions below our sight but in September he again appears and flies inverted up the heavens in the east.

CETUS, THE SEA-MONSTER



Early poets describe Cetus as a monster armored with heavy scales or as being long-necked and clawed, which brings to mind the sea-reptiles which are known to have inhabited the sea during the Mesozoic Age. Although poets are known for their tendency to exaggerate, this in itself is enough to lend a spicy interest to the legend, for one's thoughts fly back to the world's young days when reptiles of great size literally overran the earth and cluttered up the sea. Many of these forms have been reconstructed from fossils found embedded in the rock strata. These are most amazing, grotesque and even terrifying and may be seen in

any of the great museums. If a museum is not handy one may shiver with real thrills by going through the pages of a well illustrated text on geology.

Some such creature as one of these was Cetus,—according to the poets. Some authors think that the whole story of Andromeda is an allegory; others, that it may have been based, though somewhat lightly, upon a historical fact. Ancient authorities (Pliny, Josephus and others), claim that the bones of Cetus were brought from Joppa to Rome and there exhibited by M. Scarus, and it is also claimed that the people along the sea-coast at this time were driven forth in hysterical fear, for when the monster appeared it not only swallowed up the cattle as they came to browse at the river's mouth but also snatched the children as they splashed about at play. Mythology tells us that Hercules, as well as Perseus, once killed such a sea-monster as this and it is then related that he tried to narrow the width of the strait leading into the Mediterranean by pushing the rocks on either shore closer together so as to prevent further invasions of Neptune's fierce and terrible creatures.

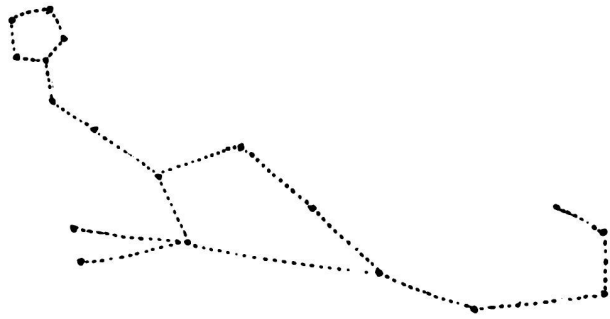
The pictures of Cetus differ in the old star-maps although he is almost always represented as being strange and ferocious. After having drawn the animal, however, with scales and claws, a mad, mad tail and sometimes even rows of teeth, the mapmaker becomes conservative and calls it "Cetus, the Whale."

As a constellation, Cetus first begins to appear in September but does not get fully above the horizon for almost four months. By January he is completely visible, his huge, faint form covering over 40 degrees of sky. His head is rather pentagonal as impressed among the stars and extends on a long neck above the celestial equator; his tail is even longer than his neck and curls upward as if he were angry—which he assuredly was when petrified by Perseus

into stone. His sides are clear and black with unadorned sky-space and seem quite devoid of even the fainter stars.

Always look for Cetus in the southeast, south or southwest, in front of and below Orion and far below Andromeda. The point of the V-shaped Hyades also directs the eye toward his pentagonal head which extends toward the east.

Just about in the center of the long, giraffe-like neck of Cetus, the villain in our play, lies Myra, a most extraordinary star.

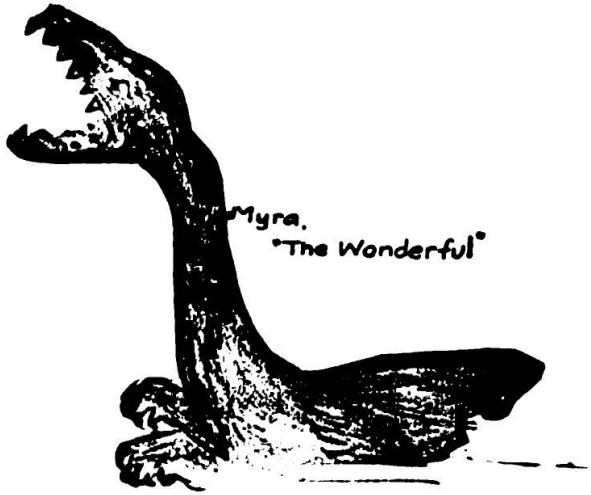


Cetus, the Whale.

This star is called "Myra, the Wonderful" because of its amazing behavior in a period of only eleven months. For three months Myra is visible to the unaided eye; during the other eight it can only be seen in a good telescope. Put in another way—for five months at a time it is completely invisible to the unaided eye; then from a mere speck it slowly brightens until in the course of three months more it has become a star of the 2nd magnitude, although it remains a star of the 2nd magnitude for only a few weeks. This change from a telescopic star of the 9th or 10th magnitude to one of the 2nd magnitude means that Myra must blaze up from 1000 times to 1500 times its ordinary

brilliancy! Such a statement may overwhelm the casual reader but we must remember (in order not to become unduly excited) that this star is so far away that such a conflagration would only mean the gradual appearance of a star where none had been visible before, and then its gradual disappearance.

Myra is indeed so far away that we are just 23 years behind time in seeing each explosion, for it takes 23 years for its light to travel to our eyes. If the roar of the conflagration could be heard here, however, the sound would not reach the earth for many millions of years, for sound travels much more slowly than light.



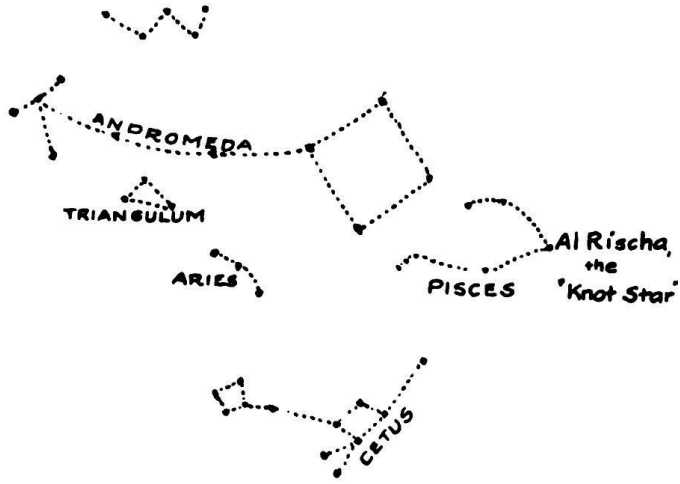
Myra, the wonderful variable star, on the neck of Cetus, the Sea-monster.

Because of the variation of its light, which is very excessive in the case of Myra, this star is called a variable star. Our sun is also a variable star, but it is variable only in a very slight degree as compared with the exuberant

combustibility of Myra. But the theory of spots which are believed to be responsible for the almost imperceptible variation in the light intensity of our sun does not altogether explain the phenomenon of Myra's variability and its mystery is still as great as ever.

Thus is ended the story of Perseus and Andromeda and many of the interesting bits of information connected with the constellations of the various characters after they were transferred to the sky.

Three small constellations lie between Andromeda, Cetus and the Square of Pegasus, and a word about them here will help to impress this part of the sky upon the mind without the trouble of carrying maps every time one feels inclined to gaze at the stars. These constellations are Pisces, the Fish; Triangulum, the Triangle and Aries, the Ram.



Pisces represents two small fish tied by their tails by two long 'star lines' which meet at a common star sometimes

called Al Rischa or the "Knot Star."

"Their tails point to an angle

Filled by a goodly star."

—*Aratus.*

Although the constellation occupies a large space in the heavens it has no conspicuous stars in it. It is best seen when the parallelogram of Orion is in the sky and may be located above and to the west of Cetus. Look for it on the first of January about 8 P. M. although it is also viewed to good advantage when passing the meridian during the evenings of October and November. Pisces lies in a region which in early times was known as "the Sea" because several other sea-creatures such as the Dolphin, which lies west of the Square, the Sea-goat and the Whale are found here.

Some authorities claim that when the fire-breathing giant Typhon appeared in Thessaly, the horrible creature so frightened the inhabitants of Olympus that they fled to the Nile where they concealed themselves under assumed shapes. Here the great god Jupiter

"was changed into a Ram

From whence the horns of Libyan Ammon came."

and the fun loving Pan into a sea-goat, now the constellation Capricornus, while the goddess Venus and her son Cupid threw themselves into the river and were changed into two fishes, which are now represented by Pisces, in the sky. The fate of Typhon has already been mentioned, and even modern Sicilians have seen Etna burst its crown to let out his fiery breath.

Just below Andromeda and above the head of Cetus is a long slim triangle-shaped figure called Triangulum, the Triangle, and a crooked line formed by a large star and two smaller ones called Aries, the Ram.

In legend, Aries was a great ram with a golden fleece and possessed the ability to fly. Mercury brought this beautiful creature to Helle and Prixus, the persecuted children of the King of Thessaly, so that they might climb upon its back and escape across the sea from their cruel stepmother. On the way over, Helle lost her hold on the fleece, sank under the waves and was drowned. Commemorating this tragedy, the sea was ever after called the Sea of Helle or the Hellespont but in modern days, the Dardanelles. The Dardanelles is a narrow channel separating Europe from Asia, and is the "Hellespont" that Leander so faithfully swam when visiting Hero, his sweetheart. Prixus, coming safely to the end of his journey, dedicated the ram to Jupiter who placed it among the stars. It is now a zodiacal constellation with the horns of the ram for its sign: ♈ . The golden fleece, while on earth, was of course very desirable so that it was fastened to an oak tree in the sacred grove of the War-god Mars at the eastern end of the Black Sea and a sleepless dragon was wound around the tree-trunk to protect it. It was to obtain this fleece that, in 936 B. C., Jason built a fifty-oared galley—the first of ships—and invited the heroes of Greece to go with him on the expedition. This adventurous undertaking was afterward known as the Argonautic Expedition. The ship Argo was placed in the sky as a southern constellation, or at least a part of it was for the bow is said to have been lost when passing through the Bosporus.

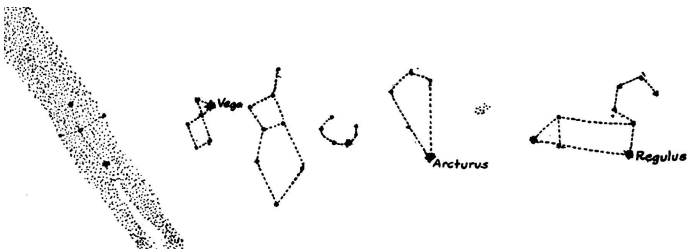
"Argo, exalted for that daring feat

To fix in heaven her shape with stars."

—Wordsworth.

But even the portion that was lifted to the sky is so large that astronomers, for convenience, have divided it into three parts,—Carina, the Keel; Puppis, the Stern; and Vela, the Sail. The beautiful star Canopus lies on the Keel.

Triangulum and Aries, traveling beneath Andromeda, rise in late September and October and pass the meridian in the early evenings during the first weeks of December.



THE PARADE OF THE ZENITH CONSTELLATIONS.

During the spring and summer months these clearly marked constellations parade slowly across the dome of the heavens. Leo, the Lion, may be easily located beneath the Big Dipper.

CHAPTER VI

THE PARADE OF THE ZENITH CONSTELLATIONS

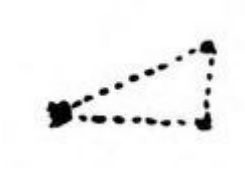
LEO, THE LION



ABOUT 9 o'clock on the 8th of April, a large, bright sickle passes near the zenith. This sickle lies just south of the Big Dipper and is a clearly defined figure among the other designs which decorate the sky during the early spring.

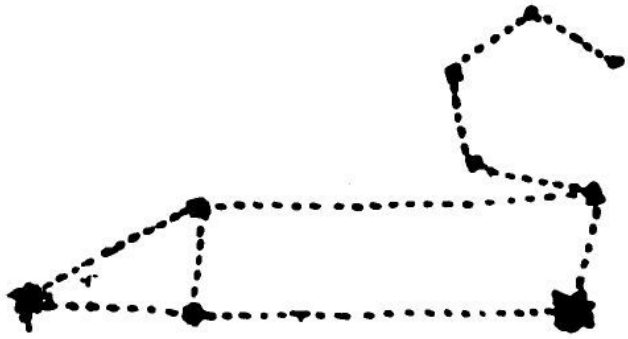


Truly, this is a strange symbol to see emblazoned in the heavens; has it too a story? Indeed, yes; this cluster of stars is the Sickle of Leo and lies on the head of the fierce Nemean lion which came from the moon and which was later killed by Hercules and transferred to the starry sky. The lion's head rests in the curve of the figure; his shaggy neck on the short straight line and his heart beneath the bright star on the end.



Not far away lies the rest of this brave creature with another bright star on the tuft of his tail. Drawn together, the sickle and the triangle now suggest a very dignified lion, although in the old star atlases he is pictured as a very ferocious lion transfixed in a moment of action.

Note well this curious sickle-shaped figure beneath the bowl of the Big Dipper. We will take this figure just at present, as a leader, while calling attention to the oddly assorted but interestingly assembled groups of stars which follow Leo in a widely curved path near the dome of the heavens, from the far northeast to the far northwest.



These groups appear one by one like a line of floats pulled up over the horizon; then drawn in a glittering procession toward the west. Each evening they appear farther along in their journey westward,—a pageant far distant in the darkness yet visible by the gleaming of its lights.

Closely following Leo, the Leader, is a representation in faint golden starlight of Queen Berenice's Hair; next the lovely orange-yellow star, Arcturus, on the dim kite-shaped figure of Boötes, the Herdsman; then a crown of star gems which belonged to Ariadne, daughter of an ancient king of Crete; a huge giant called Hercules; the golden Lyre with which Apollo raised the walls of Troy and Orpheus charmed the souls in Hades; and last, but not least, a large and beautiful Cross.

The Lion disappears behind the western "bulge of the world" during the early summer, although the last of the procession, the great Cross borne on the back of Cygnus, the Swan, does not even reach the meridian—the line midway between east and west—until September. Some of these groups are also seen later than October, but at that time their splendor is dimmed by the gorgeous winter constellations in the southeast.

According to the classic legend of the Greeks, Leo was

the celebrated Nemean Lion which Hercules killed as the first of the Twelve Labors which were imposed upon him by his cousin Eurystheus, who was king of the Perseidæ only through priority of birth. This lion was the largest and fiercest lion in the world with a skin so invulnerable that no arrow had ever succeeded in even denting it. The huge beast was also so rapacious that it was fast annihilating all the inhabitants of Nemea, which was the ancient name of the deep valley of Argolis. Hercules had no trouble in tracking the lion through the valley, which was only two or three miles long and half a mile broad, and easily found its den. Rushing in, he barricaded the opening, grasped the lion by the throat and after a terrific struggle, crushed the beast in his arms. Ever after he wore the tough, impenetrable skin as a covering for his own defense. The Nemean games, one of the national festivals of the Greeks, are believed to have been founded by Hercules after his victory over the Nemean lion. There is some evidence that there was a lion traced among the stars before the time of Hercules, but, if so, the Greeks erased the impression and substituted their own lion in its stead.

Leo, the Nemean lion in stars, is seen at his best during the early evenings of March, April, May and June, although he makes his first appearance on the 4th of March when, just as the sun sets in the west, his tail rises above the eastern horizon. In April he is at his highest point in his path across the sky, lying just to the south and below the bowl of the Big Dipper.



On the end of the handle of the Sickle shines Regulus, also called Cor Leonis which means "The Heart of the Lion." Regulus sends out 300 times as much light as our sun, but is so far away that it takes 99 years for its light to reach us. This star rises in the northeast at twilight on the 15th of February and crosses the meridian at 8 o'clock on April 23rd.

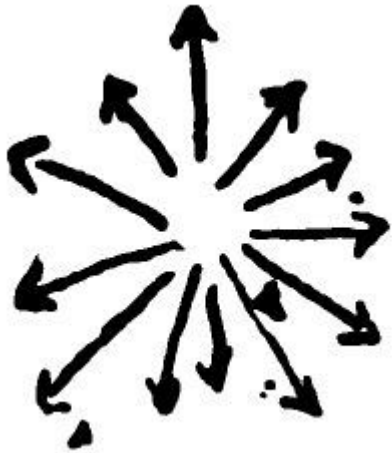
One generally thinks of stars as being bright and gay, but Regulus has a companion which is somber and so unusual in its appearance as compared with other stars that it was described by Winlock, its discoverer, as if "steeped

in indigo." Later it was found that this oddly colored star also has a companion which makes Regulus a triple star.

The second star above Regulus is also interesting. This star is a beautiful double described in such refreshing terms as "golden-orange" and "bronze-green." It may be seen in a medium sized telescope. Later we will become acquainted with a wonderful red star which also has a green companion. Such combinations are most amazing to gaze upon.

The second brightest star adorning Leo is Denebola, which flashes on the end of his tail. Denebola is 10 times as bright as our sun and is 25 light years away. Since Regulus, on the heart of the Lion, is 99 light years distant and Denebola, on the tail of the Lion, is only 25 light years, science has certainly played havoc with the poor Nemean lion. Proctor tells us that Coma Berenices (Berenice's Hair) was originally the tuft of the tail of the lion when the constellation was pictured in the maps as being more extended. This was quite an appropriate place for the sparkles and gleams of these fine, tiny stars. It is likely that it would have still been the tuft on the Lion's tail if a clever Alexandrian astronomer had not found it necessary to use his wits quickly and call it Berenice's Hair to please the vanity of an Egyptian Queen.

The apparent center for the November meteors, or "shooting stars," which appear about the 15th of the month, are within the curve of the Sickle of Leo near the star Gamma.



The apparent paths of shooting stars when projected backward meet at a point called the radiant point. It looks from the diagram as if these meteors all came from one fixed place in the sky but the effect would also be the same if we saw, for instance, seventeen trains racing along seventeen tracks laid parallel across a desert from a point on the distant horizon. They would all seem to start from this point and widen out as they approached the observer, the effect in perspective, the widening apart from a point, being the same in the case of the meteors speeding along parallel lines in space. We see only those meteors, of course, which become caught and ignited in the atmosphere surrounding the earth and which streak down the sky all aflame; the rest pass on their way, invisible. Of this more will be said later under the heading of "Comets and Meteors."

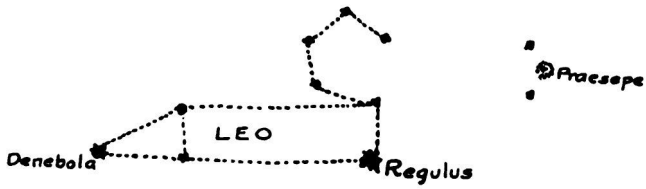
The "Leonids," as these November meteors are called, are only seen in the early morning hours on the 15th of November, while the "Andromids," which have their radiant point in Andromeda, are only seen in the early part of the evening on the 24th of November.

The famous Leonid meteors of 1833 dropped down so fast and thick that it seemed that all the stars in the heavens were falling down on the earth. This unique spectacle occurred again in 1866, and records show that, for a thousand years back, at intervals of every 33 years, we have been visited by such a "star shower." The first disappointment came in 1899, just as the general public, probably for the first time, was looking forward to it with a great deal of pleasurable anticipation. Will we again be disappointed in 1932? Although the earth passes across the pathway of these meteors every year, it is believed that along a certain section of the pathway the meteors are strung in thick profusion. It is through such a portion, literally studded with the fragments, that the earth rolls every 33 years, although it is not known for a certainty why, after all these years, we failed to see a display in 1899.

A small "dark" constellation called Cancer, the Crab, lies just in front of Leo, the Lion. Although this constellation has been pointed out since very ancient times, and holds an important position in the zodiac, it does not contain a single conspicuous star and could scarcely be located in the sky, were it not for a faintly shining spot of light about the size of the Pleiades. This spot of light is a coarse cluster of 7th and 8th magnitude stars, resolvable by an opera-glass and easily located by a little star on either side. In the mythology of Greece, this constellation represents the gigantic sea-crab which Juno sent to bite the toes of Hercules when he was struggling in the marshes with the hundred-headed hydra. Naturally, Hercules stamped his foot down on the petty annoyance, which so offended Juno that she set the creature among the stars.

It is the "misty spot," however, that has always attracted the eyes of men. The Chaldeans thought that the dim light came from a hole in the floor of heaven, and that it could

be no other than the "gate of men" through which souls descended into human bodies. It has also been regarded as the Manger in which Christ was born and the stars on either side were called Aselli, or Little Asses.



The "Manger" is now known to hold 363 telescopic stars, and is historically interesting because it afforded one of the earliest telescopic proofs that there were hosts of stars in the heavens besides those visible to the unaided eye. Galileo, who first resolved its light into stars, was able to count forty small stars in this spot, and his telescope was no better than the field-glass of today, if we may indeed make such a comparison.

In ancient times, Præsepe, the Manger, was an infallible weather sign, for if there was the slightest moisture in the air, its faint light was invisible. If the moisture was not sufficient to also obscure the two stars on either side, only light showers of rain might be expected, but if the two stars were also hidden, there would be a very bad storm. If the two stars and the Manger were all three seen clearly, one could depend on the weather not to spoil any plans for that particular evening.

"When shine the Bears, and 'twixt the asses seen,

though faint, their Manger, ocean proves serene."

—*Idylliums of Theocritus* (FAWKE'S

Trans.)

In the days of Aratus, 270 B. C., this advice as to how to judge the weather by means of the tiny cloud on the back of Cancer, the Crab, was taken so seriously that he gave it in quite extensive detail in his poem *Phenomena*:

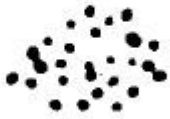
> "Watch, too, the Manger. Like a faint mist in the far North it plays the guide between Cancer. Around it are borne two faintly gleaming stars, not very far apart, nor very near but distant to the view a cubit's length, one on the North, while the other looks toward the South. They are called the Asses and between them is the Manger. On a sudden when all the sky is clear, the Manger wholly disappears, while all the stars that go on either side seem drawn to one another: not slight then is the storm, with which the fields are deluged. If the Manger darken and both stars remain unaltered, they herald rain. But if the Ass to the North of the Manger shine feebly through a faint mist, while the Southern Ass is gleaming bright, expect a wind from the South: but if in turn the Southern Ass is cloudy and the Northern bright, watch for the North Wind."
>
> —*English trans.*, by G. R. MAIR.

In English folklore, Præsepe is called the Beehive, although this name was likely given it after telescopes were invented and it was seen that the dim light was resolved into a multitude of little flecks, like a hive of golden bees.

Præsepe passes the meridian about 9 P. M. on March 15th or 2 o'clock A. M. on the morning of January 1st. It is best seen on a clear night when the moon is absent from the sky, and a glass of any kind will make it more interesting.

Both the Crab and the Hydra, who also has a constellation in the sky, are quaint ways of commemorating the adventures of Hercules, but his fierce Nemean lion is the most important just at this instant, so on with the line of floats!

BERENICE'S HAIR

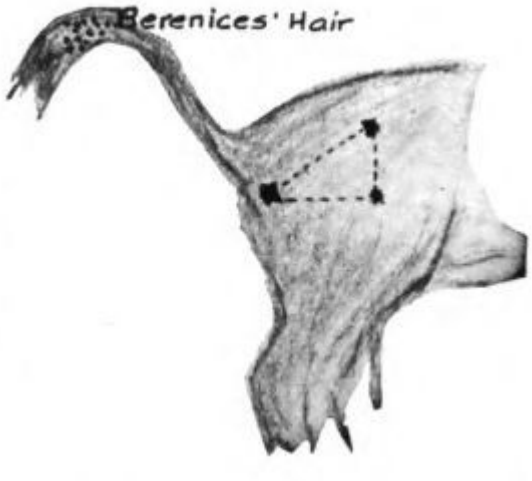


The name of Coma Berenices,—Berenice's Hair,—was derived from an Egyptian fable which dates back as far as the 3rd century B. C. Before this time, the constellation was the tuft on the tail of Leo, the Lion. Thus we find Præsepe, an interesting cluster of stars, just in front of Leo, and Coma Berenices, an equally interesting cluster, just behind him. These two clusters are among the very few clusters that may be located with the unaided eye.

Coma Berenices is most clearly visible on a dark night almost overhead in the early evenings of May. With an effect like 90 minute stars scattered on velvet, these stars are quite unlike anything else in the heavens that is visible without optical aid.

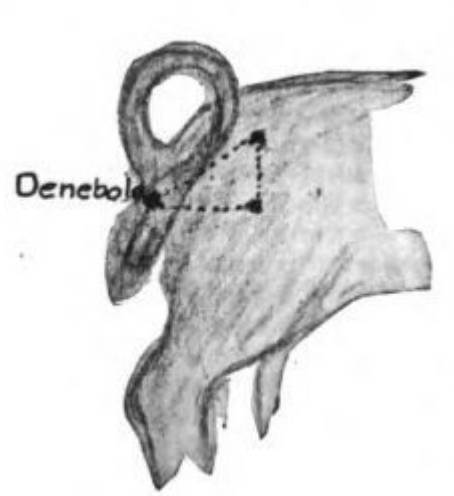
Astronomers have found that many of the stars in this constellation are of a delicate lilac color. These lilac stars are often the companions of other stars, forming such lovely color combinations as orange and lilac, white and lilac and blue and lilac, although these double stars are not easy to locate in this thick sprinkling of stars without the help of a telescope with an equatorial mounting and graduated circles. One wonders what it would be like to have a lilac sun as a source of light, and what would be the psychological reaction on generations of beings brought up under pale lights, mauve mists and shadowy purples. There seems to be a slight difference in even the general characteristics of our earthly folks when those who live in a land of perpetual sunshine are compared with those who live in a city smothered in murky fogs.

The telescope has also discovered in Coma Berenices the rare sight of over 100 nebulæ drawn together in a close group. We say a "close group," but these nebulæ only look crowded to us because they lie at such an unthinkable distance from our solar system.



An ancient story, current 246 B. C., relates that this constellation was named after the beautiful hair of Berenice, Queen of Euergetes, one of the Ptolemies of Egypt. The husband of this Queen had gone to Assyria on a dangerous campaign and, grieving over his delay in returning, the Queen vowed to cut off her long locks of hair and consecrate it to the gods in the temple of Venus, if he might only come back to Egypt safe and victorious.

Not long after this great sacrifice had been determined upon, Euergetes returned and the Queen cut off her tresses and hung them in the temple of the goddess. But that same night the hair was stolen! Conon, the royal astronomer of Alexandria, however, in his goodness of heart and thinking to protect the guardians of the temple from their majesties' displeasure, stepped forward and declared that Venus had so appreciated such love as possessed by this faithful Queen that she had caught up the strands of beautiful hair and laid them in the heavens.



All looked toward the spot at which the astronomer pointed, and, sure enough, there lay near Leo a group of

fine stars which shone like the mist on a woman's hair! Thus the guardians were saved, the husband appeased and the astounded Queen Berenice flattered and satisfied.

The Lion, Leo, however, was now obliged to change the position of his tail and instead of having it extended and brightened with this sprinkling of delicate stars, he was forced to draw it back and curl it behind the light of Denebola, where it has since remained.

BOÖTES, THE HERDSMAN



The brilliant golden-yellow star, Arcturus, has always been a favorite among star-gazers.



This star hangs like a great globe of tinted light from the end of a curve drawn from the Big Dipper's handle and is one of the first stars to appear during the summer evenings.

Two earthly honors have been given Arcturus which are well worth noting. In the excess of their great admiration, the Egyptian people in ancient times oriented huge temples to it at the cost of tremendous labor; it was also given special mention in the Bible.

Up near the Arctic circle, this lovely star never sets, but travels in a wide circular path above the horizon. Allen remarks on its use as timepiece for the seal-netters during the night fishing in December and January. The netters judge the time by the position of the star on the four points of the compass, in much the same manner that the Big Dipper is used for a clock as it swings around the pole. The heavens would appear rather strange to us as viewed from

the far north for Polaris would rest almost at the zenith and the Big Dipper with its handle weighted down by Arcturus, would seem to encircle the sky above the earth on an unfamiliar pathway.

Boötes, the constellation in which Arcturus lies, is usually described as forming a kite-shaped figure of stars, which though faint, covers a great deal of sky. Boötes, as mentioned before, was a herdsman who invented the plow, and as a reward for this ingenious method of tilling the soil, was raised to a position below the stars of the Big Dipper. But according to another story, Boötes represents Arcas, the son of Callisto, whom Juno so cruelly turned into a bear. In modern days this legend seems to have been given preference for, during the seventeenth century, Helvetius invented the Hunting Dogs, the constellation of Canes Venatici, and the huge figure of Boötes has since been usually pictured on the star maps as holding two lively dogs in leash. These Dogs are interposed between Boötes and Ursa Major. Although the Hunting Dogs have no mythology, the two constellations are thus united in a common picture and Boötes and his dogs are said to be chasing the Bear.

> "Boötes leading his hunting dogs over
> the zenith in the leash of sidereal fire."
>
> —*CARLYLE.*

In Ovid's version of the legend, the hunter was placed in the sky just as he was and not first metamorphosed into a bear and hung on the Pole Star as Ursa Minor. Not recognizing his mother in the form of Ursa Major, Boötes keeps on pursuing her in an eternal chase about the Pole. He is thus often called "The Watcher of the Bear" or "The Bear Driver." Those who choose to consider Callisto's son, Areas, as having been metamorphosed into a bear and hung on the pole of the heavens may then consider Boötes

as representing the herdsman who invented the plow.

The two Hunting Dogs, "Asterion" and "Chara," now held enchained by Boötes, form the constellation Canes Venatici, which lies just below the handle of the Big Dipper and above Arcturus and Berenice's Hair. The collar of the hunting dog Chara is marked by the star Cor Carolli, which means "Charles' Heart" and was named in memory of Charles I by Halley, the English astronomer, on the suggestion of the Court Physician, Sir Charles Scarborough.



This star is an attractive double as viewed in a small telescope with the delicate colorings of "flushed white and lilac." On the head of Asterion lies the famous whirlpool nebula, although this may only be seen in a large telescope.

This nebula has its great arms of nebulous material flung widely into space and looks as if it were whirling rapidly about, but the motion, if any, is too slow for us really to see. With a few exceptions most of the spiral nebulæ are so very distant that they may only be seen through a very large telescope, but next to the stars, they are the most abundant objects in all the sky and are of great interest to astronomers.

Arcturus, the beautiful first magnitude star which glows so conspicuously in the constellation of Boötes, is, however, the main source of interest in these star groups. The star is popular for its appearance alone, for it is large and richly golden, and always easily located, but it is also of interest in a scientific way, for it has been found to be an extremely huge and glorious sun. Our sun placed at the same distance—145 millions of millions of miles—would shine as a faint and almost invisible star, yet Arcturus is so much larger than our sun that it drifts across our sky like a bowl of light.

Arcturus is not only one of the largest but it is also one of the swiftest moving stars in the heavens. It moves so swiftly that it covers 100 miles in every second. This speed has caused it to be labeled a "runaway star." Although this star shoots through space at such an incredible rate of speed it has taken it *800 years* to describe a space (as seen by our eyes) equal to the apparent diameter of the moon. This may give the reader some slight realization of the vast distance which separates us from Arcturus. But astronomers write it this way—"It has taken *only 800 years* for Arcturus to describe a space equal to the apparent diameter of the moon," for the stars are so very distant that most of them do not seem to change their places in the heavens even in the course of many thousands of years.

Amazing as the speed of Arcturus appeared to astronomers, they later discovered a star of the 8th

magnitude in the southern hemisphere with even a greater proper motion. This star has moved the distance of the diameter of the moon in *220 years*, which means that it moves over a hundred times faster than the average star. But the late Professor Barnard of the Yerkes Observatory had the distinction of discovering a star with the largest proper motion known. The average star does not exceed one minute of arc in a thousand years but Professor Barnard's "runaway star" has the amazing proper motion of 10.3 seconds a year. In that length of time it travels twice as far as the average star does in a century!

Scientists accomplish many wonderful, and most remarkable, deeds. Even the heroes who lived in the vivid minds of the ancient peoples dwindle into insignificance beside these men with their calm patience and brilliant seeking minds.

"These mathematic men have thoughts that march

From sphere to sphere and measure out the blue

Of infinite space like roods of garden ground."

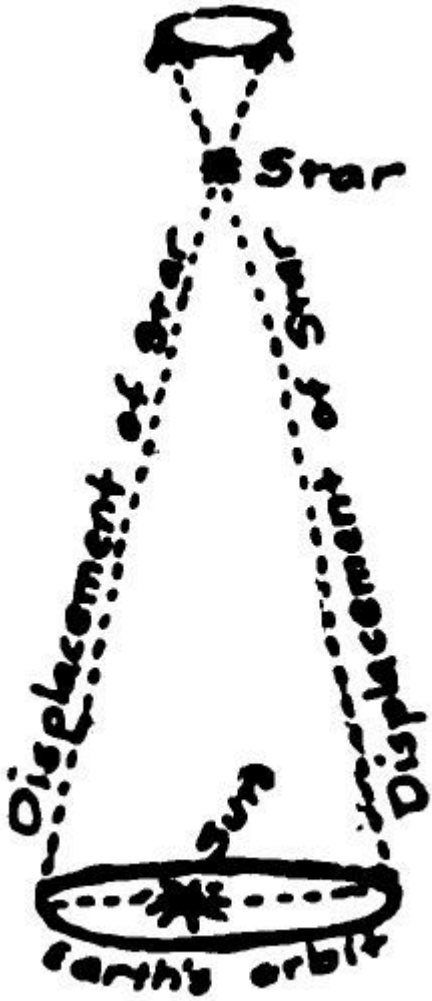
—Blackie.

Professor Michelson has now invented a new method of measuring the angular diameter of the more distant stars. This is by means of an instrument called the "interferometer" which is attached to the 100-inch reflector of the Mount Wilson Observatory. Measurements of the angular diameter of Arcturus with the interferometer combined with the knowledge of its distance give us the astounding size of 19,000,000 miles for the diameter of this huge sun.

Henderson, in 1840, was the first astronomer to make a

successful measurement of the distance to a star. The trigonometric method such as surveyors use to find the distance to the far side of a river was employed for this and with a baseline and angles he reached out and touched the nearest stars.

The baseline of a triangle whose apex touched a star which lay millions of millions of miles away would have to be very long indeed—and a very delicate and difficult task to handle it. Where in the world could one find such a baseline? Certainly not on the earth! A line extending from one side to the other of our earth would not even be as large as a point of light as seen from a star. Indeed when the moon was measured, and the moon lies only 240,000 miles away, astronomers used a baseline which extended from America all the way to France. The exceedingly clever idea of taking the earth's orbit as a baseline then suggested itself, and focussing upon a star at an interval of six months when the earth is at the two ends of the diameter of its immense orbit around the sun.



The angle between the baseline and the line of sight to the star may be noted in the summertime, for instance, and then again in the winter. The shift of the star on the heavens caused by the observer changing his place from one side of the sun to the other gives the parallax angle of

the star, which is the angle between the two sight lines of the observer where they meet at the star. If the star is distant more than 500 billion miles this shift cannot be measured with any confidence for at 900 or 1000 billion miles, the star ceases to show any displacement. When a star is near enough to be measured by this trigonometric method it seems to describe a minute ellipse "like a reflection of the ellipse of the earth's orbit." If it lies so far in space that it does not seem to change its position even when viewed from stations on either side of the earth's orbit, its distance may never be measured by using the diameter of the earth's orbit as a baseline.

Even the near stars are so very distant that their displacement is almost imperceptible. The parallax (or the apparent angular shifting caused by the changed position of the observer) of Alpha Centauri, our nearest star, would have, says Professor Moulton, the same difference in direction as a point of light 11 miles from the observer viewed with one eye and then the other, with the difficulties of observation extended over several months.

But to return to Arcturus. This beautiful golden star is called the "harbinger of spring" because it rises on the first of March just as the flowers of this season are awakening along the brooks and hillsides. Watch for it about 8 P. M. just a little north of east. At this point it is at its very best for the thickened atmosphere near the horizon fires the orange-yellow to a molten rose, while the flickering and the dancing causes burning waves of crimson, sparks of opal and glints of gold. It reaches the meridian June 8th about 9 P. M. but its eager, splintering light is now calmed to a steady glow and the star hangs like a golden lamp above the world. From July to December, this splendid star floats lower and lower through the western part of the heavens until it touches the horizon in the northwest and disappears.

THE NORTHERN CROWN



The Northern Crown really looks like a crown. Its outline is easily traced, although its stars are delicate with the exception of one which is much larger and brighter than the others. It closely follows Arcturus and is best seen during the early evenings of July when it is floating high in the dome of the heavens, a most fascinating star figure.

Long ago, in some of the old countries, people saw in this "Crown" the likeness to a broken plate held out by a beggar to receive alms; the Pawnee Indians imagined it a camp circle of warriors sitting in council around their camp fire and that the bright star was a servant preparing a feast over the fire; the Australian natives called it the "boomerang," but in Greek mythology this is the crown which Bacchus gave the beautiful Ariadne after she had been deserted by Theseus, King of Athens, on the island of Naxos which lay far out to sea.

According to a later legend, from which the Crown

obtained its name, a yearly tribute of seven youths and maidens was exacted from the Athenians by the tyrant Minos, King of the Island of Crete. These Athenian captives were then rowed over from Greece to Crete and confined in a labyrinth as a feast for a ferocious Minotaur. This labyrinth had been constructed by Dædalus, a most ingenious artist and artificer, who had so perfected the intricate maze of passageways that neither the Minotaur, nor any of his victims, could possibly escape.

Theseus, son of Ægeus, the king of Athens, grieved deeply at the fate of so many innocent sufferers, and thinking that he might be able to overcome the monster, bravely offered himself as one of the seven youths. When Ariadne, daughter of the wicked King Minos, saw the handsome Prince arrive among those to be sacrificed, she was filled with love and pity and risked her own life by secretly furnishing him with a strong sword and a long thread. Theseus then attacked the Minotaur and slew him, afterwards extricating himself from the difficult windings of the labyrinth by means of the thread. He and Ariadne then slipped down to his vessel which had remained anchored in the harbor and set sail for Athens.

On his homeward journey the goddess Minerva appeared to Theseus and told him that he must leave Ariadne at Naxos, an island celebrated for its vineyards, for the Fates had decreed that she should not go with him to Athens. Such barbarous conduct on the part of Theseus must have been past all understanding to poor Ariadne. Ræ has painted a very beautiful picture of her as she sits by the rocks on the sea-shore sadly gazing out to sea, for she was a very sweet girl and not at all like her wicked father. But Theseus suffered also for his seemingly heartless desertion, for he had promised his father, Ægeus, that if he succeeded in subduing the Minotaur he would exchange his black sail for a white one. With one thing and another happening,

Theseus forgot to change his sail, and the poor old man watching the black wing loom in the distance, supposed his son to be lost, and threw himself into the sea. This sea was henceforth called the Ægean Sea in memory of the tragic fate of Ægeus. In the meantime Bacchus, the God of the Vineyards, came along decked in ivy and vine leaves, and discovered the forsaken Ariadne asleep on a rock, worn out with sorrow and weeping.



The god was so captivated by the beauty of the Cretan maid that he did everything in his power to make her forget her unhappiness, even marrying her and promising at her death to give her a place among the gods. He then suspended her wedding crown in the sky, where it still hangs, although its jewels have grown so large that they resemble stars. These stars are now called the "Northern Crown" though they are really

"A brilliant sign of the lost Ariadne."

—*Aratus.*

Spenser pointing them out in his *Faerie Queene* says

"Look! how the crowne which Ariadne wore

Upon her ivory forehead—

—is unto the starres an ornament,

Which round her move in order excellent."

Ariadne's Crown rests about 20 degrees east of Arcturus and may be easily seen in the east just after sunset during the early spring, about the 8th of April, but it is at its best during the early evenings of July when it is almost overhead.

Alphecca, "the bright one," also called "The Pearl," marks the radiant point of a shower of meteors called the Coronids. This shower occurs while the constellation is traveling between the east and the zenith, being visible from April 12th to June 20th.

The Crown remains in view from April until late October, then disappears between the west and northwest. It lies concealed throughout the winter, then rises in the direct northeast in the early spring, its jewels sparkling as if they had been encased in a winter's casket of snow.

This beautiful little constellation is designated on the maps as Corona Borealis. The "Northern Crown" and "Ariadne's Crown" are only popular names.

HERCULES, THE GIANT



An astronomical work of Eudoxus, dated about 370 B. C., but based upon observations made probably by the Chaldeans fifteen centuries before, was versified in a poem of 732 verses called "Phenomena" by Aratus, the court poet of Macedonia, who wrote about a century after Eudoxus' time. Aratus mentions this constellation of Hercules as being of immemorial antiquity and describes it as a figure of a man in sorrow with his hands upraised and stretched "one this way and one that, a fathom's length." In the early days of the world's history it was called "The Kneeler" although even this was not supposed to be its original name. Aratus says—

> "Right there in its orbit wheels a Phantom form, like to a man that strives at a task. That sign no man knows how to read clearly, nor on what task he is bent, but simply calls him On His Knees."
>
> —*Trans. by* G. R. MAIR.

"On His Knees" was given the name of the hero Hercules when the Greeks placed their heroes and divinities among the stars, but his pictures in the modern maps do not seem to accord with the description of his posture in this ancient poem. His foot now rests upon Draco, the Sky Dragon, which probably is here imagined as old Laden, the sleepless dragon which once coiled around the tree of golden apples.

Hercules, the great grandson of Perseus, was the greatest of all the heroes. He possessed every high quality of mind and character and was endowed with such great physical strength that his life was filled with constant adventure. Armed with a huge club, he performed the most remarkable deeds, the most wonderful of these being his "Twelve Labors." Some of these labors or adventures were so thrilling that the Greeks named constellations in honor of them as well as of the hero, and they have ever since been proverbs among men. There are many allusions to these throughout literature—

"Thogh I had hadde—al the strengthe of Ercules."

—*CHAUCER.*

Leo, who leads the zenith constellations across the sky, was the same ferocious lion which Hercules encountered and killed in the valley of Nemea; he also killed the Crab now in Cancer, and the hundred-headed Hydra whose constellation is seen in the south from March to June. Some writers see in Sagitta, the Arrow; Aquila and Cygnus, the Birds; Draco, the Dragon and other constellations, memorials of the adventures of Hercules.

This huge giant gave promise of a career while very young. When no more than eight months old, two monstrous snakes appeared and pushed their hissing heads

between the bars of his cradle. Springing to his feet, he seized the reptiles by their necks, strangled them and threw them dead at the feet of his terror-stricken parents.

"The mighty infant showed them to his sire,

And smil'd to see the wreathing snakes expire;"

—*Idylliums of Theocritus* (FAWKE'S *Trans.*)

When Hercules grew to manhood his cousin, who ruled the Perseidæ, commanded him to perform ten difficult tasks, which were later increased to twelve. Hercules was at first unwilling to obey but the oracle at Delphi informed him that he would become an immortal hero if he performed the tasks, and afterwards be given a just reward. For a while Hercules was so despondent that he eventually became mad, but finally throwing off his depression, he accomplished all he set out to do with such cleverness and foresight and with exhibitions of such amazing strength, that not only did the gods carry him up to Mount Olympus after his death but gave him as a wife the lovely cupbearer, Hebe. His gigantic figure is now among the stars and many of the creatures in his adventures have been placed far above the earth in honored positions in the heavens. Let us now go back for a moment and review some of these awe-inspiring accomplishments of Hercules.

The lion and the hydra have already been mentioned. The watersnake was particularly difficult to kill for it possessed the distressing faculty of being able to immediately grow two living heads in the place of each one destroyed, thus increasing not only the snake but the number of poisonous fangs. This seemingly insurmountable difficulty was finally overcome when

Hercules thought of searing each stump with a hot iron as soon as it was severed, thus killing the root from which the head was born. As seen on his constellation in the sky, this watersnake is more conspicuous for length than for his number of heads, for his faint starry outline covers one-fourth of the southern heavens and takes four months in passing any one place. It was during the struggle with this creature that Juno induced the crab to crawl out of the swamp and seize the mighty giant's toes, afterward placing the crab on the Dark Sign, Cancer, which lies just west of Leo.

The eleventh Labor of Hercules was the obtaining of the three golden apples from the Garden of the Hesperides. The location of these gardens, according to most versions of the story, was to the west of Mount Atlas where this most rare and delightful tree was guarded by a dragon and the four nieces of Atlas. Atlas, who knew best where to find the apples, offered to obtain them for Hercules if he would hold up the heavens while he was gone. Nothing daunted Hercules, so,

"The wearied Atlas he relieved,

His arm the starry realms upheaved,

And propped the Gods above."

—Euripides.

In the meantime Atlas went to the garden and got the apples from his nieces. But according to another myth, Hercules went himself and stole the apples, after slaying the dragon that guarded them. It is to be noted that in the constellations Hercules has been placed in a decidedly uncomfortable position so that he might rest his foot upon

the Sky Dragon, Draco—so perhaps Draco, after all, was the monster that was wound around that wondrous apple tree.

There is also a possibility that the sixth Labor of Hercules has been memorialized in the sky although the weight of evidence is against it. In his sixth Labor, Hercules destroyed the cruel carnivorous birds with the arrows he had dipped in the blood of the poisonous hydra. These birds, which had brazen wings, beaks and claws, hovered over the stagnant waters of Lake Stymphalus, in Arcadia, and ravaged all the surrounding country. This praiseworthy deed may have been represented in the sky by the "bird" constellations, Cygnus, Lyra and Aquila, which hover near the stream of the Milky Way, and in the little arrow Sagitta, which lies not far away, but it is more than likely, according to the majority of the myths, that these constellations were named in honor of other things rather than to commemorate the deeds of Hercules.

Among other exploits which illustrate the unrivaled prowess of this hero, are his battles with giants, monsters and centaurs; catching Diana's brazen-footed stag by driving it deep into a snowdrift in the distant northland; obtaining the girdle of Hippolyta, Queen of the Amazons, in the land of women; capturing boars, bulls, mares and even bringing from the infernal regions the three-headed dog Cerberus.

The greatest demonstration of his strength, aside from the time that he upheld the heavens for Atlas, is reported by the historian Pliny. According to the myth which Pliny relates, Hercules had rent asunder the rocks which had previously divided the Mediterranean from the ocean; although another legend takes the opposite view and asserts that he had narrowed the strait in order to exclude the sea-monsters which had hitherto forced their way in from the ocean. This gateway, known as the "Pillars of

Hercules," consists of two promontories which bounded the western horizon of the then known world. The promontory on the northern side of the straits is now called the "Rock of Gibraltar."

Hercules one day donned a tunic that had been steeped in the blood of a Centaur which he had slain with a poisoned arrow. To escape the terrible torture, he erected a funeral pyre on Mount Etna, lay down on his lion's skin and set the pyre on fire. Amid peals of thunder Jupiter descended in his chariot and carried the hero to Mount Olympus where he was given his promised reward.

"High o'er the hollow clouds the coursers fly,

And lodged the hero in the starry sky."

As seen in the sky, Hercules kneels on Draco, the Dragon, with his head lying downward near the head of the giant Ophiuchus. These two giants cover a vast amount of sky space although neither one have very bright stars. Although Hercules rests inactive, Ophiuchus, one notes, is busily engaged, for his limbs are enfolded by the scaly body of a huge serpent

"his right hand, its writhing tail, he grasps,

Its swelling neck, his left hand securely clasps,

The reptile rears its crested head on high

Reaching the seven-starred Crown in northern sky."

In the meantime

"His feet stamp Scorpio down, enormous beast,

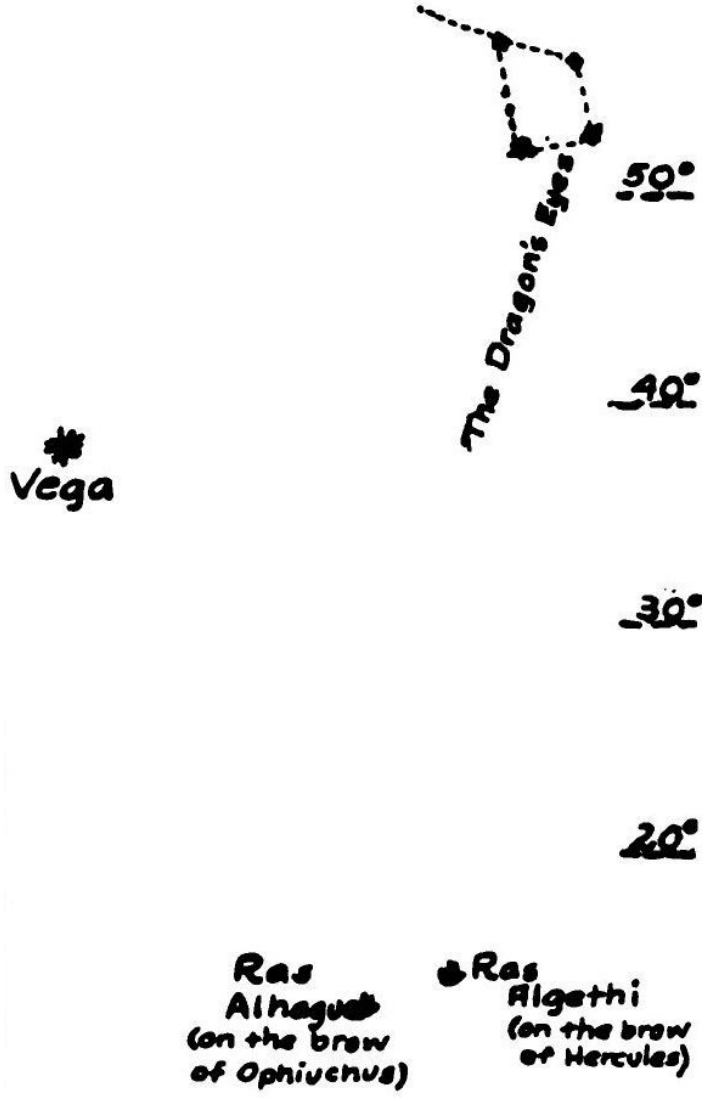
Crushing the monster's eye and plated breast."

—Aratus.

And we gaze with admiration as Aratus describes this struggle which seems by all odds to be against the giant.

Ophiuchus perpetuates the memory of Æsculapius, father of medicine. He and his serpent, as seen in the sky, are exceedingly hard to trace but men also sought to do him honor on earth by erecting temples in which he was worshiped. The brightest star in the constellation of Ophiuchus, the Serpent Bearer, is Ras Alhague, although this name has gone entirely out of use and the star is generally designated as α Ophiuchi.





This star lies on the head of Ophiuchus which is about three-quarters of the way up from the horizon to the zenith, when on the meridian. It rises a little north of east, appearing When the sun sets on the 14th of May, and

requiring 6 hours and 46 minutes to reach the line midway between east and west. Ras Algethi (α Herculis), a beautiful orange colored star on the head of Hercules, is usually noted in connection with Ras Alhague, since they stand rather isolated only about 6 degrees apart. (The distance between the "Pointers" on the outer side of the Big Dipper is equal to 5 degrees.) When Ras Algethi and Ras Alhague are near the meridian, a glance of the eye beyond will meet two stars of the 2nd magnitude also not far apart. These are "The Dragon's Eyes," Alwaid and Etanin. Recalling that Hercules has his foot on the Dragon's head, that the head stars of the two giants' lie almost together, and the feet of the lower giant, Ophiuchus, are crushing down Scorpio, the Scorpion (a conspicuous anchor shaped constellation in the south), one has a fairly good idea of this section of the sky from the Pole Star to the horizon, when Ras Alhague and Ras Algethi are near the meridian. Since both Hercules and Ophiuchus have very large but also very inconspicuous constellations, it is well to keep them connected in some such manner.

In modern days the constellation of Hercules has gained in interest through observations made by the telescope. Unfortunately the ancients were not privileged to see its gayly colored double stars and its marvelously beautiful star cluster.



Among the double stars, Young mentions an orange and blue, and a white and emerald green; the Rev. T. W. Webb points out one almost appetizingly attractive in its light apple green and cherry red while Serviss notes some charming combinations—orange and green, pale green and purple, light yellow and pale red—which may be seen with such meager assistance as an opera-glass. Serviss, by the way, has written a whole book on what may be seen in the sky with no greater aid than an opera-glass.

The star cluster in Hercules lies on the west side of the constellation, about one-third of the distance from the north end and not far from the figure of the Northern Crown. To the unaided eye, this cluster looks no more than a glimmering speck of light, but if a powerful telescope is trained upon it, it is resolved into a great cluster of stars. These stars, numbering into the thousands, are so packed together toward the center that they have been described as resembling "ice crystals in a snowball." From such a lovely

blaze within the center another observer adds that "sprays of stars reach out in all directions like tendrils of a vine."

The stars counted on a photograph of the Hercules cluster which was taken by the great 60-inch reflector on Mount Wilson, number over 50,000! This telescope resolves even the solid glow of light at the center of the cluster into individual stars.

Sir Robert Ball in "Star-land" gives a good illustration of the appearance of a globular cluster of stars as seen in a large telescope. "I take a pepper-castor and on a sheet of white paper I begin to shake out pepper until there is a little heap in the center and the other grains of pepper are scattered loosely about. Imagine that every one of those grains of pepper was to be transformed into a tiny electric light, and then you would have some idea of what a cluster of stars would look like when viewed through a telescope of sufficient power."



A STAR CLUSTER IN HERCULES.

Photograph by Yerkes Observatory through 24-inch telescope. A photograph of the same star-cluster by the Mount Wilson Observatory through a 60-inch reflecting telescope is shown on page 2.

It was at one time thought that the cluster of Hercules might be a comparatively close cluster of small-sized suns, but Professor Shapley has lately discovered that the cluster

is a very distant one; indeed it lies at such an exceedingly remote position in the realms of space that its parallax is slightly inferior to a 10,000th second of arc which corresponds to a little more than 36,000 light years. Thus it takes 36,000 light years for its light to reach us, for this light has to cross the unthinkable space of 220,000 billion miles!

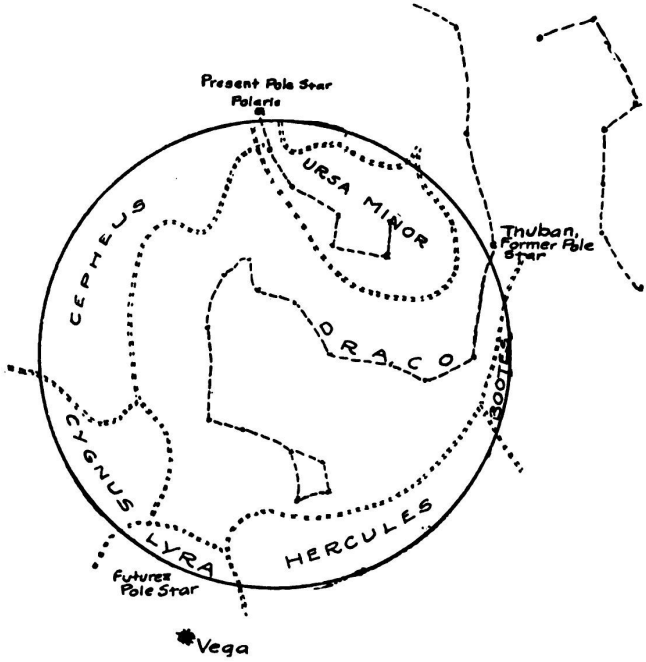
LYRA, THE HARP



Of the string of constellations twinkling high overhead during the spring and summer months, we have already mentioned Leo, the Lion; Berenice's Hair; Boötes with his golden Arcturus; the Northern Crown and the giant Hercules.

Next to Hercules, on the east, lies the constellation of Lyra, represented in legend as the sweet toned harp which belonged to Orpheus, son of the Muse Calliope. Orpheus inherited the love of music from his mother, and after the Sun-god had presented him with this wonderful harp, he played so delightfully that even trees, rocks and hills gathered around him to listen.

Treasuring the memory of such remarkable talents, the Greeks placed the instrument in the heavens at the edge of the Milky Way, where its framework was adorned by a group of stars, one of which is exceptionally bright, vividly blue and very beautiful. This blue star is called the "Harp Star," or Vega, by astronomers.



Precessional Orbit of the Pole.

Vega rises in the far northeast in the early evenings during the first of May but during July and August it passes almost overhead. When near the rim of the northern horizon yellow and red fires dart out amidst the blue, but when high above in the dome of the sky, its color is pure and coldly blue, a decided contrast to the golden warmth of Arcturus, which lies not far to the west of it.

In consequence of the precession of the equinoxes, in less than 12,000 years Vega will be the nearest bright star to the pole; indeed it will be close enough to serve as our North Star. Then, instead of wandering from the far northeast to the far northwest, it will seem to stand in the north like a pale-blue pivot, while all the other stars will circle round it. Vega will hold this position for 3000 years. The constellation of Lyra and that of Hercules are of particular interest because they mark that part of the universe to which our sun is traveling at the rate of 12½ miles a second. Some day (in half a million years or so), this gorgeous sun, a hundred times more brilliant than our sun, may glow upon us as a near neighbor. In 12,000 years, when our north pole points to Vega, the great Cross with its bright stars Deneb and Albireo, will never set but will journey night after night in a small circle close about the celestial pole, Orion will climb over the zenith and the Milky Way in all its splendor will whirl about the north.

The principal figure formed by the stars of the constellation of Lyra has been best described as an "equilateral triangle balanced on the corner of a rhomboid." This figure is easily traced although all of these stars, with the exception of the brilliant blue one, are of no more than the 3rd or 4th magnitude.

To the average eye, the little star east of Vega, at the top of the triangle, appears a trifle elongated, but a sharp eye divides the star into two stars set very closely together. With a 3-inch telescope each of these stars is found to be double. This fourfold star in Lyra is sometimes referred to as a "double-double."



The third star, Lyræ, at the base of the "rhomboid" on the same side of the figure as Vega, is a variable with three small stars near it, forming a very pretty object with low power.

Also at the base of the rhomboid, between β and γ, one-third of the way from β, a small telescope will disclose a nebula which has assumed the shape of a ring, or at least it looks like a ring at this distance. There are various types of nebulæ, some, like the "planetary" and "spiral," having definite forms, others being as shapeless as a puff of vapor. Sometimes a planetary nebula has a star at its center, and again it appears hollow, like "a little smoke ring." It is then called a ring nebula. The most famous of these is the one found in Lyra.

On the 19th and 20th of April swift meteors, known as

the Lyrids, radiate from the vicinity of this constellation, although the display is of interest rather than of any particular beauty.

The legend of this celestial harp, which is often hung by map artists around the neck of an eagle, is one of the most popular stories in mythology, and its very appearance in the heavens brings to mind the beautiful lovers, Orpheus and Eurydice. The harp was anciently represented as having been invented by Mercury, who gave it to his half-brother Apollo, the Sun-god, who later presented it to Orpheus, the son of a Muse.

Mercury, as an infant, gave promise of being a most remarkable god, for the very day that he was born, he climbed out of his cradle, wandered out of the lofty cavern of Cyllene and picked up a little tortoise that was crawling past the entrance. Gently pulling off the scoop-shaped shell, he bored neat holes along its edges, stretched dried tendons across its face, and wedged it firmly between two horns. His tiny hands then strayed across the strings, and he danced delightedly as the most delicious music issued from the shell.

"And this, whilst yet

Encradled, Hermes pierced and called it Lyre."

—*Aratus.*

Mercury then went in and slept awhile, but when darkness came, he again slipped out of his cavern and ran over to the hillside to see what further adventure awaited him. Here he found the pasture of Apollo's cows, and looking the animals over, separated fifty of the best from the herd, wrapped their hoofs in branches and drove them backwards into a large cave where he made a fire and

sacrificed two of them to the twelve Gods (himself included).



THE RING NEBULA IN LYRA.

Photograph by Mount Wilson Observatory through the 100-inch Hooker telescope.

The next day while Apollo was driving his sun-chariot over the slopes in the east, he noticed that a number of his

favorite cows were missing. Investigating the matter, he traced the theft to this baby, who stood up in his cradle, looked the Sun-god in the face, and stoutly denied it; he even inquired in a naïve manner what sort of animals cows were. Too amazed for further words, Apollo picked him up, tucked him under his arm, and went straightway up Mount Olympus to Jupiter. Here the infant stood bravely in the midst of the assembly in the great Olympian Hall and with a look of injured innocence upon his face inquired, "How could I, still wrapped in swaddling clothes, drive away Apollo's herd? You well know that I was only born yesterday and have never crossed my mother's threshold." The gods, perfectly aware of his guilt, roared with laughter and loudly applauded. Even Jupiter smiled at the infant's cleverness and, presenting him with a winged silver cap and silver wings for his feet, told him to lead Apollo to the cave where he had driven the cattle. Seeing that further subterfuge was useless, Mercury laughed gleefully and handed Apollo his harp as a peace offering.

Apollo soon played divinely on the little harp and was altogether so pleased with the instrument that he gave Mercury entire charge of his flocks and herds, as he preferred to become famous as the God of Music. The Sun-god later gave the harp to Orpheus, and because a god had played upon it, it responded to the touch of this beautiful youth in tones so pure and joyous that even wild beasts were charmed, while birds swarmed about him in the air and sea-monsters came up to hear him from the bottom of the sea. The power of his music was so great that rushing torrents slacked their rapid course to listen to him, and once, while playing, he watched amazed as a whole forest marched up to a level place on a hill where it made a shade for a large assemblage of wild animals and the multitudes of birds who sat as if enchanted while he played.

This gay and happy musician had a lovely bride named Eurydice, daughter of the Sea-god Nereus, whom he fondly loved. One day while wandering in the fields, Eurydice was fatally bitten by a viper which lay concealed in the long grass. Orpheus filled the groves and valleys with his piteous lamentations and finally, unable to live without her any longer, he boldly walked into the cave that led to Pluto's realm, and braved the horrors of the steep, dark path which led to the lower world. After a difficult journey he arrived among the Shades, and wandered playing and singing among the admiring throng. The ancients claim that the power of his music arrested for a while the torments of the damned, that his "golden tones" seemed so heavenly in these gloomy depths that the stone of Sisyphus remained motionless, the Danaides stopped their wearisome task of pouring water through a sieve, and the Furies withheld their persecutions.

"E'en Tantalus ceased from trying to sip

The cup that flies from his arid lip."

—*Saxe.*

Pluto was touched to unheard of softness and, as he granted Orpheus' plea that Eurydice be returned to him, "iron tears" rolled down the furrows of his cheeks. "But hold," said the crafty monarch, "there is one condition. If you once glance behind you to see if Eurydice is following, you must lose her again forever." Crashing chords of joyous triumph, Orpheus hurried up the rough pathway that led to the top of the world, but as he was about to pass the extreme limits of Hades and saw beyond him the opening where the sunlight reached in gently through the darkness, he grew afraid, and in order to convince himself that his beloved wife was really behind

him, he turned suddenly around—only to see Eurydice, with her arms outstretched, floating slowly backwards into the drear, dead land below. The grief of Orpheus at this second loss was even more intense than before, and half-crazed with sorrow and remorse, the poor lad stumbled to the banks of the river Strymon, where he mourned for seven days with neither food nor drink. At last he wandered up into the mountains where he fell into the hands of wild, bacchanalian revelers and came to a violent end. At the intercession of Apollo and the Muses, the harp of Orpheus was placed among the stars while the youth himself was tenderly cared for and buried beneath the shadow of Mount Olympus.



Some mythologists, however, claim that Orpheus was changed into a swan and placed in the heavens as the constellation of Cygnus so that he might be near Lyra, the constellation of the Harp, although the Latin poet Ovid claims that "Cygnus" took its name from "Cycnus," a friend of Apollo's son Phæthon. It might seem strange, on the face of it, that a celebrated singer like Orpheus should be changed into a bird as lacking in song as the swan, but it

should be remembered that the ancients believed that a dying swan sang very sweetly. At least we are quite certain that Lyra is the harp that Mercury invented, that the Sun-god endowed with a golden tone, and that Orpheus played upon when he held spellbound not only mankind, but beasts, rocks and trees.

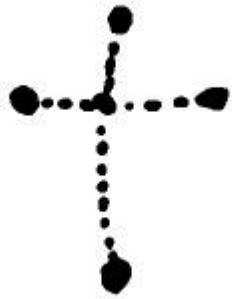
This great Harp floats across the dome of the heavens on summer evenings with the blue jewel Vega blazing on its frame. Longfellow in "The Occultation of Orion" clearly visioned

"its celestial keys,

Its chords of air, its frets of fire."

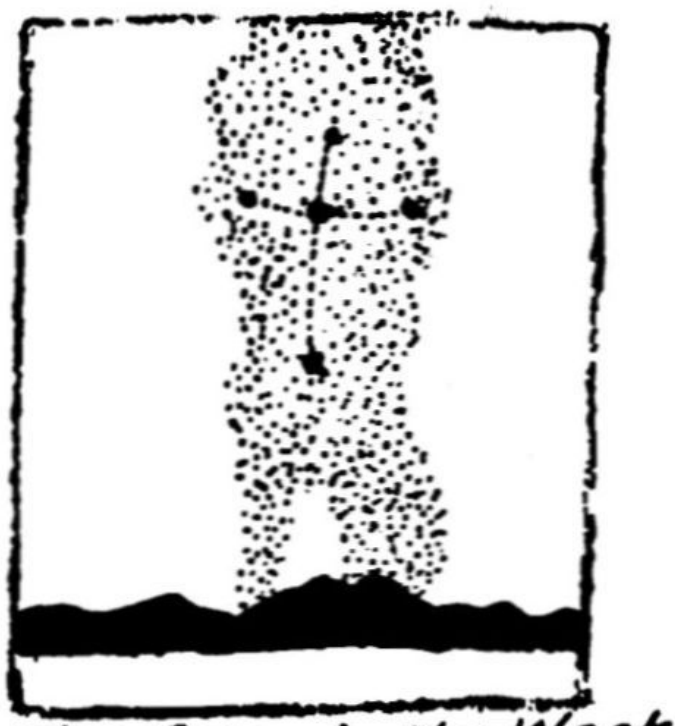
It is easy to imagine that these twinkling chords still sigh and give forth strains of music, for an Æolian Harp is a harp that sings when a wind passes over its strings, and the music of such an instrument is of a drowsy, lulling quality which blends beautifully into dreams.

THE GREAT NORTHERN CROSS



Just east of the Harp Star, in the center of the Milky Way, rests a cross of stars, clear and bright, as if a cross had really been placed there and then studded with five big stars.

During the month of May the Cross rises on its side (as viewed by an observer in the northern hemisphere), but it rests north and south as it reaches the zenith in midsummer. By December it has reached the slope in the west, and now assuming an upright position, descends majestically to the horizon. This descent is quite effective, especially at the moment when the pale orange star, which rests at its base, lightly touches a mountain range etched in the distance or the edge of a far-reaching plain. This 3rd magnitude star, Albireo, is a favorite with amateur astronomers, for it has a 5th magnitude companion star of the richest and most vivid greenish-blue.



The Cross in the West

This lovely double star with its sharply contrasted colors may be seen to good advantage in a small telescope and vies in beauty with the famous three-colored star, Gamma Andromedæ.

Deneb, the brilliant white star at the head of the Cross, is a very distant sun but is so large that it shines forth brightly among our finest stars. It is estimated by astronomers as being at a much greater distance than the Harp Star, Vega, and Vega is distant about 232 millions of millions of miles! In contrast to the huge sun that Deneb must be to shine so brightly at its great distance, there is a little star above the armpiece on the eastern side of the Cross, which is the nearest star to the earth that has yet been found, as

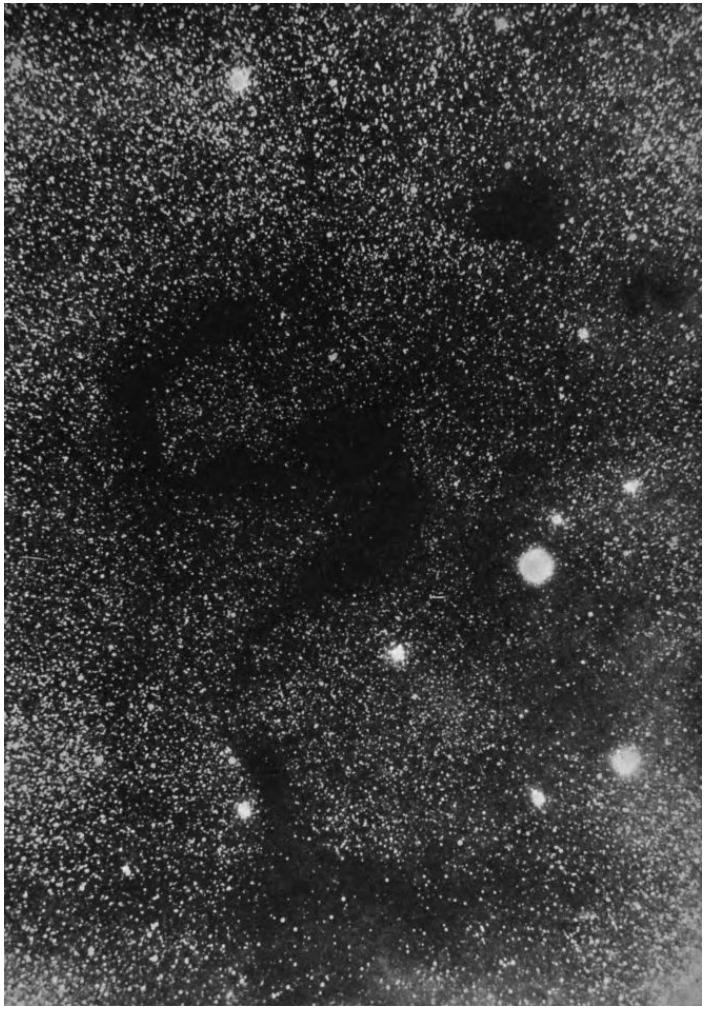
seen from the northern hemisphere.



This faint star is really a very tiny sun for nine more similar suns thrown into it and blazing as one big fire, would no more than equal our sun in brilliancy.

In the vicinity of 61 Cygni, is a large, mysterious, black spot visible on account of the glow of light from the densely packed stars of the Milky Way. This spot was first described as being "like a hole" and was curiously named "A Sack of Coals." Science later suggested that since we have dark suns perhaps we also have dark nebulæ and that such an object may be lying between us and those distant stars. The late E. E. Barnard of Yerkes Observatory made extensive studies of the distribution of nebular matter and he seems to have definitely proved the existence of "dark nebulæ." The black spots and "rifts" in the Milky Way are now generally accepted to be dark nebulous matter which cuts out the light from the stellar regions behind them. Professor Barnard made many wonderful photographs of such dark spots and compiled a famous Catalogue of 182 Dark Markings in the sky. Dr. Hubble of the Mount Wilson Observatory found that in its normal state a nebula is dark rather than luminous. If a nebula shines it is because it is either illuminated by the light from the stars

near it or because it is electrically excited in some way not clearly understood.



A DARK NEBULA (S-SHAPED) IN OPHIUCHUS.

Photograph by Mount Wilson Observatory through the 100-inch Hooker telescope.

There is also a Cross on the Milky Way with a dark nebula beside it in a conspicuous position in the southern hemisphere, although there the cross is not quite as perfect as our cross in the north, for it is formed of only four bright stars instead of five. Even our cross is not quite perfect, for one star, the "diamond-studded nail" holding it together, is just a little out of line. Julia E. Rogers in "Earth and Sky" has said that her fingers fairly "itch to put it where it belongs." Imagine! And since she has so aptly expressed it, we now all feel that way.

This outlined figure of the great Northern Cross forms the basis of a constellation called Cygnus, the Swan.



The bill of the Swan lies on Albireo, the double star at the foot of the Cross, while its wings curve gracefully back from the armpiece.

According to the story of Phæthon and Cycnus, Phæthon, after his hectic ride in the sun-chariot, fell a "charred fragment" into the river Eridanus. Jupiter's thunderbolt had hit its mark:

"And Phæthon caught in mid-career,

And hurled from sun to utter sunlessness,

Like a flame-bearded comet, with ghastliest hiss,

Fell headlong in the amazed Eridanus."

—*Worsley.*

Phæthon's three sisters, the Heliades, wept so bitterly on the banks of the Eridanus that the compassionate gods changed them into poplar trees and their tears into amber. Ovid pictures their terrible grief—

"All the night long their mournful watch they keep,

And all the day stand round the tomb and weep."

Cycnus, Phæthon's friend, also grieved deeply and watched over the waters for many days. While watching thus his neck grew longer and longer until at last it became perfectly atrocious. The gods again looked down in pity, metamorphosed the youth into a swan and placed him on the river of the Milky Way.

"For Cycnus loved unhappy Phæthon,

And sung his loss in poplar groves alone,

Beneath the sister shades to soothe his grief,

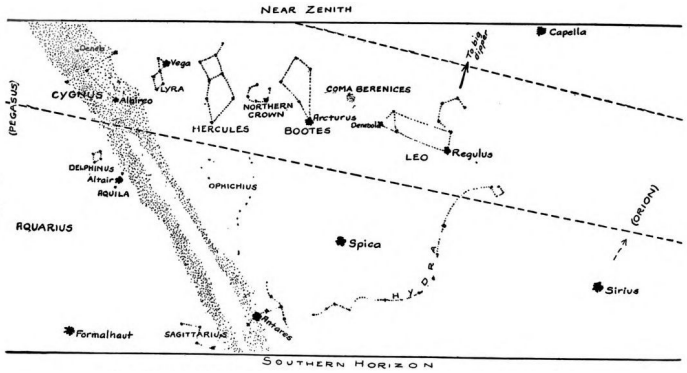
Heaven heard his song and hastened his relief.

And changed to snowy plumes his hoary hair,

And winged his flight to sing aloft in air."

—Virgil.

If this swan is really Cycnus it seems strange that he was not depicted as flying down the wavy line of Eridanus' stars instead of being placed over the silvery stream of the Milky Way, for the river Eridanus, into which Phæthon had fallen, was placed in the winter sky at the foot of Orion. This was supposed to console Apollo for the loss of his son. Perhaps the Swan is Orpheus, as some mythologists claim, carried up to the constellations to be near his well-loved harp. However, no matter which 'human' this long-necked bird is supposed to represent, we see its gigantic, graceful outlines sketched with star-like lightness beyond the stars of the Cross, and we see his snow-white wings extended and the orange light of Albireo shining on his beak, as he flies softly, head downward, along the misty river of stars.



THE ZENITH CONSTELLATIONS AND THE SPECTATORS OF THE PAGEANT.

CHAPTER VII

THE SPECTATORS OF THE ZENITH PAGEANT

AQUILA, *the Eagle*.

DELPHINUS, *the Dolphin*.

AURIGA, *the C*

THE above constellations, which lie to either side of the great summer parade of star-figures which crosses the heavenly dome, will be called, for convenience in locating them, "the spectators."

The story of the "spectator" Ophiuchus, who is grasping Serpens (which is a separate constellation but usually mentioned in conjunction with Ophiuchus), has already been mentioned under the adventures of the giant Hercules, and that of Crater, the Cup and of Corvus, the Crow, will appear in connection with the Water-snake. The four large stars in the southern part of the sky—Spica, Antares, Formalhaut and Sirius—are, however, better taken in a group by themselves, for they are thus more easily remembered as large stars conspicuous in different seasons of the year in a region where large stars are scarce.

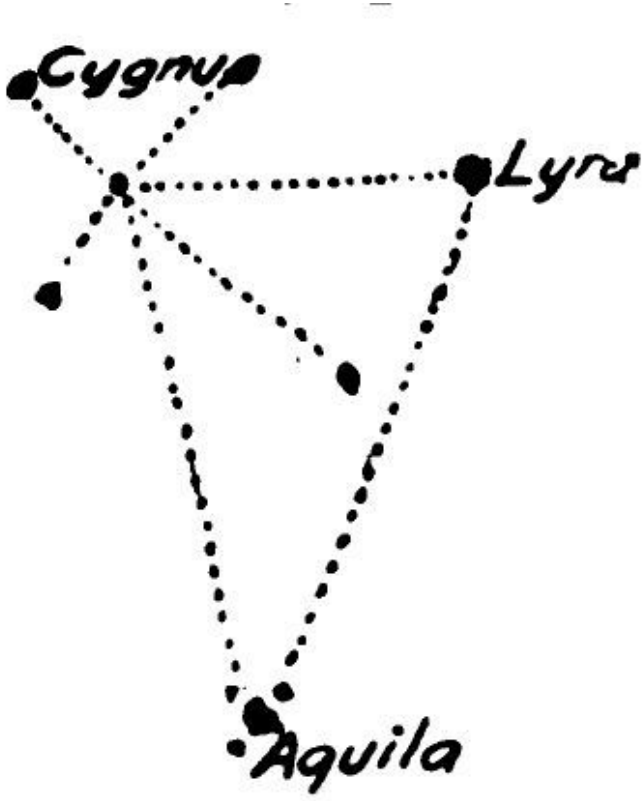
AQUILA, THE EAGLE



Aquila, the Eagle, was given a constellation not far below the Cross, at the edge of the Milky Way. This Eagle is designated as the Flying Eagle so as not to be confused with the Eagle which holds Lyra, the Harp. In mythology the eagle was supposed to be the bird of Jupiter because it could fly higher than other birds. This particular eagle stood by the throne in the palace on Mount Olympus and carried the thunderbolts in his claws.

> "He, a bird, supplies the heavens with
> sacred bolts and arms the skies."

The Eagle pictured on the star maps is a very large bird, but the only portion of him not difficult to locate in the sky are the three bright stars which hang like a bar across his neck.

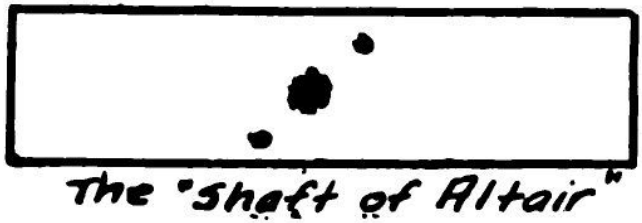


These stars alone suggest a bird flying with outstretched wings. This is a region of birds, for the great Cross with Cygnus, the Swan, drifts down the Milky Way between the two Eagles. The "three birds" are most effective and easily located when seen on the meridian in midsummer, for they then form a large triangle across the star stream, Lyra and Aquila being at the edges of the stream and at the base of the triangle with the center of the Cross at its peak.

One day Jupiter sent this eagle who is now in the sky down from Mount Olympus to seize a beautiful youth named Ganymede who was tending his father's flocks on

Mount Ida. This youth was then carried up to the palaces of the Gods and given the position of cupbearer. The Greeks believed that Jupiter gave Ganymede's grieving father a pair of divine horses as a compensation for kidnaping his boy and comforted him at the same time by saying that Ganymede had now become immortal and free from all earthly ills. The eagle was rewarded for its daring by being placed among the constellations. Ganymede was also, in due time, honored in the same manner and is represented by the constellation Aquarius, the Waterbearer, despite the fact that it was nectar, and not water, that this youth poured in the cups of the gods. Aquarius lies east of Aquila.

The large white star in the center of the three stars which hang on the neck of the Eagle is called Altair. Altair rises a little north of east with its twin stars Alshain and Trazed, about 9 o'clock on the 29th of May. It arrives at the meridian at 10 o'clock August 18th, at 9 o'clock September 2nd, and at 8 o'clock September 18th.



It is then about two-thirds of the way up from the horizon. The three stars are called "The Shaft of Altair." Altair is one of the nearest of the brightest stars and is approaching the earth at the rate of 20 miles a second. You may step out now and look up at this star with a personal interest, but it is still far away. Indeed it is so very far away that generations will live and die and still an increase in its

light will scarcely be noticeable.

A small arrow studded with five stars lies, pointing east, in the Milky Way, slightly to the north of Altair. These stars lie in the constellation of Sagitta, the Arrow, which the Greeks may have considered an arrow of Hercules aimed at one of the bird constellations, or the arrow with which the hero slew the vulture which tormented Prometheus on the top of the Caucasus mountains. It is sometimes also called "Cupid's Arrow." Sagitta is one of the oldest of the constellations, its history being lost even in the time of Aratus.

DELPHINUS, THE DOLPHIN



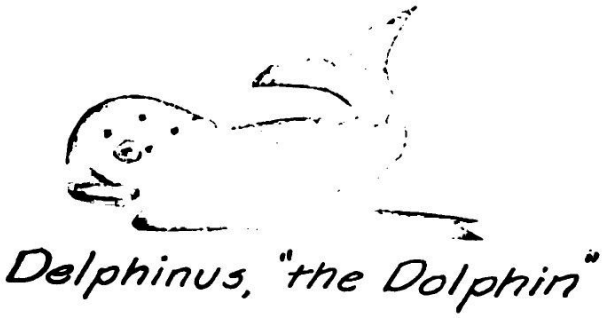
Delphinus, the Dolphin, may be located 10 degrees to the northeast of Aquila, the Eagle, and below and to the east of Cygnus, on the Milky Way. It is popularly known as "Job's Coffin," which, ridiculous or not, is said to have originated from the "diamond-shaped" form in which its stars are set. This conception, however, places less strain on the imagination than in the case of Pegasus (whose nose starred by Enif lies 10 degrees southeast of Delphinus), where the four principal stars form a "square" and are called a "Flying Horse." But the name of Job's Coffin, as mentioned before, is merely a popular name while Delphinus, the constellation known as the Dolphin, was

named in honor of a dolphin connected with the adventures of Arion, far-famed as a musician of Corinth about 700 B. C.

The dolphin which the map-makers drew on the star-maps is an exceedingly plump and queer-looking animal. As Admiral Smith comically remarks, it looks more "like a huge periwinkle pulled out of its shell." In reality dolphins are anything but periwinklian, for they belong to the whale family. They grow to be from six to eight feet in length and travel in herds, and have been seen by the writer gamboling and playing on the surface of the sea in the most remarkable manner. They are supposed to be strongly attracted toward harmonious sounds such as music, delight in racing with passing ships and seem to be of an exceptionally friendly nature toward man. On this foundation was based the legend of Arion, first given by Herodotus and afterwards decorated by the poets.

Arion had been sent by Periander, ruler of Corinth, to Sicily and Italy, and at Tarentum had won the prize in a musical contest. As he returned laden with gifts in a Corinthian ship, the musician was attacked by avaricious sailors determined to do away with him and take possession of his goods. Warned by Apollo in a dream, Arion lured close a troop of friendly dolphins by the sweet strains of his cithara. Leaping to the back of an admiring one, he was carried to the promontory of Tænarus, where he landed and journeyed on to Corinth. For this praiseworthy deed, the gods raised the dolphin among the constellations.

Another legend tells us that when Neptune, Ruler of the Sea, courted the lovely, dark-eyed nymph Amphitrite, he came riding on the back of a dolphin.



As his courtship was successful, he rewarded the dolphin in the usual way, by gaining permission to have him placed among the stars.

SAGITTARIUS, THE ARCHER



Sagittarius, the Archer, is supposed to be a centaur, one of a fabulous race seen on the plains of Thessaly and about the woods of Mount Pelion. This race was supposed to possess the body of a horse and the head and shoulders of a man but none of them had ever amounted to much or accomplished anything of worth in the world, with the grand exception of one centaur, whose name was Chiron. Chiron lived in a stone cave near the summit of Mount Pelion and it was here that all the heroes of Greece—Hercules, Jason, Castor and Pollux, Aesculapius, Achilles

and others—spent their early lives, for Chiron was famous for his knowledge and served these young men as a tutor. He not only taught them all the manly arts but he aided them in various enterprising adventures, such as marking out the constellations for the heroes when they went with Jason in the Argo in search of the Golden Fleece.

One day Hercules unfortunately opened the fatal wine-jar, and the odor, floating about on the breezes, attracted hordes of common centaurs who fought ferociously to gain possession of it. Hercules managed to kill most of them with the arrows he had dipped in the blood of the poisonous hydra, but his old master was also accidentally wounded by one of the terrible barbs. Any wound, however slight, inoculated with this poison, was certain to prove fatal, but the centaur Chiron was immortal and could not die. Retiring to his cave, he prayed to the gods to deprive him of his immortality so that he might be released from his suffering, and to accept him as an atonement for Prometheus, the gigantic Titan "Forethought," who wished for immortality so that he might always be an aid to man. This Titan, in his eagerness to aid mankind, had once displeased the gods by secretly climbing up to heaven, lighting a reed at the fire of the sun, and bringing down the holy flame as a gift to the human race. He thus was the founder of civilization.

"Resentment stung the Thunderer's inmost soul,

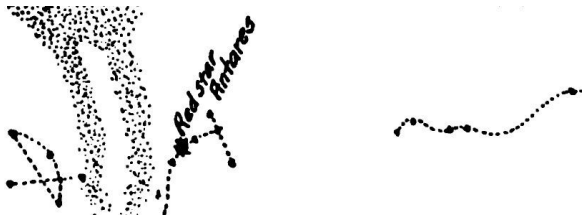
And his heart chafed in anger, when he saw

The fire far-gleaming in the midst of man."

—Hesiod.

Not only did Jupiter punish the Titan by chaining him to a

crag in the Caucasus mountains at the eastern end of the earth, but he sent Pandora to the Titan's brother Epimetheus, and Pandora, through her unrestrained curiosity, opened a forbidden box and let out all the woes and sorrows which now roam the world. Since, however, ungrateful mankind had informed on Prometheus, he rewarded them with a remedy for old age—which was slyly stolen by a snake as the gift was being conveyed down the mountain. Thus snakes renew their youth by casting off their skins while men suffer helplessly with all the evils that prey upon the old. But Jupiter now felt such great pity for Chiron in his torture that he somewhat forgot his indignation at Prometheus (and anyway mortals had been using fire for many generations and it had spread to such an extent that it was now past regaining), so the great god granted Chiron's prayer that he might sacrifice his immortality for the release of Prometheus.



The Bow, the Scorpion and the Hydra's Tail.

Hercules then made his way up the precipice where Prometheus was bound, killed the vulture which was torturing him, struck off his chains and set him free. The centaur was then made mortal, released from his sufferings by the gentle balm of death, placed in the heavens and beautified with stars.

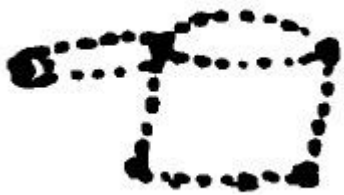
This centaur, now called Sagittarius, the Archer, was given a constellation near the southern horizon, indeed, he lies so far to the south that he is partially hidden from view

and only the head and bow and arrow may be seen by most of us living in the United States. His constellation may be easily located by first finding the Scorpion, which has a large, well-defined anchor-shaped figure marked in the center by a brilliantly red first magnitude star.

The Greeks imagined that the Arrow of the Archer was drawn and held against the bow. Ovid says that the Archer "Thrusts the Scorpion with his bended bow."



However, most of the people in these United States call the Bow and Arrow a "Milk Dipper" because its stars seem to outline a little Dipper embedded in the stream of the Milky Way.

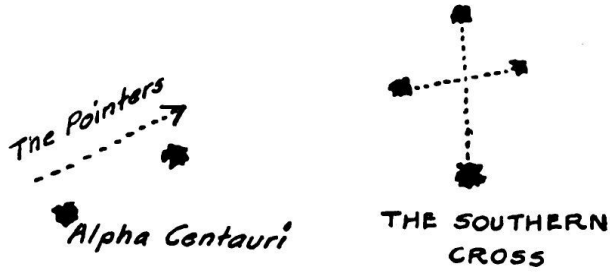


Thus we have fancy adorned and plain fancy. The arrow, the stars in the bow and two other stars form this little

Dipper which is best seen directly in the south, near the horizon, on September first at 8 P. M. Sagittarius is low in the south at the same time that Vega is on the meridian.

In the star-maps, the Centaur is shown halting at the edge of the star stream and aiming across its mist of light at the great red star which flutters on the heart of the Scorpion. The Scorpion, however, is pictured as observing with interest the nearby tail of the many-headed watersnake although he is almost crushed by the mighty foot of the giant Ophiuchus whose head lies high up in the sky against that of Hercules. The Centaur's group of stars, the constellation of Sagittarius, is a zodiacal constellation, with the arrow and part of the bow for its symbol. ♐

There is also another centaur in the sky but no part of him can be seen in these latitudes. This constellation contains two famous stars, Alpha and Beta Centauri, sometimes called the "Southern Pointers" because they point to the figure of the Southern Cross.



These two stars are on the Centaur's forefeet. Alpha Centauri is the nearest star to the earth, lying at a distance of only 25,000,000,000,000 miles. Unthinkable as this number of miles may seem, it is such a short distance across the fields of the heavens that Alpha Centauri and our sun would appear to be very close together as seen

from the planets of other stars. Thus our kingdom of the sun is not an isolated isle among the dim star-lights of space, but shines as one of the stars in a community of such kingdoms. The tiny star 61 Cygni is the nearest star to the earth as seen from the northern hemisphere.

HYDRA, THE WATER-SNAKE



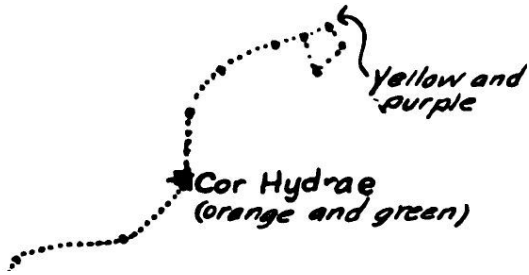
Hydra, the Water-snake, first rears a venomous head above the eastern horizon on January 5th about 9 P. M. He slowly squirms along the southern horizon, his length being so appalling that it takes him four months to completely pass any one point in the sky.

Along the body of this Water-snake are scattered a few 4th magnitude stars. The twinkling lights of these stars may be followed far to the south and then east, almost to the boundary of Scorpio. Indeed, when the Watersnake is completely above the horizon, as he is in April, these stars show that his long length stretches over nearly a quarter of the sky! Some poets state that this creature had one hundred heads, others claim that he had only nine. However this may be, there is only one that is easily traced and this lies, triangle-shaped, just below Leo, the Lion.

The only noticeably bright marking on the Water-snake

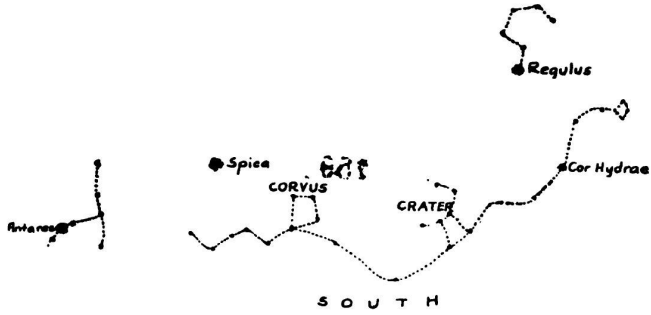
is the orange-hued star of the second magnitude which lies upon the reptile's heart. This star is called Cor Hydræ after its location, but it also has the name of Alphard, the Solitary. Since the naming of the star, science has discovered the latter name to be rather a misnomer for it has a telescopic companion of a pale shade of green. Cor Hydræ rises in the early evening on the 21st of February, and passes the meridian about 9 o'clock during the middle of March.

The northernmost star of the group that marks the head is also a double. This double consists of two stars of the 4th and 8th magnitudes, the larger one being yellow and the smaller purple.



Double Stars on Hydra, the Water-snake.

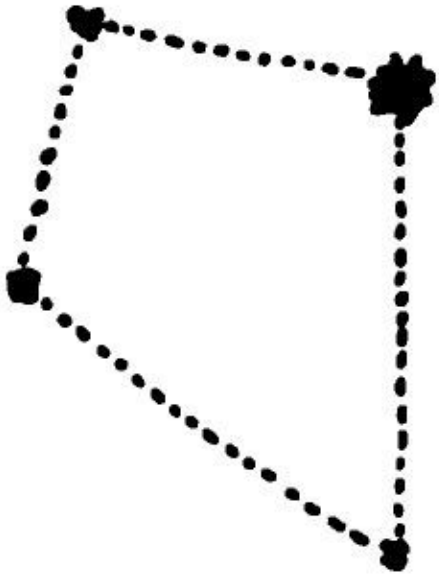
Two geometrical figures called Corvus, the Crow, and Crater, the Cup, rest on the back of this Lernean Hydra. These two small constellations are easily traced, one having the form of a quadrilateral figure and the other a section of a circle. Kippax says that Crater has been variously called the Cup of Hercules, the Cup of Achilles, the Cup of Medea and the Wine Cup of Noah. The Greeks called Crater the "Goblet of Apollo" but according to Manilius it was the "generous Bowl of Bacchus," God of Wine.



During the springtime, Hydra, the Water-snake, may be seen creeping along the horizon in the south.

Although this Water-snake is generally represented as the one connected with the Labors of Hercules, there is also another legend which combines the Crow, the Cup and the Snake in one tale. The crow was at one time Apollo's favorite bird until one day, in anger at its tale bearing, the Sun-god turned its color from pure white to black and forbade it to fly any longer among other birds. On another occasion this provoking little servant was given a cup and told to fetch some water for a sacrifice to Jupiter. Instead of attending to its duty, however, it loitered at a fig tree until the fruit became ripe, then returned to the God with a watersnake in his claws and a lie on his tongue. For punishment the crow was fixed in the sky with the cup and the snake, the latter being charged never to allow him to drink—although the constellation Hydra, which stretches over a quarter of the sky, is certainly not the same little reptile which the crow carried from the spring.

AURIGA, THE CHARIOTEER



"The Charioteer" is an ancient title retained by the constellation Auriga, although in the star-maps one usually finds a man of huge stature carrying a goat and two frightened kids.

"Far in the north his giant form begins,

Reaching athwart the sky the distant Twins."

Auriga, according to the earliest Grecian legends, was a chariot-driver identified with Erechtheus, son of the God Vulcan. Erechtheus inherited lameness from his father who was twice thrown from Mount Olympus, the second time falling on the Island of Lemnos instead of the sea,—which broke his ankle. His son, fretting under the inconvenience caused by his deformity, invented the four-horse chariot which provided himself and others with an easy way of

traveling from place to place. For this achievement Jupiter rewarded him with a constellation, choosing five bright stars which actually somewhat resemble an ancient chariot.

"His art great Jove admired, when first he drove

His rattling Car, and fix'd the Youth above."

—Manilius.

Yet, on the star-maps, the Charioteer is pictured with a goat on his shoulders, instead of driving a chariot, although sometimes a chariot has also been represented. Allen says that modern research gives us reason to believe that the constellation was delineated by the early star-gazers of the Euphrates valley millenniums ago and perhaps the Greeks merely impressed their legends on another figure as it is possible they also did in the case of Hercules. The goat which the Charioteer holds, according to one tradition, was the goat on whose milk the infant Jupiter was fed after he had been carried to the island of Crete to escape being devoured by his father Saturn, the God of Time.

"The sacred goat upon his shoulder rests,

To infant Jove she gave a mother's breast."

and then

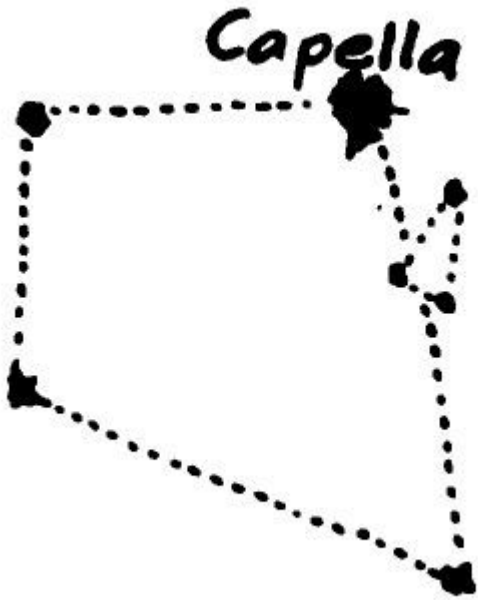
"Grateful he placed her there,

And bade her kids their mother's honour share."

It is further related that one day while playing with the goat, Jupiter accidentally broke off one of its horns. In atonement, he filled the horn with fruits and flowers—the

horn of plenty—and consoled the goat by giving it a constellation. The brilliant star, Capella, lies on the heart of this goat, the name signifying "the little She-goat," and not only the Greeks and Romans, but the ancient Peruvians, far across the ocean, connected this star with the affairs of shepherds. English poets refer to Capella as the "Shepherd's Star."

In the hand of this "mighty man seated on the Milky Way," who is sometimes called the Charioteer or the Wagoner, are the two kids which were raised with their mother to the stars.



These kids may be recognized by a small triangle of stars not far from Capella. They were often called the "frightened kids" by the ancients. No wonder they looked

frightened—the long horns of the red-eyed Taurus are lowered in the sky below them, the gleaming blade of the hero Perseus is brandished among the stars not far to the side of them and the huge bulk of the Great Bear is shadowed in the darkness just beyond them. The ancient people also called them the "horrid, mad stars" and feared their influence on the weather, for it so happened that these timid little creatures were either near the eastern or the western horizon during the storm weather. Since this coincidence happened year after year without fail, it was felt that the Kids were in some way responsible for it.

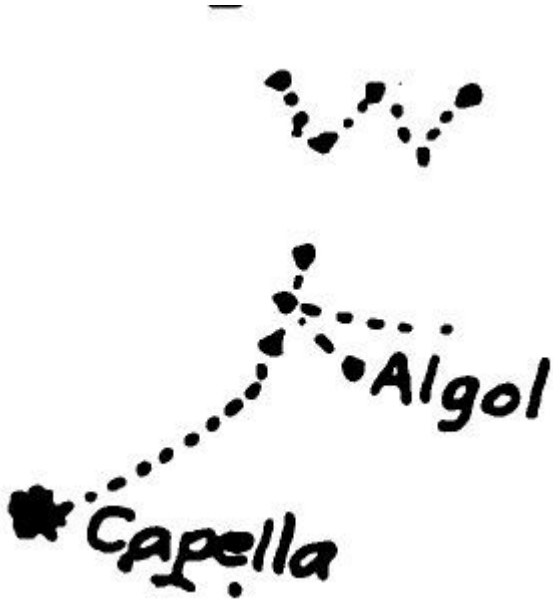
"Tempt not the winds forewarned of dangers nigh,

When the Kids glitter in the western sky."

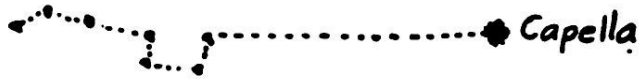
—Callimachus, 240 B.C.

Such severe storms were so common on the Mediterranean when they glittered in the eastern sky during their early rising in October, that their appearance was a signal for the closing of navigation. After the stars had made their final disappearance in the west, the people held a festival to celebrate their great relief and joy. The Kids were certainly not a popular star group with the ancient seaman's wife, for literature pictures her as clasping her hands and gazing fearfully out to sea as the winds and waves swirled and leaped under the influence of the "mad stars" and imperiled the safety of her dear ones.

The beautiful first magnitude star Capella may be seen any month of the year except July. It lies below and to the north of Perseus (three bright stars dangling below the Big W) and may be sighted in a straight line from the top of the bowl of the Big Dipper.



In the early evening on February 5th it lies exactly on the meridian halfway between Orion and the North Star, while in August it is low in the northeast and in June low in the northwest. The spectroscope has shown that Capella really consists of two great suns of nearly equal brilliance. These two stars lie so close together that there is not much more than half the distance between our earth and sun between them,—and they revolve around this common center of gravity in only 104.2 days!



As they revolve around this point the lines in the spectroscope periodically split, thus proving the double nature of the star. In the present state of our knowledge about eight stars out of twenty are binaries or multiples.

Short as seems the period of revolution of Capella and its companion compared to Sirius and its companion, which is about 50 years, or the couple of couples composing Castor, which is about 900 years, there are stars so close that they complete a revolution in a few hours. The very atmospheres of one pair of suns, δ Cephei, perhaps intertwine like lovers' arms, for they whirl about their common center of gravity in only 4½ hours!

The distance of Capella from the earth has been estimated as being about 34 light years. A light year is the distance that light would travel in one year at the rate of 186,000 miles a second. This is about six million million miles! Thus the twin suns in the system of Capella could have rolled off their tracks and exploded into atoms 29 years ago and yet we would know nothing of this catastrophe for 5 years to come.

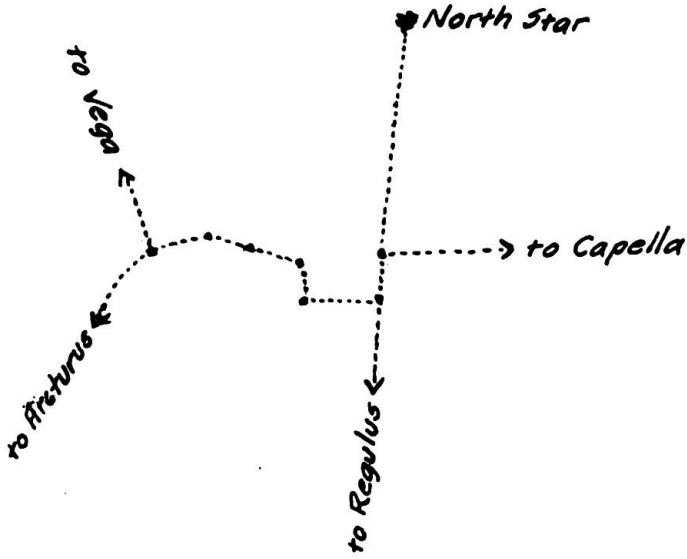
The fact that light takes a certain amount of time to travel and is not instantaneous, was first discovered by watching the little moons of the planet Jupiter, although it has since been determined from experiments on the surface of the earth. For a long time, an astronomer could foretell on what night and hour an eclipse of a given satellite would occur but he could not make the predicted minute agree with the actual time of eclipse. During the seventeenth century, Roemer, a Danish astronomer, discovered that the eclipses come 8 minutes and 18 seconds early when the earth is nearest to Jupiter and 8 minutes and 18 seconds late when it is on the opposite side of its orbit. He thus was the first to suspect that light could not flash instantaneously across the 186,000,000 miles which is the diameter of the earth's orbit. After it was found that light required 8 minutes and 8 seconds to come from the sun to the earth, it was a simple matter to find the space that it would move over in a year. This number, 63,368 radii of the earth's orbit or about six million million

miles, has been since taken as a handy unit of measure in estimating the distances to the stars. Thus a *light year* is the distance that light will travel in a year at the rate of 186,000 miles a second. An astronomer expressing the distance of a star in terms of this unit would say that Alpha Centauri is 4.26 light years distant instead of 25,000,000,000,000 miles, and 4.26 years would represent the time that it takes light to come from that star to the earth.

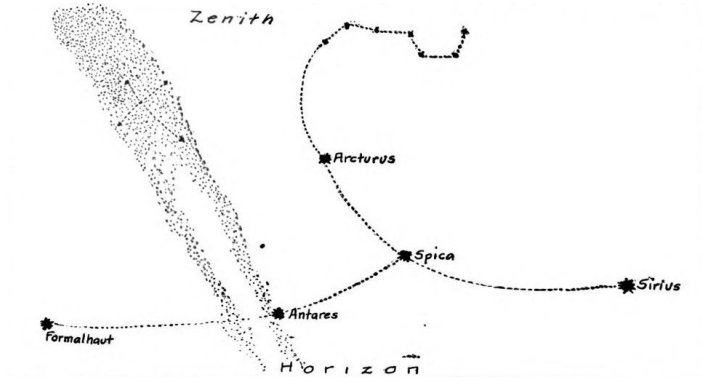
Although it takes light only about 8 minutes to reach the earth from the sun and about 4 years from the nearest star, it requires only one second from the moon, which is nearer than the sun, and 47 years from the North Star, which is a long way from being our nearest star. Sirius, our largest star, is distant only 8½ light years, but Vega and Capella, which rank just below it, are respectively three and four times farther away. Some stars are so distant that it requires thousands of years for their light to reach us. According to the calculations of Kapteyn, only one-eighth of the 6200 stars whose distance was measured are nearer than 100 light years. Four of these stars are known to be within 10 light years—Alpha Centauri, Sirius, Barnard's "runaway star," and one of the 7th magnitude known as Lalande 21,185. Yet all of these stars, those which are only a few light years away and those which are hundreds of light years away, seem suddenly to be our neighbors, when we think of them as being grouped within the protecting arms of the Milky Way, and the space between, which science has measured, loses some of its awfulness.

Our neighbor Capella is a beautiful star. It flashes like a great solitaire, a star-poem of loveliness in color. Early in August, in the far northeast, its creamy-whiteness is accentuated by seashell pinks which splash through the thickened atmosphere like the effervescence of a rainbow. This star, with two others,—Vega, a delicate blue and

Arcturus, an orange-gold,—are the three brightest stars nearest the north. Since they are easy to locate and visible most of the year they are usually the star lover's favorites among the stars. Learn to locate these exquisite isles of starlight by using the Big Dipper as a base from which to start.



How to locate Vega, Capella, and Arcturus with the aid of the Big Dipper. Note also drawing on page 43.



THE FOUR GREAT SOUTHERN STARS.

CHAPTER VIII

GREAT STARS OF THE SOUTH

SPICA FORMALHAUT

ANTARES SIRIUS

WITH the exception of the stars in the constellation of Orion,—Spica, Antares, Formalhaut and Sirius are the only stars of the first magnitude south of the celestial equator which are visible from any point in the United States. The Orion stars are winter stars and will be taken up in the chapter to follow, but these four stars, each of which in turn looms lonesomely in the south, are representatives of the seasons, and their very names, Spica, Antares, Formalhaut and Sirius, bring to mind successively, spring, summer, autumn and winter.

Spica, the "Spring Star," rises at sunset on the 10th of April and crosses the meridian during the early evenings of April, May and June. Its beautiful silvery-white flame first appears just a little south of east and it takes only 5 hours and 25 minutes to cover half of its arc across the sky. It is then a little less than half way up from the horizon and hangs on the same curve from the Big Dipper's handle as Arcturus.

Antares rises at sunset on the first of June and passes the meridian early in the evening during June and July. It rises

farther south of east than Spica and takes only 4 hours and 23 minutes to reach the meridian. It is then only one-quarter of the way up from the horizon. Being a brilliantly red star in a conspicuous anchor-like constellation near the Milky Way, it is very easy to locate.

Formalhaut rises at sunset about the 10th of October and reaches the meridian about 4 hours later. It first appears in the southeast and skims in a short arc closer to the horizon than any other first magnitude star.

Sirius rises in the southeast about 9 o'clock on the first of December, but anyone wishing to see this magnificent star during the summer months should look toward the east about 4 o'clock in the morning on the 16th of August. In 5 hours and 3 minutes this star reaches the meridian, one-third of the way up from the horizon. Sirius is the largest and loveliest star in the sky, possessing such a vivacious character combined with a sparkling, diamond-like beauty, that it is a delight to every eye that beholds it.

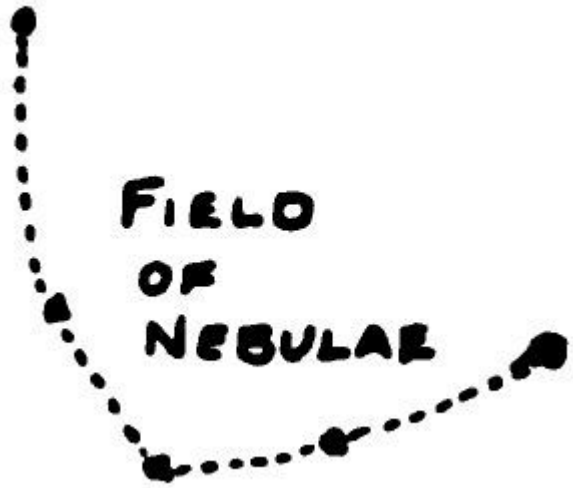
SPICA



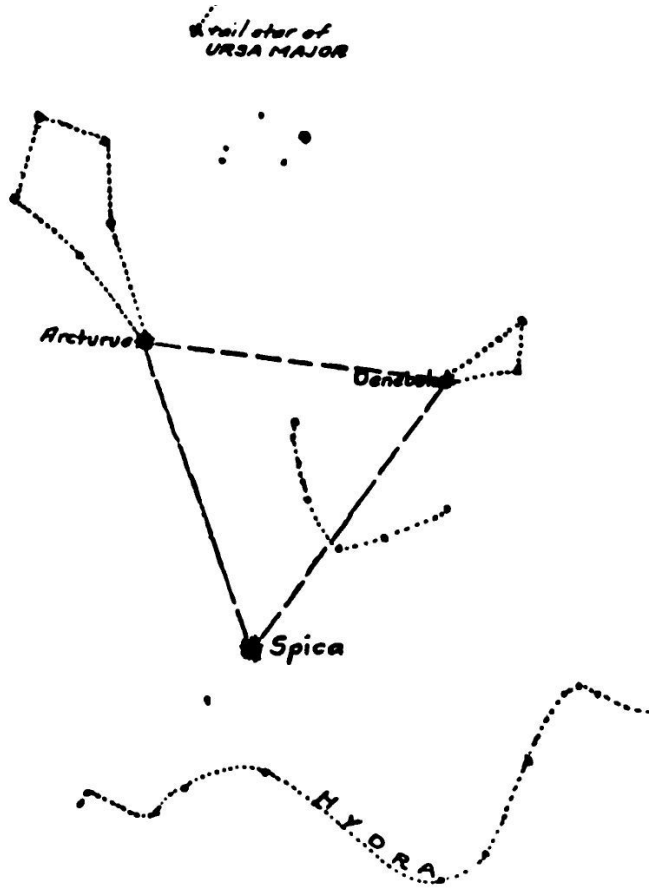
The constellation of Virgo, in which Spica is found, is easily recognized by its brilliant white star and its large V or corner of five stars which marks off the upper portion. The Arabian astronomers called the corner "The Kennel" or "The Retreat of the Howling Dog." Just beyond the Kennel gleams the star-dust on Berenice's Hair, and above this sprinkling of minute stars, howl the furious hounds of Boötes struggling madly to pounce upon the Bear.

A most remarkable nebulous region lies within the triangular corner of Virgo, although the nebulæ are very faint and only visible through a large telescope. Nebulæ as a class are found in abundance in the vicinity of the north pole of the galaxy, which lies in the constellation Coma Berenices, this corner alone containing almost 300, although they are rarely found along the path of the Milky Way.

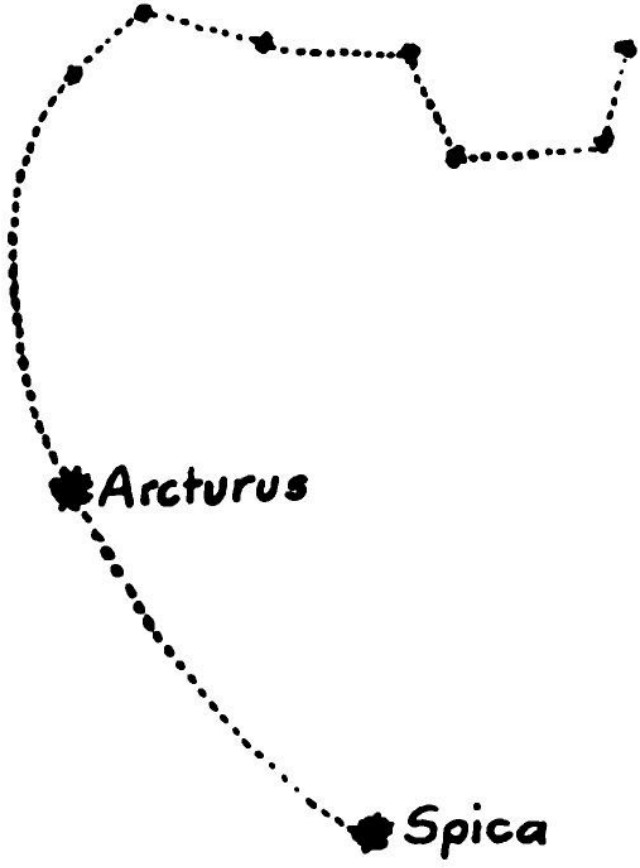
The yellow 3rd magnitude star on the upper end of the corner in Virgo has for many ages been called Vindemiatrix, which means "Grape-Gatherer."



It is believed that the star was given this curious name because it was observed to rise before the sun in the season in which grapes ripened. Vindemiatrix has a minute distant companion of a deep red color. The star at the other end of the corner has the interesting name of Zavijava, while the point is noted as a binary having a period of 185 years.



Spica, the "jewel of the Virgin," is best located by dropping an imaginary line through Arcturus from the handle of the Big Dipper. It rises about an hour later than Arcturus (who first appears at sunset during the latter part of March), and travels in a curve through the south.



These two stars contrast beautifully as they swing through the sky like gold and silver globes of fire strung on an invisible thread. A tale current among ancient people was that Virgo, the Virgin, was once Astræa, Goddess of Purity and Justice, who lived on earth during the Golden Age when all men were happy. During the Silver Age contentment still prevailed and the Gods lingered although men were less perfect and the world less tranquil. When the Bronze Age was ushered in men became so inferior

that the work of Astræa's office was ignored and she fled in sorrow to the sky.

> "Even so long as the earth still nurtured the Golden Race, she had her dwelling on earth. But with the Silver Race only a little and no longer with utter readiness did she mingle—
>
> "When the Bronze Race was born she loathed them for they forged the sword of the highwayman, ate the flesh of the plowing ox and engaged in strife and discord."
>
> —*Aratus* (*Trans.* C. R. MAIR).

Somehow the goodness and purity of Astræa were incorporated in one beautiful star called Spica, and this star shone with such exceeding whiteness that the whole constellation became Virgo, the Virgin. The pictures drawn on the maps vision a goddess with wings carrying a palm branch in one hand and an ear of wheat in the other. In some of the older maps, the goddess carries a balance or a pair of golden scales with which to weigh the fate of mortals, but this is now a separate constellation—Libra, the Scales—lying to the east of Virgo. In classic days, the two bright stars which mark the Scales were on the claws of the Scorpion which were then pictured as more extended.

The ancient people worshiped the constellation of Virgo with its beautiful white star, and, even as a quiet prayer may be said in music instead of in words, the purity of Spica seemed to glow like a benediction upon their revering hearts.

Even to the modern world, the springtime loveliness of this large and beautiful star is refreshing. But we are wont

to gaze upon it more with awe than reverence for science tells us that it is not only one white star but two, the mass of each being much greater than that of our sun. These two stars are only 11,000,000 miles apart and whirl around their common center of gravity in the amazingly short period of only four days!

Such is the jewel found on the Virgin's ear of wheat, although the myths do not all agree that Virgo is Astræa.

> "Whether she be the daughter of Astræus, who, men say, was of old the father of the stars, or the child of other sire, untroubled be her course."
>
> —*Aratus.*

However, they all do seem to agree that the constellation is connected in some way with the thought of harvests.

Virgo was early identified as the Egyptian Isis who dropped an ear of wheat as she fled from the monster Typhon when he appeared around the Nile. As a result the wheat was scattered in a wide path along the heavens which is now called the Milky Way. Among other characters, Virgo has been regarded as Ceres, the Goddess of the Harvests, and even as Ceres' daughter Proserpine. Plutarch seems to think that the Greeks are indebted to the Egyptians for their story of Ceres. Thus the Egyptian Isis would be Ceres, or Demeter. Isis also taught the use of corn which once stood neglected in the fields. The story of Ceres and Proserpine is particularly beautiful and deserves a place in every one's thoughts. One cannot have too many associations as he gazes at the starry skies, for each bit of even ancient gossip added to modern facts increases the pleasure in knowing different stars. This is particularly true if one does not own a telescope of any kind, indispensable as it may be to an astronomer.

The temple of Ceres, or Demeter, meaning "Mother Earth" (that is, not the whole solid earth, but the portion that produces vegetation), stands in the sacred city of Eleusis, on the Thracian plain, and all men who earn their living by the soil come here to do her honor. This temple was built on the spot where the Goddess met Triptolemus and taught him the use of grains, also how to plow, sow the seeds and gather the crops after they had ripened. Triptolemus then went forth and taught the nations of the world.

One day while Ceres was watching the harvests, Proserpine, her lovely daughter, disappeared.

"While like a child with busy speed and care

She gathers lilies here, and vi'lets there;

While first to fill her little lap she strives,

Hell's grizzly monarch at the shade arrives.

See's her thus sporting on the flow'ry green

And loves the blooming maid as soon as seen."

"Swift as a thought he seized the beauteous prey

And bore her in his sooty car away."

—*Ovid's Metamorphoses*
(MAYNWARING'S Trans.)

Pluto, it seems, had come above the ground to survey the surface of the Sicilian land, for the roof of his kingdom

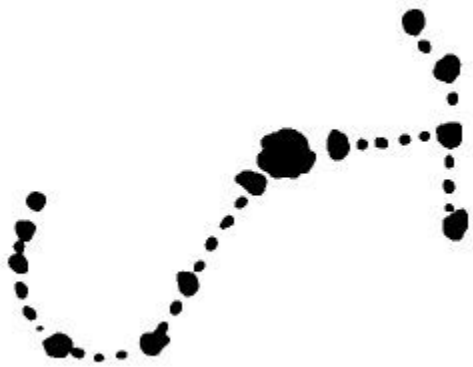
had been considerably shaken on account of the struggles of the giant Typhon confined beneath the roots of Mount Etna. Poets claim that no sooner had the Underground God appeared than Cupid, the mischievous son of Venus, pulled a gold-tipped arrow from his sheath, and laughing gleefully, shot the gloomy monarch in the heart.

Ceres, in the meantime, nearly frantic with grief, searched over land and sea for her lost daughter, and when night fell, so that her search might not be hindered, she tore up young pine trees by the roots and dipped them in the fires of Mount Etna. She could not eat, saying (as Tennyson puts it) that the "nectar smack'd of hemlock" and the "rich ambrosia tasted aconite," while ancient poets claim that neither Aurora, the Dawn, nor Hesperus, the Evening Star, ever saw her rest. Yet unweakened by fatigue and lack of sustenance, the goddess turned to the earth and forbade it to bear until Proserpine was returned to her.

When Ceres discovered that the King of the somber, joyless region under the ground had carried off Proserpine and made her the Queen of his Shades, she left the home of the gods in anger and went to live among mankind. Jupiter at last becoming fearful for the fate of man if earth no longer bore fruit or grain, sent Mercury down to inquire of Pluto if there was any hope of Proserpine's return. The Fates sent reply that if Proserpine had not tasted the pomegranate, the food of death, she could not be detained, otherwise she must remain forever. Ascalaphus then stepped forward and said that he had seen the Queen eat some of the seeds of this fruit,—for which tattling he was turned into a screech owl. Jupiter, pitying Ceres in her disappointment, succeeded in effecting a compromise by inducing his brother to allow Proserpine to spend six months of every year with her mother. This, the Greeks say, is the cause of summer and winter.

When Proserpine appears, Ceres commands the seeds, also, to force their way above the ground, the orchards become bright with a wealth of blossoms and the fields fresh with sprouts and vines. Ceres then is happy and the world a busy, beautiful place in which to live, but when Proserpine leaves, she cares not what happens, and the earth grows withered and drear. Of all the myths, Virgo seems the most charming when identified as Proserpine. Watch for the white flame of Spica as it rises just south of east on the 10th of April, for Spica shines on the ear of wheat in the hand of Ceres' daughter and is a symbol of the coming spring.

ANTARES



The red star Antares lies on the heart of the Scorpion and stands out conspicuously with a bright star on either side.

In Greek legend this is the same Scorpion which so

frightened Phæthon, rash child of the Sun-god, when he was driving his father's chariot along the zodiac. The headstrong youth had experienced trouble enough in passing by the ferocious Nemean Lion, and he was just getting a free breath while driving by the Virgin and the Scales when he came to this terrifying creature sprawled along and almost blocking the sky path. Unable to longer control either himself or his excited horses, Phæthon turned the steeds aside and blazed a new pathway, which soon grew cold and left a gray ash across the sky. The strip burned out by the scorching heat of the chariot may still be seen at night and is claimed by some to be the Milky Way.

There is still another legend which tells how the scorpion came to be a constellation. In ancient Greece there was once a mighty hunter named Orion. Armed with only a club, this powerful and handsome giant was able to conquer any beast in the world but, unfortunately, he boasted so continuously that Juno resolved to teach him a lesson. One day while he was battling with a monster in a swamp, a poisonous scorpion slipped up and stung him on the heel. The wound proved fatal, although he was afterward given a constellation as if in atonement for the rather mean advantage taken of so brave a hunter.

"The vast Orion thus he doomed to die,

And fix'd him, his proud trophy, in the sky."

—Lucan's Pharsalia.

But the scorpion was also honored in the same way, only he travels across the sky in the summer months while Orion is seen during the winter. Thus the two are considerately placed so that they do not shine above the earth in the same season.

"And so 'tis said that when the Scorpion comes

Orion flies to the utmost ends of the earth."

—*Aratus.*

The constellation of the Scorpion lies southeast of Libra, the Scales, and is the ninth and most brilliant in the zodiac. The gigantic and clearly marked star design on his figure shows that the creature's head and outstretched claws extend upward and toward the west; the upraised tail, curving through the Milky Way and close to the horizon, lies south and eastward; while his feet touch the fainter stars to the right and left. In the vicinity of his heart lies a star so large and red and beautiful that it was named "Antares," which means "the rival of Ares" (the planet Mars). This star so impressed the ancient people of Greece that they built a temple in honor of it, where they might gaze upon it in solitude and worship it as if it were enthroned. This temple is one of the oldest found in Greece.

Pease, with the aid of the interferometer on the great 101-inch telescope on Mount Wilson, has measured the diameter of Antares and has found it to be a very enormous red sun. This figure taken in connection with the best determined value of its distance, indicates that its diameter is *four hundred million miles*! The volume of this star is therefore about twenty-five million times as great as the volume of our sun. As far as we know, this is the largest star. This is surely most interesting. We might have imagined these gloriously tinted stars as small-sized novelties scattered about the heavens for our special edification—certainly we did not expect to find that some of them were so tremendously large that they would pass by our little golden orb as a speck of incandescent sand.



THE BATTLE OF ORION, THE GIANT, AND TAURUS, THE BULL.

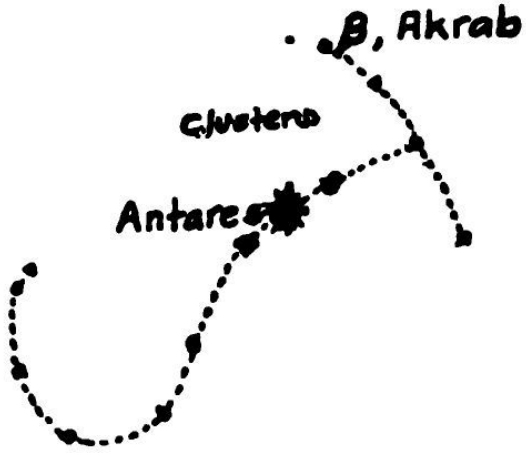
Not only is Antares of interest because of its great size and charming color but it also possesses a companion star of the vividest shade of green. This companion was first noted during an occultation in 1819, quite amazing its observer by sliding out from behind the moon just before the large red star emerged and dimmed its light by its powerful ruddy rays. The green-hued star is very tiny in comparison to Antares and may only be seen with the aid of a 5- or 6-inch telescope. Under good atmospheric conditions it is a very beautiful object.

The flame-red sun Antares beside its woodsy-green companion is one of the most impressive color combinations among the stars. Imagine living on a planet whose orbits encompassed such ostentatious stars! A green sunrise with a livid sky and a red sunset with a scarlet one —then a red sunrise and a green sunset—if colors affect one the way it is sometimes said that they do, the inhabitants of such a planet might live through "red hours"

and "green hours" like "Dr. Jekylls" and "Mr. Hydes."

What a surprise to the eye and a delectable bit for the imagination are the blue, gold, green, rose, lilac, purple and other fires in the sun-lit sky. Here is something "as rare as a day in June." It would seem as if the whole solar system were enchanted if we might visit the planets of a white and sapphire blue sun, for instance, or those of one of topaz-yellow and heliotrope hue. On the other hand it might seem beyond the bounds of reason to an inhabitant of a planet with a dark blue sun that a ray of white light contains the whole seven primary colors and that these colors are separately and in combination absorbed by the different objects on such a planet as our earth, permitting us to observe a wonderful exhibition of tints and colors, gayety, shade and brightness. If he, in his semi-dark blueness, could possibly visualize such a marvel as this, he surely would be well-nigh overwhelmed with the wonder of it. Perhaps our sun was the only star of the millions of stars in our Universe—(or in the innumerable Universes which drift in space beyond the island of our Universe)—that was able to produce planets that could bear life; and yet again, since the spectroscope has proved that our sun is constituted like many another star in the heavens, perhaps these other stars, like our sun, also have planets. At least it is reasonable and rather exhilarating to think about it.

All the brilliant red stars are young and in the giant stage of their career but the faint red stars are dwarfs and on their decline. The dwarf red stars are believed to be cooling for they possess chemical combinations only possible in a decreasing temperature relatively low for stars. This must mean that such stars are growing old, for metallic vapors are never found in stars that are young.



Scorpio, the Scorpion

In a still later stage, these metallic vapors condense and form a solid crust. About 500 red stars have already been observed but they are all at a distance vastly remote from the territory of our sun. Antares, however, is among the most youthful of the giant red stars and will gradually rise in temperature and become brilliantly blue during the next few thousands of millions of years.

Halfway between Antares and Akrab (β on the end of the upper claw), lies a very rich and condensed cluster of stars. This cluster, which is one of the finest known, may be easily seen in a small telescope. On the eastern side of the cluster is a dark nebula. Akrab is a triple star of the 2nd, 4th and 10th magnitudes. The little star 2 degrees east of Akrab is of the 4th, 5th, 7th and 8th magnitudes and is claimed by some to be the most beautiful quadruple in the heavens. Many other interesting stars may be seen around this conspicuous figure with a 2½- or 3-inch telescope, and

a handy little reference book for the amateur fortunate enough to possess such a telescope is William Tyler Alcott's "In Starland with a Three-Inch Telescope."

FORMALHAUT



Formalhaut is called the "Fish's Mouth" star because it is supposed to shine on the mouth of Piscis Australis, the Southern Fish. This Fish is represented in the star-maps as holding open its mouth in utter contentment while a long line of small, glittering stars wash down in a stream of water. This water flows from the Urn of Aquarius, the Water-bearer, who stands just below the head of Pegasus, the Winged Horse. The Urn is formed by a little Y of 3rd and 4th magnitude stars, and, to the Egyptians, was an emblem of the rainy season.

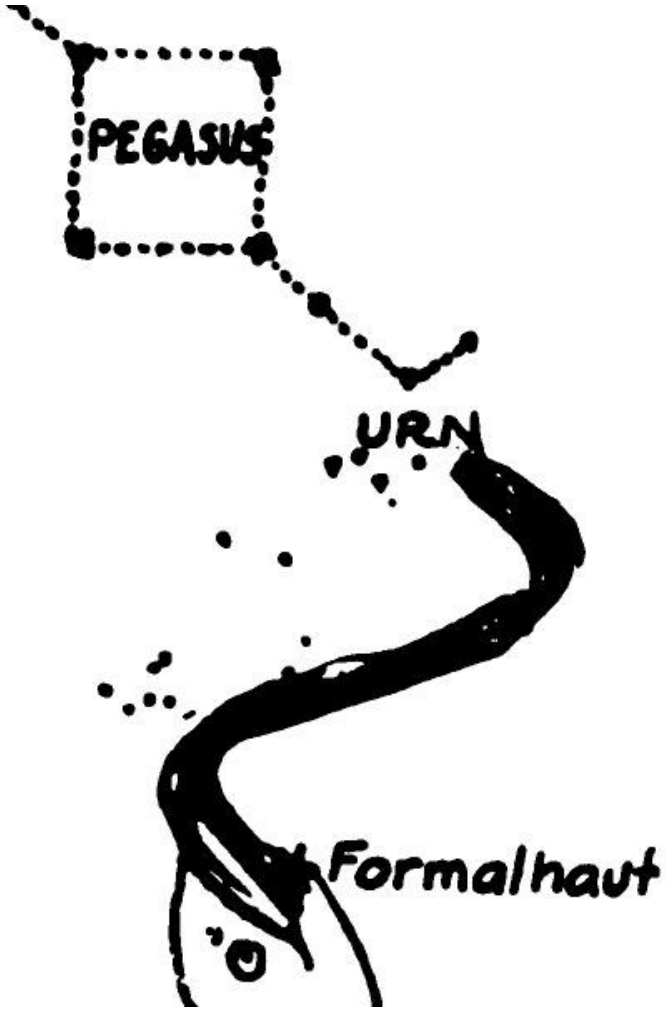
"Rolls from Aquarius' vase a limpid stream

Where numerous stars like sparkling bubbles gleam."

—Aratus.

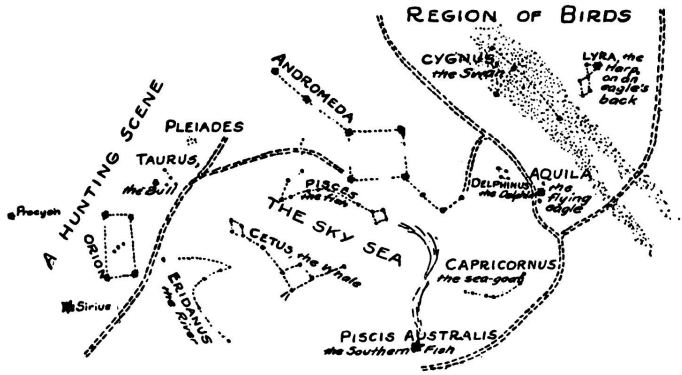
The Southern Fish must not be confused with the two tied fishes of the constellation of Pisces, known as the "Northern Fish," which lie to the east of the Waterbearer's

Urn. This region of the sky has been called the "Sky Sea," for not only does it contain three fishes but also Cetus, the Whale, Delphinus, the Dolphin, and Capricornus, the Sea-goat.



The three fish and the Seagoat were placed in the sky to commemorate the adventures of the Goddess Venus, the

little God Cupid and the God Pan with the terrible fire-breathing monster Typhon. When Typhon appeared with a deafening roar, shaking his head and belching fire, the immortals fled in a panic before him, and when Venus and Cupid and Pan jumped into a river, they were transformed into two fish and a Sea-goat.



The constellations which border the "Sky Sea." All of these stars are not in view at the same time.

The Southern Fish is connected in some way in the story but just how is not quite clear. Northwest of Aquarius lies the region of birds, while beyond the "Sea" to the southeast is the hunting scene of the giant Orion. The River Eridanus may also be seen flowing from a star near Rigel, on the foot of Orion, to a point on the shore of the "Sea."

Formalhaut rises in the south at twilight about the 10th of October and wanders westward in a small arc above the horizon. It is visible such a short time that it is said that it comes "when the leaves begin to fall and goes while they are still falling." This star rises in the south at the same time that Capella rises in the northeast, but an easier way of locating it may be found by estimating two-thirds of the distance across the sky from the outside stars in the bowl

of the Big Dipper. It also lies almost exactly in a straight line with the two stars on the west side of the great Square of Pegasus at a distance equal to 3⅓ times the distance between them and the southernmost of the two.

SIRIUS



If all the diamonds in the world were melted into one huge, magical jewel, its sparkling brilliance would pale beside Sirius, the diamond of the heavens.

This wonderful, iridescent beauty, fresh as a prismatic ice-flame, if such a thing might be, is best appreciated on a clear, cold winter night when the little stars swarm out like fire-flies and the large stars burn like Aladdin gems of frost and fringing fire.

The ancient Greeks, strange to say, dreaded the sight of this beautiful star, for they not only imagined that its "burning breath" caused the unhealthy and oppressive heats of summer but that it was directly responsible for their parched grass and blighted corn, their mad dogs and raging fevers!

The unpopularity of this star was due to the fact that during the hottest days of July it rose just before the sun and preceded that luminary all day long in his pathway

through the heavens. Not knowing that Sirius lay many millions of millions of miles beyond our solar system, they quite naturally supposed that his bright rays blended with those of the sun, greatly intensifying the heat. Thus Sirius caused the hottest season of the year and all the dried fields, mad dogs, plagues and fevers were attributed to its malignant influence. Since the huge star belonged to the constellation of Canis Major, the Great Dog, it was called the "Dog Star" and these hot, sultry days, the "dog-days." The dog-days lasted for about 40 days, extending from 20 days before the heliacal rising of the Dog-star Sirius to 20 days after. Owing to the precession of the equinoxes, the heliacal rising of Sirius is different from what it was to the ancients and the dog-days are now counted from the 3rd of July to the 11th of August.

Unlike the Greeks, the ancient Egyptians held Sirius in the highest esteem and built splendid temples in its honor in the valley of the Nile. J. Norman Lockyer has made an extensive study of Egyptian temples and has described them most interestingly in his book "The Dawn of Astronomy." During his explorations he found seven temples which were constructed solely to guide the light of Sirius through an opening in the side of the temple, down a long hallway to a point on the central altar. Olcott in "Star Lore of All Ages" visualizes the following beautiful scene in the most notable of these, the temple of Isis at Denerah:

> "Here the rising beams of Sirius flashed down a long vista of massive pylons and illuminated the inner recesses of the temple. What a wonderful scene there must have been enacted within that darkened edifice, when, in the presence of a vast multitude silent in meditation, there suddenly appeared a gleam of silver light, that laved the marble altar in

a refulgence born of the infinite, a beam, altho' the watchers knew it not, that had started on its earthward journey 8½ years before it greeted their eyes."

Why did the Egyptians reverence this star and hold it sacred while the ancient Greeks watched the same heliacal rising and vehemently denounced it for journeying so close to the sun at a season when additional heat was least desired? The Egyptians thought little about the heat, but with the appearance of this star just before the rising of the sun they knew that the season had arrived for the annual overflow of the Nile.

"Far in the south the daring waters rise,

As in disdain of Cancer's burning skies;

Thence, with a downward course, then seek the main,

Direct against the lazy northern wain."

—Lucan's Pharsalia.

This heliacal rising of Sirius, which the Egyptians called Sothis, was an event which needs must be heeded, for, having no calendars in those ancient days, it served as a warning that the river would soon overflow its banks and make a vast sea of the lowlands. It then behooved the husbandmen and gardeners to act quickly, and move themselves and their herds and flocks up to the dykes in a place of safety.

"Nile's redundant waters never rise

Till the hot Dog inflames the summer skies;

Nor to his banks his shrinking stream confines,

Till high in Heaven th' autumnal Balance shines."

—Lucan's Pharsalia.

During the inundation the lowlands are so completely covered with water that towns and villages rise like islands, while here and there are seen the tops of groves and fruit-trees like shrubs on the surface of the sea. This "yearly tribute of rains" which the Nile brings from other countries, gives new life to the parched land of the Egyptians. Herodotus, centuries ago, said that Egypt was the gift of this river, for without it their country would be a part of a lifeless desert. In the words of Amru, Egypt first appears as a dusty plain, then as a fresh sea, and finally as a bed of flowers. To still better understand why seven great temples were erected for Sirius, the "Nile Star," whose constellation was sometimes called "the watch-dog on the Nile," let us read Osborn's graphic description in "Monumental Egypt" of the transformations resulting from the watering of the sands by the overflow of the great river which the Egyptians guarded and held sacred.

> "The Nile has shrunk within its banks until its stream has contracted to half its ordinary dimensions, and its turbid, slimy, stagnant waters scarcely seem to flow in any direction. Broad flats or steep banks of black, unbaked Nile mud, form both shores of the river. All beyond is sand and sterility; for the ham-seen or sand-wind of fifty days duration has scarcely ceased to blow. The trunks and branches of the trees may be seen here

> and there through the dusty, hazy, burning atmosphere, but so entirely are their leaves coated with dust that at a distance they are not distinguishable from the desert sand that surrounds them."

Then comes the inundation:

> "Perhaps there is not in Nature a more exhilarating sight, or one more strongly exciting to confidence in God, than the rise of the Nile. Day by day, night by night, its turbid tide sweeps onward majestically over the parched sands of the waste howling wilderness. Almost hourly, as we slowly ascended it before the Etesian wind, we heard the thundering fall of some mud bank, and saw by the rush of all animated Nature to the spot, that the Nile had overleapt another obstruction, and that its bounding waters were diffusing life and joy through another desert."

After the flood comes sowing time and the effects of it all are exhibited:

> "in a scene of fertility and beauty such as will scarcely be found in another country at any season of the year. The vivid green of the springing corn, the groves of pomegranate trees ablaze with the rich scarlet of their blossoms, the fresh breeze laden with the perfumes of gardens of roses and orange thickets, every tree and every shrub covered with

sweet-scented flowers."

No wonder that the appearance of Sirius was hailed with reverence when its rising just before the sun meant also the rise of the life-giving river and the prosperity of the inhabitants of Egypt! However, as mentioned before, with the precession of the equinoxes, the heliacal rising of Sirius has changed and its brilliant light no longer announces the rising of the Nile.

Sirius is one of our nearest stars for its light requires only 8½ years to reach the earth. Yet its nearness does not account altogether for its quite exceptional brightness, for our sun at the same distance would appear as a star of the 6th magnitude and be invisible to the unaided eye. Only two stars, as far as has yet been discovered, lie closer to the earth than Sirius. The second brightest star in the sky is Canopus, visible from the southern hemisphere, but so far away that its distance can scarcely be estimated.

Halley, a celebrated English astronomer born 1656, made the first discovery of the relative motion of the stars when he noted that Sirius had moved from the position assigned to it on Ptolemy's map of 150 A. D. We have now reliable data for discussing the proper motion of about 10,000 stars. The proper motion of stars consists of a displacement in various directions of the individual stars. Thus the configuration of a constellation may slowly change, and, although many groups of stars all travel in the same direction, there are also conspicuous instances where they move in different directions. The Big Dipper and the Southern Cross are two star groups whose stars are traveling along different courses and after a period of time extending over thousands of years, the 'dipper' and the 'cross' effect of these two constellations will have altogether disappeared.

For a while Sirius was believed to be traveling in a

straight line, but soon irregularities were discovered in the great star's motion, an "undulatory progressive motion" on each side of a middle line. From a knowledge of these oscillating movements, Bessel inferred that Sirius must have an unseen companion attracting or pulling it as the two stars traveled together around a common center of gravity. In 1862, Mr. Alvan G. Clarke of New York detected this companion situated at an angular distance of only 7" from Sirius,—about as far distant as Uranus is from the earth. The larger star is only about twice as massive as its companion but is 20,000 times brighter. The light that we see from Sirius then comes from two stars which together radiate 48 times as much light as the sun. Compared to Sirius, our sun is rather an inconspicuous star, although Barnard gave us great satisfaction by discovering a neighbor not much farther away than Sirius which gives out only $\frac{1}{2500}$ as much light as the sun!

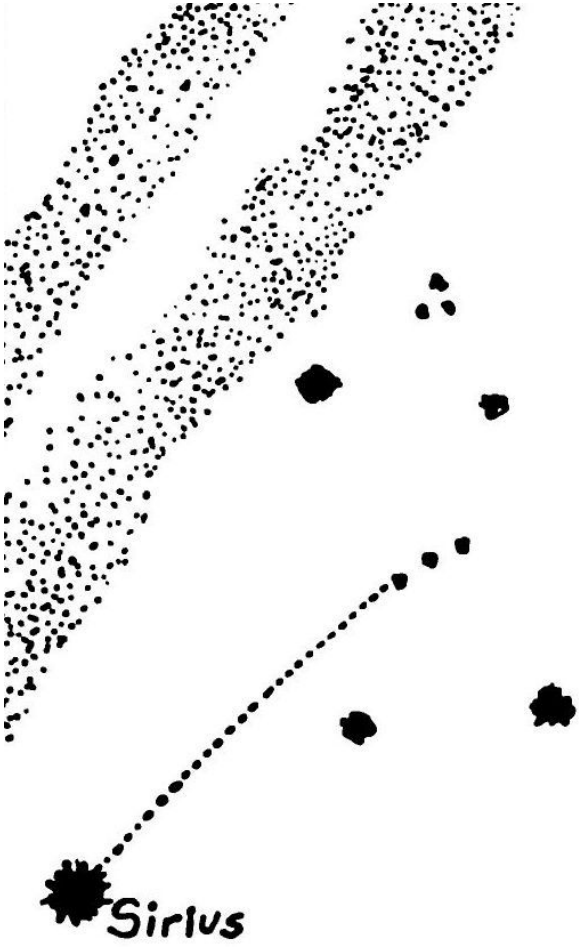
Sirius, the "Dog Star," rests on the nose of the Great Dog, in the constellation Canis Major, and may be found in a straight line from the three evenly spaced stars in Orion's Belt. He was originally Orion's hunting dog, and, as if to give atmosphere to a hunting scene in the sky, Lepus, the Hare, has been placed on a constellation just in front of Sirius and below the feet of Orion, where he is "pursued continually through all time" by the Dog with the huge star.

A vividly red variable star glows in the constellation of Lepus, the Hare. Every so often, this little star becomes radiantly red. This additional light is caused by the star bursting explosively through the layer of absorbent vapors which are smothering the life from its flames. Some day this crimson star will flare and flicker for the last time and its final ray be wafted to our earth—the Swan Song of a dying star.

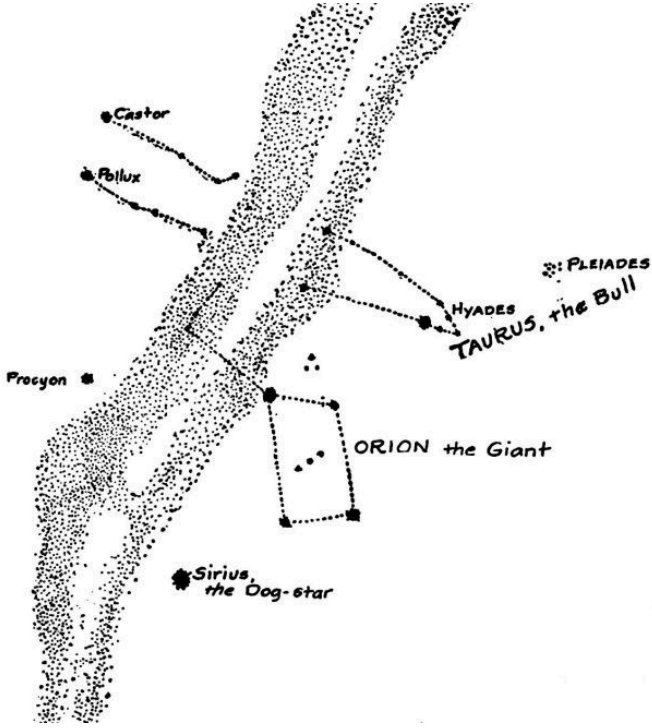
About 9 o'clock during the first part of December, Sirius

rises on its pathway south of east, the brilliant beauty of its light adding to the celestial scene like a torch among a thousand candles. This is true though the month of December exhibits the loveliest assembly of stars to be seen in all the year.

From December on into early spring, the Dog Star is the cynosure of every eye. Night after night, through the winter evenings, it flashes in the sky a little farther west; finally it gleams in the western sky at sunset, jewels the rim of the horizon, and disappears.



Orion and the "Dog Star."



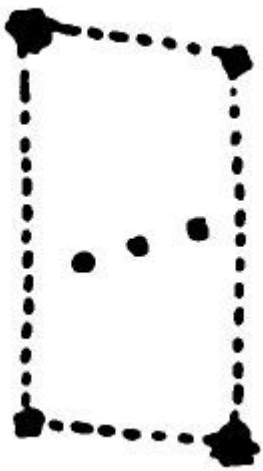
THE WINTER BATTLE OF ORION, THE GIANT, AND TAURUS, THE BULL.

These beautiful constellations first make their appearance during October, although they may be viewed to better advantage during the winter-time, when they lie directly in the south.

CHAPTER IX

THE STORY OF ORION AND TAURUS, THE BULL

ORION, THE MIGHTY HUNTER



OF all the interesting star-scenery that we pass as we travel in our year-long, never-ending path around the sun, the most magnificent and impressive is the figure of the beautiful constellation of Orion.

This constellation is not only one of the largest, but its stars are so particularly vivid as a group and so uniquely arranged as a design, that they never fail to catch the eye of even the casual observer,—like the carpenter, who, on noticing it for the first time, humorously exclaimed, "Well, look at the house-roof up in the sky!" thus unconsciously recognizing the stars as being united in a common picture or constellation.

All the ancient legends agree in describing Orion as a giant of extraordinary height and the greatest hunter in the world. Classical evidence is abundant as to his huge stature, though obviously, this evidence is not trustworthy. Pliny reports that an earthquake in Crete disclosed the bones of a giant 46 cubits in length, held by some to be Orion. A cubit is an ancient measure of about 18 inches so that if Pliny's report is correct, Orion was 69 feet tall.

There are many stories which relate the adventures of Orion but these vary even to the point of contradiction. Even the manner of his death is open to question, the two most popular versions being as follows:

Diana, the lovely Moon-goddess, sometimes neglected to carry the moon across the sky so that she might spend the evening hunting with her nymphs upon the mountains. On one of these occasions she met Orion, the mighty hunter, and straightway fell in love with him, thereby so greatly displeasing her twin-brother Apollo, the Sun-god, that he determined to put an end to the affair. The opportunity, unfortunately, came soon afterward when the hunter was wading in the sea. Pouring his golden rays on Orion so that the brightness would conceal him, the god suggested to the goddess that they practice archery on the beach. Then, pointing to a bright object shining on the waves in the distance, Apollo persuaded Diana to try her skill by aiming one of her arrows at it. Diana aimed, and since she had never missed, the arrow hit its mark. Amid

the ruffled waters tossed about in the giant's death agony, the goddess recognized the face of her beloved, and weeping bitterly, accused Apollo of the wildest category of sins. Proceeding then to Jupiter, she begged that god to place the hunter among the stars where she might always see him shining in the night time, as she drove her silver chariot along the pathway of the zodiac.

Another legend claims that Orion's death was caused by the sting of a poisonous scorpion which Juno had commanded to spring out of the ground and punish him for his unparalleled boasting. This has already been referred to in a previous chapter. Although the scorpion and the hunter were both placed in the sky, they were considerately situated in such positions, that when the Hunter appears in the east, the Scorpion disappears below the horizon in the west, thus saving the hunter the embarrassment of seeing his innocuous conqueror.

Still another legend describes the attempt of Æsculapius, famous physician and son of Apollo, to restore Orion to life. This attempt so angered Jupiter, due to the influence of Pluto, who had become irritated by the physician's power to detain a soul after it had started for the Kingdom under the ground, that Jupiter sent one of his thunderbolts and annihilated Æsculapius, otherwise his brother's realms might in time have become depopulated. Apollo, in fury, shot the one-eyed Cyclops who had furnished the thunderbolts, and then sought Jupiter, as had his sister, and requested him to place the physician in the sky and light him up with everlasting stars, for this was the second son that he had killed with a thunderbolt and he was feeling rather badly about it. Jupiter, having no objection to this, kindly granted the request, and it is believed by many that the physician is represented by Ophiuchus, a huge sky figure whose head rests next to that of Hercules.

When Orion was placed in the sky, he was allowed to

bring along his lion's skin, which hangs on his arm, his sword, which swings from his girdle, his great club, which he flourishes above his head, and his two dogs, who watch his battle with the red-eyed Bull.

"Begirt with many a blazing star,

Stood the great giant Algebar

Orion, hunter of the beast."

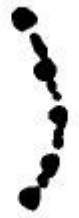
—Longfellow.

Taurus, the Bull, is easily recognized by his V-shaped face and the red glare of the star which marks his eye. This angry creature charges with lowered head, his golden horns just above the Hunter, who defends himself with his club now decked with glittering star-points and forces the Bull to back before him all the way across the sky.

A first glimpse of the Hunter and the Bull may be obtained in the east about midnight during late October although it is more convenient to look for them in November or December when the Hunter's huge figure stands squarely in the south. By the middle of May, the battle scene has reached the western horizon. One by one, each sparkling light disappears not to be seen again until the following October. One should say perhaps 'at a convenient hour' for in the summer-time Orion may be seen in the east at dawn. Aurora, the Dawn-goddess, up bright and early to open the sun gates for Apollo, saw the handsome hunter on the sky slope decked with red and white and yellow lights of stars. Like Diana, she loved him immediately, but, in the words of the poets, he pales before her colorful radiance as she reaches upward to announce the coming of the sun. Because dawn takes away the stars,

Orion is said to have been carried away by this goddess and even yet this story may be seen enacted when watching the glory of Orion captured by Aurora as she flashes rosy-tinted in the east.

THE LION'S SKIN OF ORION



During the course of his adventurous wanderings on earth, Orion once came to the Island of Chios, in the Ægean Sea, where he fell in love with a maiden named Merope. In order to display his skill as a hunter, he cleared the island of its scourge of wild beasts and brought their skins as presents to his sweetheart. This he accomplished alone and unaided except by his mighty club and the protecting hide of a lion. This is the same lion's skin that he wears in the sky during his struggle with Taurus, the Bull, only here it is adorned by a faintly curved row of tiny 4th and 5th magnitude stars, and about ten stars of the 6th magnitude. This "tawny skin" hangs over the Hunter's left arm between his western shoulder and the Bull.

"And on his arm the lion's hide

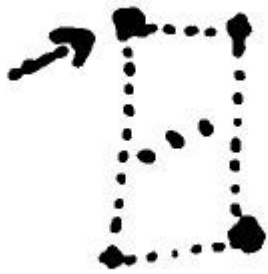
Scatters across the midnight air

The golden radiance of his hair."

—*Longfellow.*

The skin appears first of all above the eastern horizon and its little stars flutter vigorously as if being shaken warningly at any who might defy him. Then Orion, arrayed in large stars, slowly rises from his reclining position along the eastern ledge. One might imagine that he at first peers along the south in search of the poisonous scorpion which had stung him on the heel, for this must have been a supreme humiliation for so brave a hunter. But there is nothing in the south but the river Eridanus and the lightly starred Sea-monster with his head reared upward toward Andromeda. Feeling reasonably safe from any rear attacks, Orion now confidently climbs the darkened eastern slope; his Lion's Skin twinkles as he tautens his arm; his great Club is raised in readiness above his head, and joying in the combat, he henceforth wages, in unmolested peace, his eternal battle with Taurus, the Bull.

BETELGEUSE, ON ORION'S SHOULDER



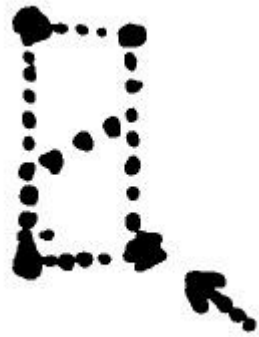
Just opposite the Lion's Skin, on the right shoulder of the Hunter, rests the beautifully tinted star, Betelgeuse. This star, like Antares, makes one think of roses, although Antares is more the shade of a deep red rose, while Betelgeuse is a wild rose pink. Diana probably notes the decoration as she passes in her chariot, for on certain dates she drives directly in front of his head-stars. On the opposite shoulder lies the yellow Bellatrix, "the female warrior or Amazon star." The title of this star was likely given it in honor of Orion's mother, who was fabled as Euryale, the famous Amazon Queen.

On account of recent discoveries concerning it, Betelgeuse has become one of the most interesting of our stars. When Professor Michelson of the University of Chicago discovered a means of measuring the diameter of stars, he measured Betelgeuse and found it to be of the most enormous size. Indeed, if this huge rose-tinted star were placed in the position of our sun, it would fill the solar system nearly to the planet Mars!

This unique achievement of measuring the diameter of a star made the world sit up in amazement. The measurement was made at the Mount Wilson Observatory with the largest reflecting telescope ever made, a telescope which has an aperture of a little more than 100 inches. A

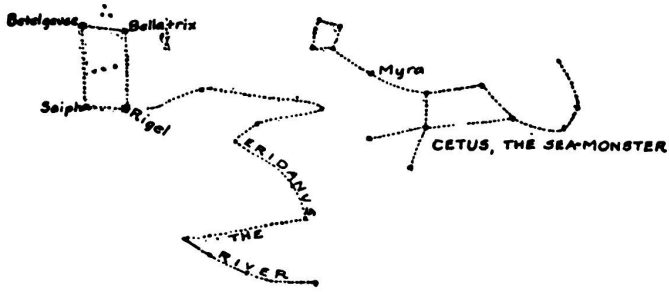
set of mirrors was attached in such a way that for the purpose of measurement the effect of a 20-foot aperture was obtained and Professor Michelson was able to prove that the disk of Betelgeuse has an angular diameter of approximately one twenty-second of a second—which means that if the distance deduced from the best determined parallax of the star is correct, the actual diameter is 230,000,000 miles! But this giant red star is a globe of little density; the dwarf red stars, although about the same mass, are found to be more compact. Hale in "The New Heavens" says that there are good reasons for believing that "the mass of Betelgeuse cannot be more than ten times that of the sun's volume. Therefore its average density must be like that of an attenuated gas in an electric vacuum tube." It is difficult to adjust one's everyday conception of a star to such a sheer and rarefied object. Such a star seems almost too spiritual to exist, and is certainly an amazing thing to picture in the heavens. But Betelgeuse is not a starry spirit, but a full-fledged mammoth star, though it is only recently (in a cosmic sense) that it started on its career.

RIGEL, ON ORION'S FOOT



The brilliant white light of Rigel on Orion's foot shines in charming contrast to the pink-tinged Betelgeuse which lies upon his shoulder.

Rigel is a young star but not as young as Betelgeuse, for Betelgeuse, like ruddy Antares, is among the youngest of the stars.



"The scorched waters of Eridanus' tear-swollen flood

Welling beneath the foot of Orion."

—*Aratus.*

It has been many hundred million years since Rigel was as big and red as Betelgeuse now is. Rigel belongs to a group which includes the hottest of all the stars and even at a distance of at least 450 light years, it still appears so brilliant that it is one of our brightest stars. It has been estimated that in actual luminosity it exceeds our sun about 13,000 times.

A blue star of the 9th magnitude lies close beside Rigel. This little star may be seen with even a small telescope.

Just a little west of Rigel wanders a crooked line of stars, first toward Cetus, then southward toward the horizon. This is the "poor remains" of the river Eridanus. Aratus speaks of it as those "poor remains" because it represents what is left of the "amazed Eridanus" after Phæthon had, like a streaming comet, plunged into it and partly burned it up. Aratus also calls it "The River of Many Tears" because the Heliades, Phæthon's sisters, who were metamorphosed into poplar trees, "all the day stand round the tomb and weep" great amber tears.

This constellation, which is best seen directly in the south during September, is a tribute of respect to the grief of the Sungod who had gazed with horror at the wild flight of the sun-horses and the thunderbolt of Jupiter that had hurled his boy through the air. Touched by Apollo's remorse for allowing the youth to drive his horses, Jupiter drew the river to the heavens, thinking that it might be a consolation to Apollo, as he performed his daily task, to view the kindly river, now flecked with stars, which had once caught the "charred fragment" of Phæthon and "cooled it in his waters."



"But earthbound winds could not dismember thee,

Nor shake thy frame of jewels."

—Charles Tennyson Turner.

ORION'S HEAD



The head of Orion is marked by two small stars and a larger one. These stars form a tiny triangle named Meissa, which means "The Head of the Giant." The three stars form rather a small head for the rest of the giant's well proportioned body, so they are sometimes placed on the side of his head and sometimes as beauty-spots upon his face, according to the fancy of the artist who portrays him. The triangle is faint but very easily seen and a happy addition to the figure; without them, or if they happened to lie in another position, the constellation might well have represented something other than a giant.

There is a curious optical illusion which occurs when the moon is among these stars, for the big, round full face of the moon actually *passes through* the sides of this (seemingly) tiny triangle. But one must be on the alert to view this interesting occurrence for the Moon-goddess travels swiftly in her chariot over the sky and leaves even her lover no more than a passing caress. The explanation is, that the triangle of stars on Orion's head appears small in comparison with the great quadrilateral figure which lies below it, and the delusion as to the size of the moon is accounted for partly as a result of its brightness (the bright rays spreading its image on the retina), and partly because there is nothing in the sky with which to compare it. When the moon rises behind a tree on the hillside it seems a mammoth thing, a silver ball so huge that it seems almost absurd to state that it can flit between the sides of Orion's

triangle. Yet the closer it comes to Orion's head the smaller does it seem to become and the larger becomes the triangle. When the two touch sides, the triangle is seen to be large enough to contain the moon, which slides through without touching its stars.

ORION'S BELT



Although most popularly known as the "Belt of Orion," this Belt is also known by other names. In the Book of Job it is referred to as the "Bands of Orion"; in the mythology of Greece and Rome, as the arrow with which Diana killed the hunter when he was wading in the sea, and in the mythology of Northern races, as Frigga's jeweled Spinning Wheel with which the Goddess wove the long threads of fleecy clouds. Miss Proctor says that the Eskimos believe that the stars may be three seal hunters who have lost their way, and call them the "Lost Ones," although they also think that the Belt resembles three steps cut in a snowbank. The native Australians unite the Belt stars in a picture with the Pleiad group above Orion's shoulder and, according to Allen, imagine them as three young men "dancing a corroboree" while the Pleiades are the maidens playing for them. In England the Belt is called the "Ell and Yard," the "Yard Wand" and the "Golden Yard," because its stars are

equidistant like a measuring rod; it is also called "Jacob's Staff" and sometimes the stars are called the "Three Kings," although the Germans call them the "Three Mowers." Far south on the hot deserts, the Arabs see the Belt stars as a "String of Pearls" and the Arabian astronomers, giving each pearl a name, called the first Mintaka, the second Alnilam and the third Alnitak. Other countries have called the stars "The Spangles" and "The Golden Grains," while Tennyson speaks of them as being "burnished by the frosty dark," which is the poet's way of saying that the stars of the Giant's Belt are exceptionally beautiful.

Modern astronomers turning their telescopes upon the stars of this Belt note that there is more to be seen here than meets the unaided eye, for suspended from either side, like an added attempt at decoration, hang tiny stars of different sizes, daintily colored. Mintaka (δ), the double star on the west, is a white and pale violet, of the 2nd and the 7th magnitudes. Alnitak (ζ) on the lower end to the southeast, is a topaz-yellow, light purple and gray, of the 2nd, 6th and 10th magnitudes. The faint star just below Alnitak is composed of an exquisite group of delicate stars of various colors.

If the north pole of our earth was shot out like a dart, it would hit the dome of our sky somewhere in the vicinity of the North Star. Likewise, if the earth's equator could be conceived of as swelling and swelling and swelling, it would hit Orion just about at the top star of his belt. The circular line where this imaginary terrestrial hoop would fit against the heavens is called the celestial equator and it, of course, is in a position equally distant between the two heavenly poles. A good way to remember just where the celestial equator passes is noticing the pathway which the star mentioned above traces in its journey from east to west. A teacher of astronomy would now add that not only

is the terrestrial equator marked as the celestial equator in the sky, but every meridian of the 'swollen' earth is traced up there as an hour circle, all of the hour circles being fastened in a great framework to both poles, as they are on earth. But instead of latitude the astronomer says declination, and in place of longitude he says right ascension, just as in place of meridian, he says hour circle. He then can designate the places of the stars in the sky in exactly the manner in which he designates the position of a sea or a city on the earth and as large telescopes are provided with equatorial mountings, so that their axes conform with that of our earth, objects in the sky can be located by the use of graduated circles and verniers, thus greatly facilitating astronomical research.

THE GREAT NEBULA OF ORION



One of the most impressive spectacles in the sky lies on the center of the Sword of Orion. This Sword is adorned

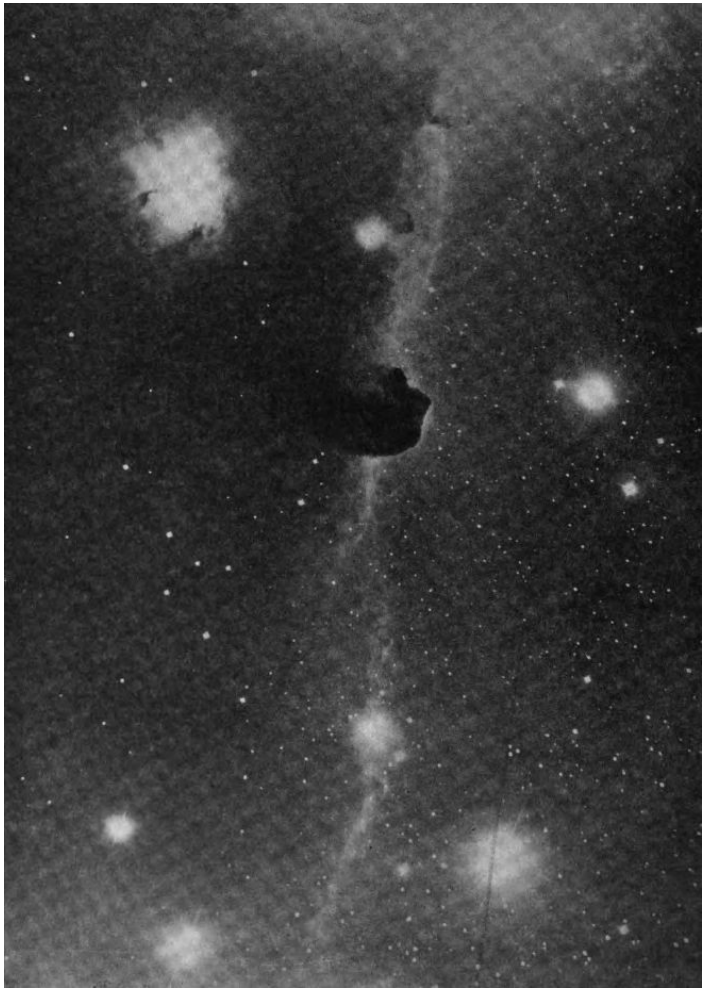
with three stars, the central one appearing misty, "like an eye in tears." A large telescope discloses that this is not a star after all but beautiful cloudy masses of nebulæ, which cover the whole central part of the constellation. A photograph uncovers a still further surprise (for the eye of a camera is more sensitive to light than the eye at a telescope), and one sees then that the nebula spreads in all directions, over and beyond most of the stars on the Hunter's figure.

> "It is a wonderful sight," says Peck in "The Constellations," "the whole field of view is filled with an irregular mass of green shining mist, which is apparently broken up into flocculent masses, delicate clouds of light, sprays and wisps, and standing out from the cloudy background, like a sprinkling of diamond dust, are seen faint, glittering stars."

Vast masses of dark nebulæ in the Nebula of Orion are also effectively revealed in telescopes. The dark nebula is visible in the photographs as veil-like clouds obscuring the light of the stars beyond them, or, again, as definitely outlined black blotches lying like some huge object on a brilliantly glowing background. Such a 'blotch' is the Dark Bay or Dark Horse Nebula in Orion whose photograph is so fearfully suggestive and wonderfully beautiful.

Nebulous clouds are, in general, dark rather than luminous. These clouds are believed by many astronomers to be cosmic dust-particles driven out from bright stars. These particles finally collect in great clouds which, when far from the light of stars, are dark. When the accumulating clouds of dust become so heavy that gravitation begins to draw their particles together, heat is generated and the

mass begins to glow, although sometimes dark masses, if they are close to stars, will glow with reflected starlight. The gaseous clouds are devoid of solid or liquid matter, and consist, the spectroscope shows, of glowing gases, apparently nebulium and hydrogen. Thus the Nebula of Orion, which is a gaseous nebula, is never spoken of as a "universe," like the Nebula of Andromeda, which may be resolved into stars.



THE DARK BAY OR DARK HORSE NEBULA IN ORION.

Photograph by Mount Wilson Observatory through the 100-inch Hooker telescope.

The finest example of an irregular nebula is the Nebula of Orion; of a ring nebula, that found in the constellation of Lyra; and of a spiral nebula, the one found in the constellation of Canes Venatici, just below the handle of

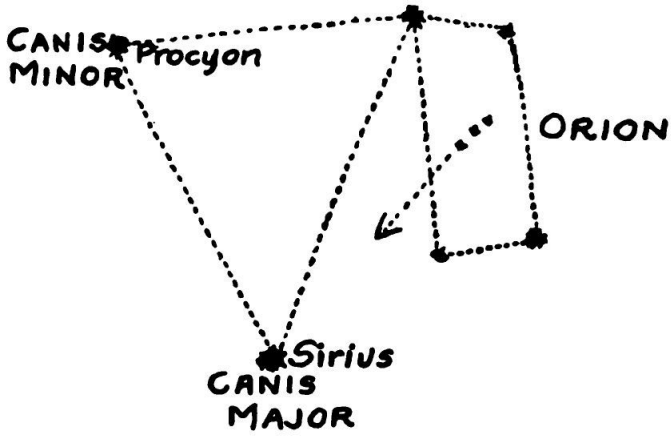
the Big Dipper. The spiral of Andromeda, which is turned edgewise to the earth, is the largest nebula in the sky.

ORION'S TWO DOGS—CANIS MAJOR AND CANIS MINOR

Canis Major, the "Great Dog" of Orion, lies in a straight line southeast of his Belt Stars. Canis Minor, his "Small Dog," lies across the Milky Way, 20 degrees northeast of Betelgeuse, the pink star on his shoulder. The three stars form a large and easily traced triangle.

Canis Minor is usually pictured as a Spaniel standing on the bank of the Milky Way and gazing across its river of stars at the giant Orion with his club upraised against the Bull. Although this dog is usually said to be Orion's dog, it is sometimes claimed to be one of Diana's hounds that followed her in the hunt. Other legends claim that Canis Minor was the dog of Icarus who discovered the slaying of his master by the shepherds of Attica and for this was placed among the stars. Procyon, the brightest star in this constellation, is called the "Little Dog's Star." It appears above the eastern horizon on the 23rd of January just after darkness, and shines for about half an hour before Sirius appears upon the scene.





Sirius is the head star of Canis Major and the brightest star in the sky. This dog sits at the feet of Orion watching Lepus, the Hare.

TAURUS, THE BULL



"Aries glorious in his golden wool,

Looks back and wonders at the mighty Bull."

—Manilius.

This is the bull that Orion chases backwards across the winter's sky, although only his foremost portion is visible among the stars. The rest of this creature might be imagined as hidden behind a cloud; but no, mythologists say the other half is immersed beneath the waves of the sea. Beneath the waves of the sea! It looks to us as if he were defending himself with considerable gusto against the advance of Orion, for did we not see him clamber backwards up the slope in the east only an hour and a half ahead of the giant who rose with his star club lifted menacingly above his head?

"Thy hoofs, unwilling, climb the sphery vault;

Thy red eye trembles in an angry glare,

When the hounds follow, and in fierce assault

Bay through the fringes of the lion's hair."

—Bayard Taylor.

If thus engaged, why was Taurus placed in the sky with a little cross-section of the sea about him? It was quite likely, we find, to preserve a note on the following legend:

Jupiter, the great ruler of Olympus, once changed himself into a snow-white bull. Such baffling disguises were the delight of this god when he had some particular object in view. This particular time he wished to carry off Europa, Princess of Phœnicia. He found the Princess playing in the meadow

"joyous, fresh, with roses bound

About her sunny head, and on her cheek

The glow of morn."

and placing himself conspicuously amongst the scenery, he soon caught her attention.

As soon as Europa spied this strange, white, gentle-appearing creature, she ran over to it, caressed it, and finally climbed upon its back. No sooner had she done this, than the bull, gathering the speed of the wind, ran to the sea-shore, plunged into the waves, and swam to the Island of Crete.

"Sweet Europa's mantle blew unclasp'd

From off her shoulders backward borne;

"From one hand droop'd a crocus; one hand clasp'd

The mild bull's golden horn."

—Tennyson.

This little Princess gave her name to the continent of Europe and the white bull was placed among the constellations.

Thus a plausible explanation is found for but half of the bull being shown among the stars—he is carrying Europa across the waves—then we look on his starry mane and find—not sweet little Europa clinging there, but seven lithesome maidens! These are represented by a lovely group of stars called the Pleiades. How does this happen?

Well, that is another story.

One day, while hunting, Orion came suddenly upon seven graceful sisters dancing on the mossy turf in the woodland. He watched entranced until the happy creatures noticed him, and filled with terror at his gigantic stature, turned and fled.





For five long years they ran, with Orion close behind, until weary and distressed they begged the gods for aid.

Then Orion saw the maidens vanish as seven fluttering doves which flew far up into the sunlit sky. That evening Diana saw them, and telling them to keep up heart, drove her moon-chariot past Olympus where she directed Jupiter's attention to the unfortunate plight of the maidens. Jupiter then changed the doves to stars and placed them on the back of Taurus, the Bull. Here they rest protected by a pair of golden horns, secure but still pale, for every winter's evening just as surely as they rise above the horizon, up comes Orion just a little way behind and

pursues the Bull across the heavens with his dogs and club.

Æschylus, however, claims that the Pleiades were named after the daughters of Atlas because of their touching sorrow when their father was laden with the weight of the sky. Thus many of the stories of Orion's adventures seem to conflict with other fables. Since the stars of the Pleiades bear the individual names of seven of Atlas's daughters, Æschylus was probably right. The stars outlining the face of Taurus were named after the half-sisters of the Pleiades and are called the Hyades.

THE HYADES



The group of five stars which deck the face of the mythological Bull have the individual names of Phaola, Ambrosia, Eudora, Coronis and Pholyxo. However these names are rarely, if ever, used and the bright red star at the top of the V is generally known as Aldebaran, the name given it by the Arabian astronomers.

During ancient times there was a certain amount of ill-feeling directed toward the Hyades, just as in the case of the "mad stars" in Auriga, for it was thought that since this group of stars rose in November when the stormy weather

usually began they exerted an unsettling influence on the atmosphere, which caused rain. The word itself is derived from the Greek word meaning rain.

"Thro' scudding drifts the rainy Hyades

Vext the dim sea."

—Tennyson.

In April when the Hyades set they also "Vext the dim sea" so by watching these stars the ancients were forewarned when the stormy weather and rain was at hand. Hesiod, who gave the ancient world one of its most famous poems, "Works and Days," mentions that when the Hyades are near the horizon they seem to disturb the calm of the waters and when the "Pleiades, Hyades and Orion set, it is time to plow again. But not to go to sea!" Aratus further warned the seamen at this point by reminding them that only a thin plank separates the sailor from Hades.

Kippax remarks that the "watery" or "moist" reputation of the Hyades may be due partly to the legend that the sisters were metamorphosed into stars for immoderately bewailing the fate of their brother Hyas who had been killed by a wild boar. Perhaps the sisters still think of Hyas when near the horizon and their unrestrained tears pour in floods upon the earth. But according to another legend, the Hyades were cloud nymphs and it was their nature to be incessantly weeping.

The beautiful, rose-colored star Aldebaran, "the eye of the Bull," flashes on the end of this V of stars. Like Antares, Betelgeuse and the planet Mars, its rare and colorful light shines like a beacon among the gold and silver of more somber stars.

Aldebaran is a much larger sun than ours and gives 45 times as much light. What a contrast to our sun with its sunflower shade would be this one of a wild-rose pink! But the restful greens of little earth are much to be preferred, with Aldebaran a star in the heavens, 28 light years away.

A little to the west and north of the star, on the tip of the southern horn of Taurus, lies the "Crab Nebula," so-called on account of its resemblance to a crab. This nebula is often mistaken for a comet. The two horns of the Bull reach over into the Milky Way, just below Capella.

The star group of the Hyades rises a little north of east about 12 P. M. in September. By the first of November they are all rising as early as 8 P. M. and by the latter part of January are directly in the south. At such a time, they have been picturesquely likened to a "flock of wild geese flying southward."

Even so small a glass as an opera-glass will disclose a rich field of small stars about Taurus. These stars look as if they had been shuffled and had fallen together in interesting little groups of lights, which are very pleasing to the eye.

THE PLEIADES



The Pleiades are visible from August until May. Five of the stars in this group may be plainly seen although most

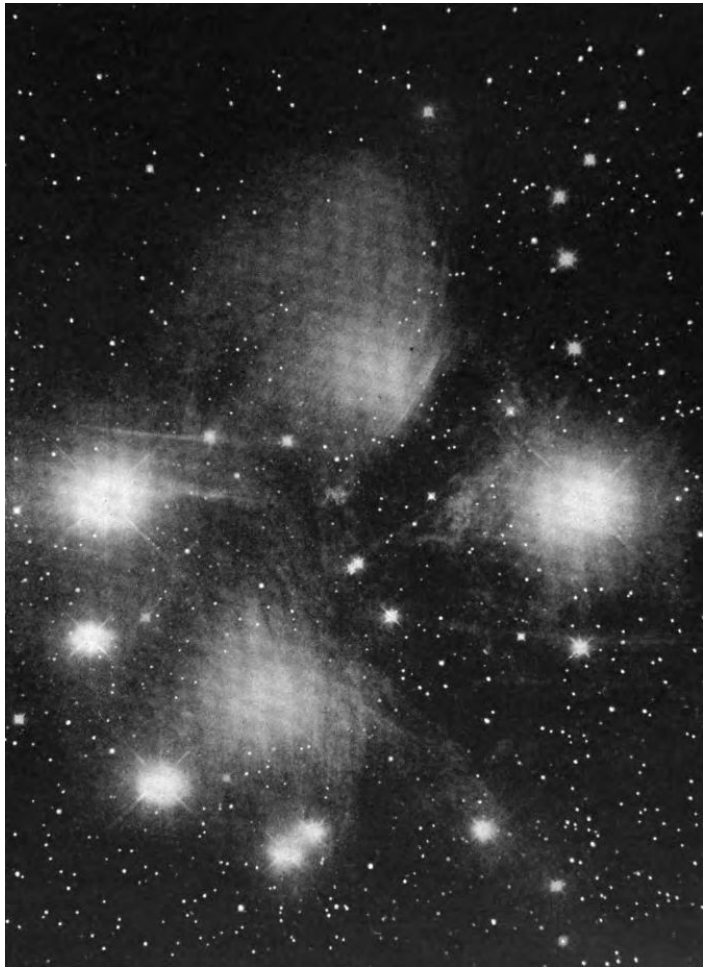
people can see six and many with keen eyesight can see seven and even nine. The telescope reveals about 3000 more surrounding the group which gives the appearance of mistiness in the vicinity of each star. These stars fill a space in the heavens equal to about 180 millions of millions of miles!

The five more important stars of the Pleiades lie in the form of a short-handled dipper. This is the fourth clearly marked dipper found in the sky—the Big Dipper, the Little Dipper, the Milk Dipper and the Dipper of the Pleiades. These stars are also, with the Hyades, Præsepe, Coma Berenices and the cluster on the Sword Handle of Perseus, among the few clusters visible to the unaided eye.

"Small is the place that holds them and singly they
dimly shine."

—*Aratus.*

Seven of the stars in the Pleiad group, named after the daughters of Atlas, are called Alcyone, Merope, Electra, Celæno, Taygeta, Maia and Asterope. Two other stars were named after the father Atlas and the mother Pleione. The Hyades and the Pleiades, or the twelve sisters which Taurus carries across the sky every winter's evening, are altogether called "The Atlantides." Atlas, by the way, also gave his name to the second largest body of water on earth, the Atlantic Ocean.

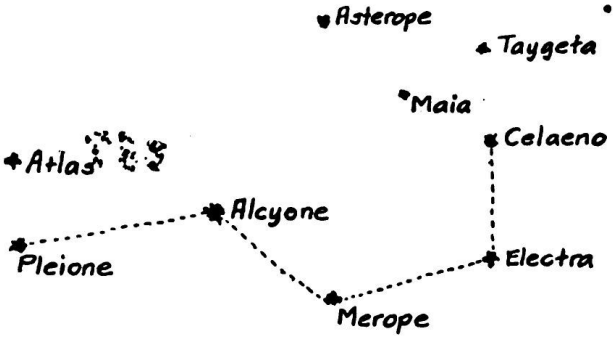


NEBULOSITY IN THE PLEIADES.

Photograph by Yerkes Observatory through the 40-inch refracting telescope.

Since the Pleiad group may be seen from every civilized country in the world, the stars have a host of legends, songs and stories twined about them. One idea, however, has run like a herald through all these widely separated countries and that is that one of the stars of the Pleiades

was lost and that there were originally seven bright stars.



The "Little Dipper of the Pleiades."

Although it is generally agreed that one of the Pleiads was lost, opinions seem to differ as to whether it was Electra or Merope as these two sisters had earthly reasons for sorrow; Merope, for instance, hiding embarrassed because she had married a mortal when all of her sisters had married gods. Another legend claims that it was Pleione, mother of the seven sisters, who was lost. Pickering, taking a practical view, believes that the true "Lost Pleiad" was Pleione, for the spectroscope reveals her star to be a variable star.

To the ancient people of Greece who taught even their children how to tell the time of the day by the position of the sun and what to do when certain stars rose and set, it would have been unpardonable not to have known the Pleiades. They thought that the gods had set the stars in the sky to keep the people from living in confusion. Thus Jupiter tells

"when the land

Must be upturned by ploughshare or by spade—

What time to plant the olive or the vine—

What time to fling on earth the golden grain.

For He it was who scattered o'er the sky

The shining stars, and fixed them where they are—

Provided constellations through the year,

To mark the seasons in their changeless course."

—*Aratus.*

The farmer and the sailor, especially, watched the rising and the setting of the stars and abided by the advice in Hesiod's "Works and Days":

> "when the snail, in fear of the Pleiades,
> climbs up the young plants, sharpen your
> sickle for the harvest—"

"At the rising of the Atlas-born Pleiades begin harvesting but plowing when they set."

"When Atlas-born, the Pleiad stars arise

Before the sun above the dawning skies,

'Tis time to reap; and when they sink below

The mom-illumined west, 'tis time to sow."

The rising of Orion an hour and a half later was also a sign from heaven that the season for threshing had arrived.

"Forget not when Orion first appears

To make your servants thresh the sacred ears."

But when the giant is in midheaven it is time for vintage. At this time Orion has backed the Bull pretty far over in the west and the Greeks watch the frightened Pleiades drop into the sea. It is now a dangerous time for small crafts to venture forth.

> "When the Pleiades, fleeing the mighty strength of Orion, fall into the murky sea"

make the boats secure for the sailing season is over.

"The Pleiads and Hiads make the seasons,

The Dogstarre maketh the heat of Sommer."

—1507, *Golding De Mornay.*

Yet the people around the Mediterranean were not the only ones who considered the importance of these stars. Spence in "Myths of Mexico and Peru" tells with what trepidation the ancient Mexican people watched, every period of 52 years, the passage of these stars across the zenith.

> "With the conclusion of each period of fifty-two years a terrible dread came upon the Mexicans that the world would come to an end. A stated period of time had expired, a period which was regarded as fixed by divine command, and it had been ordained that on the

> completion of one of those series of fifty-two years earthly time would cease and the universe be demolished. The Mexicans then abandoned themselves to utmost prostration and the wicked went about in terrible fear. As the first day of the fifty-third year dawned the people narrowly observed the Pleiades, for if they passed the zenith, time would proceed and the world would become respited."

Perhaps the reason for periodical recurrence of this fear lay in the old Mexican tradition that the world was once destroyed when the Pleiades culminated at midnight.

Poets in all lands have sung the praises of the Pleiad stars. Probably the most quoted are those from Tennyson's "Locksley Hall." These are so truly beautiful that one almost involuntarily repeats them whenever the huge giant Orion or this lovely star group comes into view.

"Many a night from yonder ivied casement, ere I went to rest

Did I look on great Orion sloping slowly to the west.

"Many a night I saw the Pleiads, rising through the mellow shade,

Glitter like a swarm of fire-flies tangled in a silver braid."

And Bayard Taylor speaks of

"The stars that once were mortal in their love,

And by their love are made immortal now,

Cluster like golden bees upon thy mane."

The poets, with their magic words, make the stars seem close to us, despite the fact that science tells us that the Pleiades, for instance, lie so far away in space that it takes 200 years for their light to reach the earth.

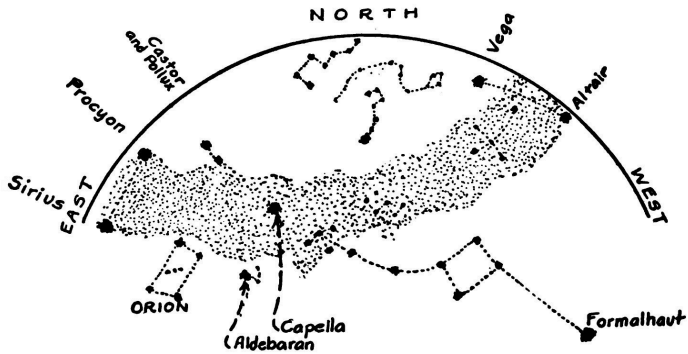
Since December, when Orion and Taurus are at their best, is the month of beautiful stars, let us look around the heavens and see how many of them we are able to recognize.

From the far northeast to the far northwest, passing just a little north of the zenith, the Milky Way stretches in one continuous line of splendor. Up and down the heavenly vault, hundreds of diamond-like little stars glitter like gleams from pinholes in heaven, while the large stars hang down through the cold, black nights almost within reaching distance. One may now count ten brilliant stars of the first magnitude, but the configuration of stars which forms the constellation of Orion and the peerless Dog Star, Sirius, are the stars which hold the eye. Watch the Dog Star rise in the east about 9 o'clock during the first part of December or about 8 o'clock later in the month. If all the other stars burn like wind-enflamed jewels, Sirius sputters and sparkles like a bonfire of Jupiter's lightning rods.

Across the Milky Way from Sirius, the yellow star Procyon, the head-star on the Little Dog, is also appearing, while in the west, two large stars are setting, the scene being almost duplicated. Thus, paraphrasing the words of the ancient poet Aratus, "when the Dogs appear in the east, the Birds set in the west."

Above Procyon, and on the same side of the Milky Way, shine Castor and Pollux, the Heavenly Twins, seemingly with an eye on the battle of the Giant and the red-eyed

Bull; above the Bull's horns glows Capella, always an attractive star but not as radiant when near the meridian as when rising in the east. This is also true of Cassiopeia's Chair, now in the zenith, and of the Segment of Perseus, the Chain of Andromeda and the Square of Pegasus, which lie just below her.



The December Sky.

The Cross is now descending in the west, closely following Vega and Altair, while low in the southwest, Formalhaut is just about to disappear below our view. The North Star shines, as always, in its fixed place in the sky, but Ursa Minor now hangs perilously by the tip of his tail with nothing between him and the northern horizon but the straggling form of Draco and the brightly decorated tail of Ursa Major. Ursa Major is just about ready to climb the eastern slope and patiently continue on his endless circle around the pole. Along the southern horizon, the stars are faint, for here lies Cetus, the dark-sided Sea-monster, and the glints on the river Eridanus which rolls down to the 'Sea.'

CASTOR AND POLLUX



According to legendary history, Castor and Pollux were the sons of Leda and the brothers of Helen of Troy. These twins were noted near and far for their bravery and had divine honors paid to them both in Sparta and in Rome. Their boyhood days were spent on Mount Pelion under the guidance of the wise centaur Chiron, but they spent most of their manhood adventuring, one of their best known exploits being the journey after the Golden Fleece on the ship Argo. During this journey a great storm arose and the frail little bark, whose only power was its fifty oars and the strong arms of the heroes, was tossed about like a shell. Orpheus, with his magic harp, sought to calm the waters and soothe the fears of the oarsmen, and had just about succeeded when two stars suddenly shone above the heads of the twins. This, of course, was static electricity, which sometimes appears like two stars of light attaching itself to each mast, but the Greeks considered it a sign from Jupiter that all was well and that there was nothing to fear from the storm. The Argo went on in safety, and ever after lights at the mastheads were called "Castor and Pollux" and sailors predict fair weather from their appearance.

"The Greeks called them Castor and
Pollux—which some call Hermes fire;

Saint Elmo others."

—*Sir T. Herbert.*

Sometimes, however, but one light is seen. This is then called "Helena," after their sister, and is regarded as foreboding a storm.

As a reward for their great affection (for the twins even shared their immortality together since only one was immortal), Jupiter placed them among the stars under the name of Gemini, and the two bright stars in this constellation were placed upon their brows. Sailors love these stars for they are well above the eastern horizon during the first part of January and are visible during the remainder of the stormy season of the year. They watch them and know that if both stars are visible at the same time, the weather is clearing.

"Thus the twins, indulgent save

The shatter'd vessel from the wave."

—*Idyllium* XXII (FAWKE'S *Trans.*)

If the storm continues to rage and the stars remain hidden behind the clouds

"sailors trembling

Call on the twins of Jove with prayer and vow."

—*Shelley.*

Gemini, the constellation of the Twins, lies near the stream of the Milky Way, just above Procyon, below Capella, and in front of Leo, the Lion. The feet of the

Twins are among the stars at the edge of the stream, while their heads extend northeast, in the same general direction as the horns of Taurus, the Bull, which are thrust into the stream on the other side. The Twins have no connection with the story of Orion and the Bull, although their constellation is so situated that one might consider them as interested spectators.

The stars on the brows of the Twins are not exactly twin stars for one is brighter than the other and, although they look much alike to the unaided eye, a telescope reveals their delicate colors. The star on Pollux is then seen to be a pale orange while that on Castor is a greenish-white. Pollux is also a triple star, described by one observer as "pale orange, lilac and gray." Castor is equally interesting, for a 3-inch telescope resolves it into two brilliant stars.



The spectroscope, making further discoveries, disclosed the fact that a companion whirls around the fainter component, completing its orbit in 3 days, while the brighter component also has a companion which completes its orbit in 9 days. These four stars, which form the star we call Castor, revolve in pairs about a common center of gravity, completing their period in about 900 years.

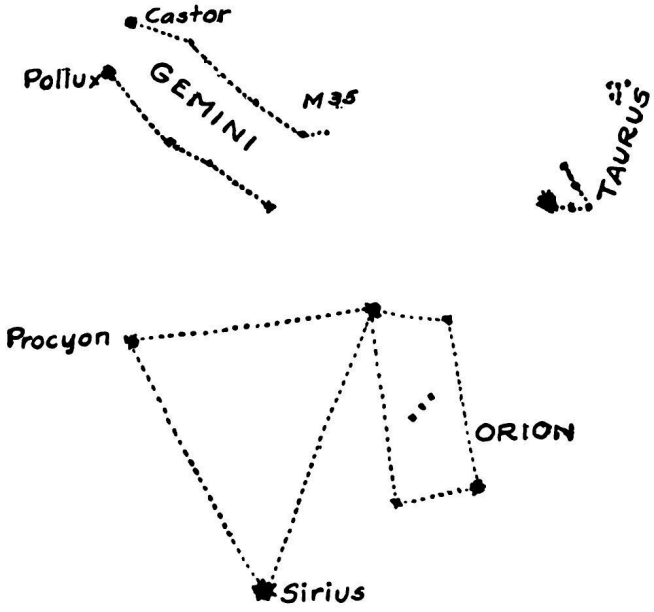
The Heavenly Twins claim a unique distinction—that of having a planet found at their feet; Sir William Herschel, an English astronomer, has the equally unique distinction of having found the planet. This planet was surely an odd and interesting thing for a mortal to discover for it is not only a gaseous globe 32,000 miles in diameter, but its pole points almost at the sun at one time in its 84-year journey, causing it to have 42 years of daylight and 42 years of night! This was the first planet added to the five known since antiquity and its discovery was a joyful surprise. The boundary line of the solar system was now greatly increased for Uranus travels in an orbit which lies at an average distance of 1,771,000,000 miles from the sun. In accordance with the ancient custom of naming the planets after the immortals on Mount Olympus, the planet was named Uranus, after the God of the starry sky.

A wonderful star cluster was later discovered also at the feet of the Twins,—a little northwest of the feet of Castor. This is designated at 34M on star-maps and may be located in the sky even with a field-glass.

Castor and Pollux may be found a little south of the zenith during the evenings of February and March. Castor, which is the higher star, passes the meridian first, but Pollux, the brighter star, passes it 11 minutes later. They are sometimes called "Ledæan lights" in honor of Leda, their mother. Owen Meredith in "The Wanderer" says

"The lone Ledæan lights from yon enchanted air,

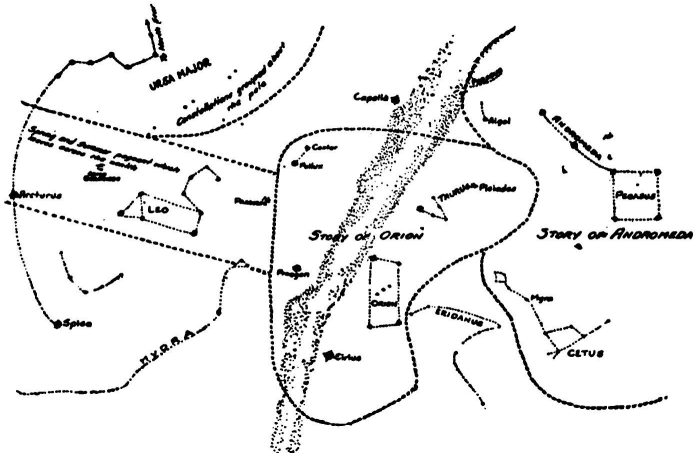
Look down upon my spirit like spirit's eyes that love
me."



Because of their nearness and similarity to one another, old English people sometimes call them the "Giant's Eyes."

We have now covered the most important constellations and have seen that a little knowledge of romance, beauty, story and fact add wonderfully to the spectacle of a heaven filled with stars. The thrill of rediscovery is for every individual who learns a little science; the romance and beauty for every heart which feels a little song.

From an open plain, the boundless sea, or the solitude of a mountain, the stars seem to hold their greatest appeal. If one knows the name of a star or two, one will find, as in "The Wanderer," a comradeship that is comforting.



Relative positions of the constellations "grouped about the pole," those appearing in "the story of Andromeda," the "Spring and Summer Pageant," and the "story of Orion and Taurus, the Bull."

Bayard Taylor, who often wrote about the stars, looked up, in a foreign land, and saw "Above the palms, the peaks of pearly gray," Canopus, a star of the southern hemisphere, only surpassed by Sirius.

"An urn of light, a golden-hearted torch,

Voluptuous, drowsy-throbbing mid the stars,

As, incense-fed, from Aphrodite's porch

Lifted to beacon Mars."

Then—

"Ah, bliss to lie beside the jasper urn

Of founts, and through the open arabesque

To watch Canopus burn!"

Let us face the heavens and dream for a moment, forget the earth—let it drop away—just drift and dream.

"Ring out, ye crystal spheres!

Once bless our human ears

(If ye have power to charm our senses so;)

And let your silver chime

Move in melodious time,

(And let the base of Heaven's deep organ blow;)

And with your ninefold harmony

Make up full concert with angelic symphony."

—Milton.

How rapturously the poets have dwelt upon the music of the crystalline spheres! How sad that the volume of it was so excessive that the ear could not hear it! And great it must have been with the whirr of a globe so huge that it contained eight concentric crystalline spheres whirling around every twenty-four hours and resounding with the stars as they rolled in their orbits.

This idea of the crystal spheres of ancient astronomy was beautifully described by Milton in "Paradise Lost." Milton believed without a doubt in the theories of Copernicus who taught that the sun was a center of a system of planets which revolved about it at various

distances, but he probably used this old conception of the universe because it gave him more artistic freedom in the writing of his great epic poem. Let us pursue this fascinating theme, while drifting and dreaming, and see in what way the great poet painted it in as a background for his story.

Milton pictured the boundless cosmos as divided into two parts—the "resplendent Kingdom of Heaven" which rested in brightness above, and the "turbulent darkness of Chaos" which surged in blackness below. Our "cheerful sun-illumined Universe" was thought to be contained in an opaque sphere which hung from the floor of Heaven by a golden chain. At the rebellion of Satan and his rebel followers, God hurled them through the floor of Heaven and down through the darkness of immeasurable space to a place in Chaos hollowed out to receive them. This place contained such dire discomforts that Satan in his wrath swore revenge.

Satan had heard that in order to hollow out this awful place in Chaos, the ether, which was believed to fill all space, flew upward

"spirited with various forms,

That rowl'd orbicular, and turned to starrs."

the stars walling-in a Universe which was to contain a dwelling place for a new race which might eventually take the place of the rebels cast from Heaven. The stars were then surrounded by a translucent shell which protected this new creation from the cold and tempests of outer space.

Satan searched long and ardently through the darkness for this splendid ball of light. Finally he found it, hanging on its golden chain from Heaven, and, descending within by the radiant stairway of the angels, passed the stars and

the planets in their sliding spheres of impalpable crystal, and discovered the earth, radiant in the brightness of the sun! Of the further adventures of Satan we need not speak, but the handling of the whole subject is masterly and brought to Milton undying fame.

The idea of the crystalline spheres first came to Eudoxus in the 4th century B. C. from watching the movements of the planets among the stars. He imagined that there must be nine of these hollow, transparent globes enclosed one within the other and surrounding the quiescent body of the earth; first, the "primum mobile," which carried around all the inner spheres and communicated to them a universal motion, next a sphere for all the stars, then one for the sun, one for the moon, and one for each of the five planets then known. These spheres were conceived to be of the finest crystal, for past the wandering stars or planets, the light came penetrating from that distant sphere studded with stars.

The daily movements of these stars were watched as they were carried along on their spheres, and it was seen that they moved in law and order. Noting that the planets seemed to be placed at intervals corresponding to the scale in music and being at the same time greatly impressed with the discovery that music was based on mathematics, he beautifully combined these discoveries and arrived at the entrancing conclusion that so great and orderly a movement of so many crystal spheres must give forth strains which united in a wonderful harmony of incredible volume and sweetness. The picture is enchanting—a beautiful world set in the midst of whirling, star-gemmed, crystalline globes, which by their motion, create a melody so divine that it may only be heard by the gods!

With the advent of modern science, our thoughts now wing their way through unobstructed star spaces of once crystalline spheres, to the great space beyond, and find in

the void of what the ancients termed "chaos," not one "sun-illuminated" universe but millions of them, some so distant that they appear no more than a filmy mist on a petal or a ghost of a fairy cloud!

To the true lover of the stars, one universe or a million makes not a whit of difference. The silent song of the heavens is as sweet today, its mystery as alluring, its delights more marvelous, than in the days of yore when planets rolled out heavenly notes and stars shone through the seven spheres of pure, translucent crystal.

CHAPTER X

ALONG THE MILKY WAY

THE MILKY WAY

ONE of the loveliest, and most amazing, phenomena of the heavens is the Milky Way. In olden times, imagination ran riot as to just what this luminous band of light could be. It was almost as great a mystery as the tides, which were called the "grave of curiosity."

Fully equal to solving the problem to their own satisfaction, even as they did the motion of the stars, the ancient people considered that here, perhaps, was a crack or seam where the two halves of heaven were imperfectly joined thus giving to earth a glimpse of the glory beyond the darkness.

"Whether the skies grown old here shrink their frame,

And through the chinks admit an upper Flame,

Or whether here the heaven's two Halves are joyn'd,

But oddly clos'd, still leave a Seam behind."

—Manilius.

In ancient Judea it was imagined as a Long Bandage

wrapped around the heavens.

Others thought that the Milky Way was not an imperfection in the floor of heaven but a pathway left open for the angels. A French legend has it the glimmering of lights held by angels to guide mortals on their way to heaven. Some of the tribes of American Indians have a legend somewhat like the French legend for they, too, thought that it was a road on which souls journeyed to their "happy hunting ground." The large stars, on either side of the road, were camp fires which cheered and warmed the travelers on their way.

Aristotle imagined that this misty arch of light was the result of gaseous exhalations which had risen from the earth and now rested between the region of the ether and that of the planets.

"The stars, and Sun himself, as some have said

By exhalations from the deep are fed."

—Lucan's Pharsalia.

Posidonious thought that it was a compound of fire less dense than that of the stars but more luminous. Still others fancifully considered it to be the course of the sun-chariot after Phæthon had lost control of his horses and that along here were the imprints of the hot hoofs and the ruts scorched by the fiery wheels.

A more modern legend of Swedish origin tells of the construction of the Milky Way by two lovers who were mourning for each other on separate stars. After toiling a thousand years they built this "bridge of starry light" which spanned the space between the two stars and enabled them to once more be united.

"And now Salami and Zulamith, when this long toil was done,

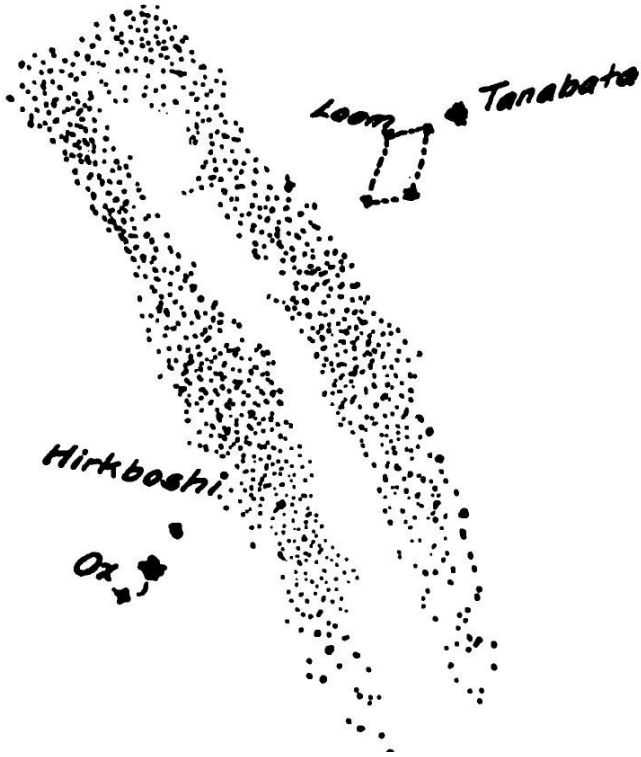
Straight rushed into each other's arms, and melted into one.

So they became the brightest star in heaven's high arch that dwelt,

Great Sirius, the mighty sun, beneath Orion's belt."

—*Topelius.*

The Chinese, Japanese and Koreans thought of the Milky Way as a river. An ancient tale, current in these countries, connects this "river" and the constellations of Lyra and Aquila in the quaint and charming romance of two lovers who were so happily married that they could not bear to be separated. As a result, they neglected their duties to such an extent that the God of the Firmament placed the bride on a constellation on one side of the celestial river and her husband on a constellation on the other side. "Now," said he, "on the 7th night of the 7th month you may meet—if you are able." This date occurs during the summer-time, in July, at a time of the year when the Milky Way and these stars are well placed for observation, and, on a clear night anyone with a keen eye and an open mind may witness a remarkable thing happen. Every magpie in sight flies upward, higher than it ever flew before, up to the very fields of heaven where the Milky River wends its way.



Ranging themselves side by side, the birds make a bridge of their bodies and wings which spans the celestial river and solves the problem of how the lovers shall meet. On this happy night, the stars of Lyra and Aquila burn with five different colors. If, however, the weather is stormy and rain falls, the river rises and flows over the plains and all the magpies in China, Korea and Japan cannot reach across it. The children of Korea stone every magpie they see loitering around its usual haunts, to remind it of its duty.

Lafcadio Hearn, who wrote the Japanese version of this story in a most delightful way, said it seemed to be the origin of a festival called Tanabata. During this festival the Japanese write poems with dew "from the River of Heaven," which is collected fresh from yam leaves. These

poems are written on strips of blue, green, red, yellow and white paper to match the colors of the stars, and are tied on bamboo stalks set up about the houses. Mr. Hearn in his "Romance of the Milky Way" refers to the story in this exquisite manner:

> "In the silence of the transparent night, before the rising of the moon, the charm of the ancient tale sometimes descends upon me out of the scintillant sky, to make me forget the monstrous facts of science and the stupendous horror of space. Then I no longer behold the Milky Way, as that awful Ring of Cosmos, whose hundred million suns are powerless to lighten the abyss, but as the very Amanogwa itself—the river Celestial. I see the thrill of its shining stream, the mists that hover along the verge, and the watergrasses that bend in the winds of autumn. White Orihime I see at her starry loom and the Ox that grazes on the farther shore—and I know that the falling dew is the spray of the Herdsman's oar."

There are any number of references to the Milky Way throughout the realms of poetry. Amelia describes it as

"a fair illumined path

That leadeth upward to the gate of heaven."

Milton—an

"ample road whose dust is gold

And pavement stars as stars to thee appear."

Ovid—a "high-road" "whose groundwork is of stars":

"A way there is, in heaven's expanded plain,

Which, when the skies are clear, is seen below,

And mortals, by the name of Milky, know.

The ground work is of stars; through which the road

Lies open to the Thunderer's abode."

—*Ovid's Metamorphoses*
(DRYDEN'S *Trans.*)

Chaucer calls it "Watling street":

"Lo," quoth he, "cast up thine eye,

See yonder, lo! the galaxie,

The which men clepe the Milky Way

For it is white; and some parfay

Callen it Watling streete."

This great street was "brent with hete," he goes on to say, when the "Sunne's sonne" lost control of the sun-chariot, "that he could no governaunce." In Germany this same street was called "Irmin's Way," for the Saxon God Irmin was believed to ride along here in a ponderous brazen chariot now seen in the constellation of the Great Bear.

In 1609 Galileo, the distinguished Italian astronomer, turned his newly invented telescope toward this mysterious illuminated arch, and saw, to his delight, that it was a "track of countless stars." This fact, which he proclaimed to the world, has even more lure for the imaginative mind than a "road whose dust is gold." A modern poet describes it as

"Infinity's illimitable fields where bloom

the worlds like flowers about God's feet."

Thus the cold glass eye of the telescope does not, like the eye of the Medusa, turn a singing heart into stone. Some of the early writers, such as Ovid, evidently suspected that the Milky Way consisted of millions of distant stars, but the suggestion did not take well with the mass of people who preferred the belief that it was a radiant stairway used by the angels.

The "silvery glow," which is such an attractive feature of the star stream, is caused by the accumulated light of a dazzling torrent of stars. These stars, or suns, are so unthinkably distant that their individuality is lost like particles of mist, thus causing the bright faces of Sirius, Capella and other great stars to seem suddenly close.

This path of stars, called the Milky Way, stretches entirely around the sky, or seems to do so, because our solar system rests almost within its center—"almost" meaning within about 60,000 light years, which is comparatively close to the center of a Galaxy some 300,000 light years in diameter. If we could step off the earth and look at these stars they would appear as a gigantic wreath; as it is, we see one half of the wreath from the northern hemisphere and the other half by traveling to the southern hemisphere. At least this much of the ancient conception of the universe was correct—that our earth was

situated near its center—but the idea that the sun, moon and stars whirled around it for its particular benefit, is looked upon as a vast conceit.

We now know for a certainty that our glorious Galaxy of stars is itself but an item in space, for since the recent investigations with the 60- and the 100-inch telescopes at Mount Wilson observatory with which the outer portions of the spiral nebulæ were resolved into swarms of stars, we know that there are hundreds of thousands of Galaxies separated from ours by a million light years, and from one another equally far. Probably the smaller nebulæ are even more remote. And we used to imagine that our own Galaxy floated through an infinite void of boundless space as lorn and lonely as Wordsworth's "cloud"! Then science goes still further and wonders if all these Galaxies form a part of a starry region which extends indefinitely in all directions or whether the star producing region is limited and surrounded by empty space!

> "The eagle flying in the face of the sun is as naught to the audacity of man poised on a speck in space, marshalling the heavenly host about him and calling them by name across an abyss of space that may take years, hundreds of years, thousands and possibly millions of years for light to cross."
>
> —*J. R. Collins.*

Our thoughts, now half stunned, fly back across unthinkable starless intervals, back like a magnet to the phosphorescent gleam which is ours in the boundless ocean in which a universe is but a gleam. Nearer—nearer —nearer—the gleam has softened to a touch of mist, the mist has expanded to a definite shape studded with stars

which are brightening, and widening apart. Now the shape has become an ethereal form, and before us rises a marvelous creation. As seen from this outer point, our Galaxy is neither a ring nor a wreath but is formed of huge spirals which reach far outward into the heavens. This cathedral of light, whose "lace-work" is of suns, covers an area so magnificent that a beam of light traveling 6,000,000,000,000 miles a year would require some 300,000 years to cross it! Around a modest, medium-sized star in the central cluster of this overwhelming and heroic structure, whirls a tiny planet named Earth, and on this Earth, the infinitesimal human being named Man, whose questioning mind thus flies from star to star.

"Round

That world of worlds His arm the Almighty wound;

The bright immensity He raised, and pressed,

All trembling, like a babe, unto His breast.

Think ye that I, who thus do ye maintain;

Thus always cherish ye, or all were vain—

Ye all would drop into your native void,

If by my hand ye were not held and buoyed.

—with God, 'tis one

To guide a sunbeam or create a sun—

To rule ten thousand thousand worlds or none.

Go, worlds! said God, but learn, ere ye depart,

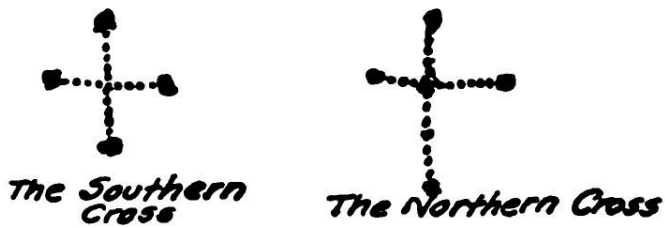
My favored temple is an human heart;"

—*Festus*, *Philip James Bailey.*

THE TWO CROSSES

At the foot of the Northern Cross, the Milky Way divides into two large channels which are quite irregular along the edges. These two channels do not unite again for a distance of 150 degrees, which leads us around to the southern hemisphere. As seen from the southern hemisphere, one of these divisions is particularly bright, while the other is not only fainter but looks as if its streams of stars had encountered obstacles along their pathway and had been forced to run up little rills along its sides.

On the Milky Way in the southern hemisphere, is the famous Southern Cross.



This Cross contains four bright stars set close together, one of the first magnitude, two of the second magnitude, and one of the third magnitude. Although its figure is not quite

so large nor as perfect as that of the Northern Cross, its stars are brighter and it holds a prominent position near the southern pole. In the first maps of the southern hemisphere, South America is designated as "Terra sancti crucis," the land of the holy cross. When Vega is our Pole Star, the Northern Cross will hold a prominent position near the northern pole.

Near the Southern Cross, as is the case near the Northern Cross, lies a remarkable dark blot which stands out sharply against the silvery path of the Milky Way. This dark body is 130 times larger than the area of the full moon and is much more impressive than the one seen in the north. It is said that superstitious sailors used to shudder and cross themselves because it lay so close to the Cross, but in those days, dark nebulæ were thought to be holes in the heavens and the combination was suggestive of what happened to sailors who were good, or who failed to be good.

Not far from the Southern Cross is a telescopic treasure which has long been enjoyed by astronomers. This treasure is a cluster of colored stars so delicately beautiful that the loveliest of rubies, emeralds and sapphires seem to have been filled with fire and turned to stars. There are over a hundred of these sparkling jewels in a space of only one forty-eighth of a square degree. What a delight it would be to suddenly uncover such a wonderful casket in our treasure hunt among the stars! But imagine the pleasure in watching the sky from the surface of a planet swinging in a field of such stars. Quite a thrill was experienced at the thought of a daytime tinted by a colored sun, or even two colored suns, but now imagine a night-time adorned with large and glowing pink, green, orange, red and yellow stars!

"their skies flowered with stars,

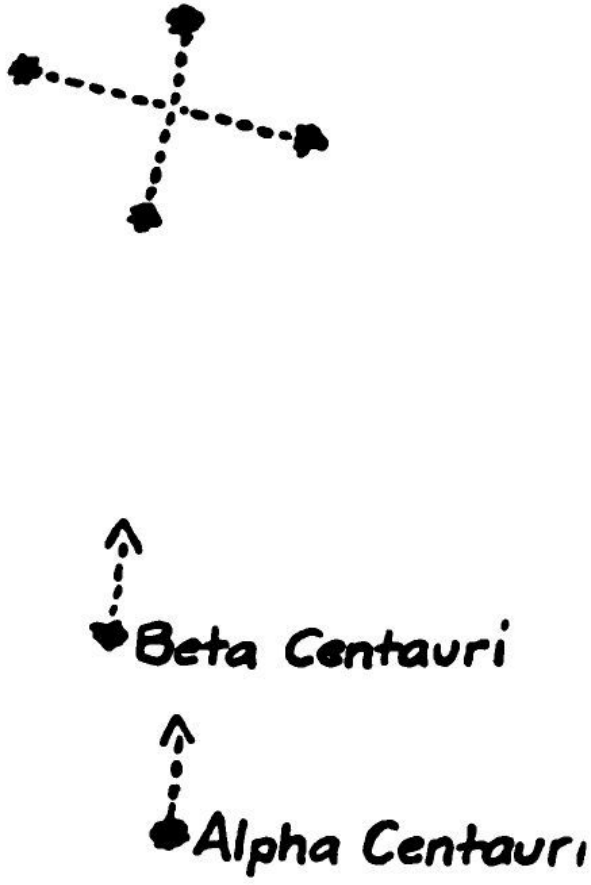
Violet, rose, or pearl-hued or soft blue,

Golden or green, the light now blended, now

Alternate."

—*Bailey.*

Just below the Southern Cross lie two stars which outrival the twin stars of Castor and Pollux.



The two pointers on the forefeet of Centaurus, the Centaur, and the Southern Cross.

These two stars are often called the "southern pointers" because they point out the Southern Cross. They belong to the constellation of the Centaur, Alpha Centauri being noted as lying closer to the earth than any other star. The light we call Alpha Centauri comes from two suns instead of one. These suns are separated from each other by a

distance of 2,000 million miles and gravitate one round the other in a time equalling 81 of our years.

Above the Cross shines Canopus on the stern of Argo, the ship of the Argonauts. Canopus ranks next to Sirius in brightness. The bright stars of Orion and the Scorpion are each in their season seen high in the sky. Thus the appearance of the heavens would seem quite strange to one who had come from the north.

THE MAGELLANIC CLOUDS

The Magellanic Clouds, which are almost as famous as the Southern Cross, lie to one side of the Milky Way, as seen by persons south of the equator, but they have no apparent connection with our Galaxy of stars. The "clouds" resemble the Milky Way and are easily discernible with the unaided eye, the larger one being 200 times the apparent size of the moon—about as large as the bowl of the Big Dipper—and the smaller one-fourth as large.

Photographs reveal the large Magellanic Cloud as being composed of nebulæ, individual stars and star clusters, the stars ranging from the fifth to the fifteenth magnitude. Flammarion counted 291 distinct nebulæ, 46 clusters and 582 stars. Herschel counted several hundred nebulæ and clusters "which far exceeds anything that is to be met with in any other region of the heavens." Dr. Harlow Shapley, director of the Harvard Observatory, found the linear diameter of the cloud to be 15,000 light years, and that it lay at such an immense distance that it required 110,000 years for its light to reach us. This cloud is like a small universe in itself, although many of its stars are anything but small for Dr. Shapley found that hundreds of them exceed the brightness of the sun by 10,000 times.

The large Magellanic Cloud lies between the southern

pole and Canopus; the smaller one between Beta Centauri and the pole. These starry clouds, which look so much like real clouds, were named after the celebrated navigator, Magellan.

CHAPTER XI

OUR NEAREST STAR—THE SUN

STARS are suns which lie at such vast distances that they seem no more than twinkling points of light. Through the aid of the spectroscope we have learned a great deal about these stars but so distant do they lie that no telescope on earth can bring them close enough for us to see the outline of a face.

There is one star, however, that lies so near that when it is in the sky its light blots out that of all the other stars. This sun, which classic poets call our "day star," lies only 93,000,000 miles away; the next nearest star is over 200,000 times as far. This distance of 93,000,000 miles is close enough to enable us to examine the face of such a star as ours with comparative ease, indeed, it is close enough to enable us to feel the warmth of the fierce fires which rage upon its surface.

It is not at all a difficult matter to realize the distance from our earth to the sun. A train traveling 60 miles an hour would reach the sun in 176 years; an airplane flying at the rate of 200 miles an hour would reach it in 50 years. Thus the distance seems to shrink as we adjust our rate of speed. A ray of light crosses the same space in about 8 minutes.

The existence of all life upon the earth is absolutely dependent upon the sun.

> "It is perceived that the sun of the world, with all its essence, which is heat and light, flows into every tree, and every shrub and flower, and into every stone, mean as well as precious."
>
> —*Swedenborg.*

Equally dependent are the seven other planets which, with the earth, whirl in elliptical orbits about this source of heat and light.

"The Sun the seasons of the year supplies

And bids the evening and the morning rise;

Commands the planets with superior force,

And keeps each wandering light to his appointed course."

—*Lucan's Pharsalia.*

The planets are sometimes called the "family" of the sun, although his family also includes the retinue of each planet, which in the case of six of them at least, consists of from one to ten moons. Our sun is no different than thousands of other stars in the sky; is it likely that our star alone of all the countless millions which shine in our universe, should be the only one to possess this additional charm of maturity? One looks far out in the darkness to the hosts of radiant stars—then wonders—how many stars have flocks of planets—how many travel alone?

THE SURFACE OF THE SUN

Compared to a point of starlight, the disk of our "day star" looks most exceedingly huge, and this at a distance of 93,000,000 miles. One is therefore not quite so surprised to learn that this great sunball, which rests like the hub of a wheel in the center of the solar system, has a diameter of 886,000 miles. The 8000 miles which measures across the earth seems quite inconspicuous when compared with such a diameter as this.

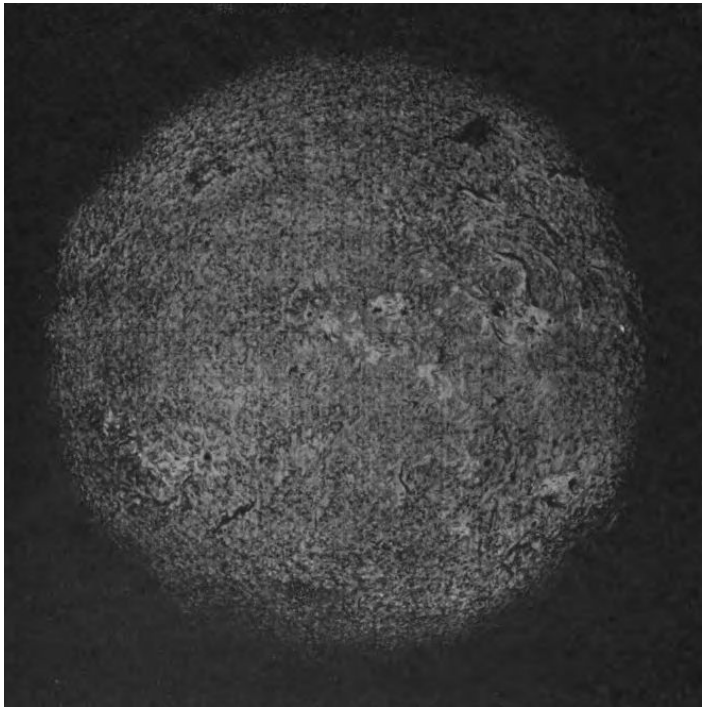
Completely covering the sun's surface is a mass of intensely hot crimson gases. These gases are like a turbulent upper atmosphere with a depth of 5000 to 10,000 miles. Raging and seething in long tongues of flame, they swirl up for thousands of miles above the surface, or are thrown far above it in titanic explosions. Formerly, these burning gases could only be seen at the time of total eclipse when the black disc of the moon passed in front of the glaring face of the sun leaving only the red flames licking out beyond the dark edge. The invention of the spectroheliograph now makes it possible to photograph these projections when the sun is shining. One should never try to see them by looking at the sun unless the glare is shut off either by the moon or by artificial means, for the sun is so unbearably brilliant that the eyesight of an observer would soon be ruined.



SOLAR PROMINENCES.

Huge flames ejected from the surface of the sun, photographed at Yerkes Observatory with the Rumford spectroheliograph attached to the 40-inch refractor.

This colorful gas which covers the surface of the sun, is called the *chromosphere* or color-sphere on account of the vivid color which it acquires from the hydrogen and calcium of which it is largely composed. The colossal flames which rise above its surface are called *prominences*. Some of the prominences shoot up with a velocity ranging from 300 to 600 miles a second, sometimes to a height of 200,000 miles, and even higher. The largest so far recorded extended upward for 500,000 miles. Others extend horizontally for a distance of over 300,000 miles, racing forward at the rate of a thousand miles a minute, although sometimes they remain in an unchanged position above the surface of the sun for days at a time. These flames seem tremendous compared to our terrestrial standards, but they would not seem so large on the globe of the sun which is 3,000,000 miles in circumference.



HYDROGEN FLAMES ON THE SURFACE OF THE SUN.
Photographed with the aid of the spectroheliograph at the Mount Wilson Observatory.

It seems strange to think that the "tranquil stars" must also be seething in such wild commotion,—blazing orbs torn by terrific tornadoes of fire. It is fortunate that we cannot hear the terrible roar as well as see the light of their conflagrations. Since sound waves do not travel through space like the waves of light and heat, the tumult on even our nearest star could never reach us; yet sound is such a laggard traveler compared with fleet-winged light, that light could cover the distance of 93,000,000 miles in less than 8 minutes while sound would require over 14 years to travel over the same space. Thus, even if we could hear the voices of these explosions, they would never coincide with

the scenes enacted.

The bright yellow surface of the sun which every one sees, is called the *photosphere* or light-sphere. If strongly magnified through a telescope, this surface is seen to have a decided "mottled" appearance, like a layer of little clouds with dark spaces between, spread over the whole face of the sun. These are now known to be masses of calcium gas.

Practically all that is known of the physical constitution of the sun has been discovered through the study of the fine, dark lines in the solar spectrum. Through the aid of the spectroscope, many terrestrial elements have been discovered, among these being calcium, sodium, magnesium, potassium, aluminum, silver, iron, nickel, copper, zinc, tin, lead, hydrogen, oxygen and carbon. All these elements are either in the form of permanent gases or metallic vapors.

The *photosphere* or light-sphere lies below the *chromosphere* or color-sphere. Beyond the crimson color-sphere lies another envelope of very delicate light called the *corona*. This may only be seen at the time of total eclipse. It was once thought to belong to the moon but it is now known that the moon has very little atmosphere. Besides, the moon's black disk may be seen floating across this beautiful halo of light.

The corona has been described by those who have seen it, as having a "soft, pearly radiance" "tinged with green"; its form is quite irregular and varies at different times, extending from 1,000,000 to 3,000,000 and sometimes even 9,000,000 miles beyond the surface of the sun. In the eclipse of 1879 the streamers were quite extensive in the equatorial plane of the sun where they united in a formation like the petals of a narcissus while at the solar poles they were shorter and extended in well-defined rays. Yet no matter what its form, it is a magnificent background

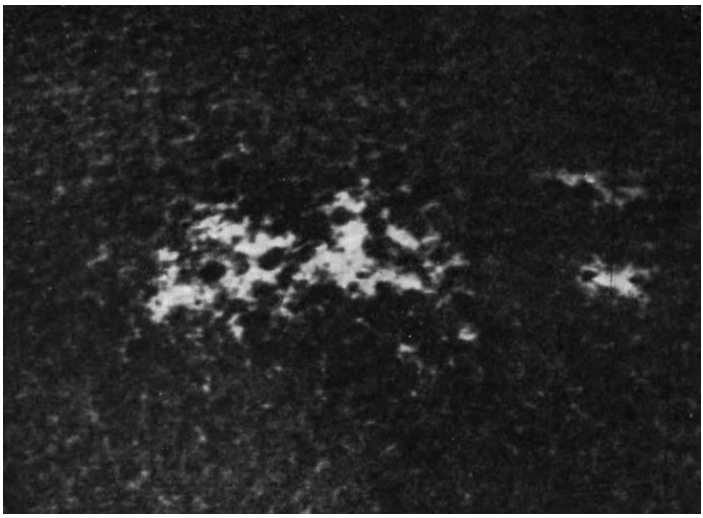
during the sun's eclipse for the narrow rim of deep crimson projects beyond the inky edges of the moon.

The corona seems to be caused by electrical discharges in a medium of fine dust and rarefied gases, chiefly coronium and protofluorine. Various electrical phenomena take place in the strong magnetic fields of the sun as a whole and in the sun-spots, and the changing fields of magnetic force cause the changing appearance of the corona.

The sun-spots, however, are of the greatest interest to amateurs for these may often be seen with very little optical aid. These dark, movable spots were first noted by Galileo, although the idea that the sun could have spots upon its surface was ridiculed by the scholars of the medieval schools who argued in the fervid language of scholastic philosophy and medieval dogmatism, that the sun was a sphere of pure fire undefiled by any spots.

Sun-spots are, as a rule, thousands of miles across and usually appear in groups which cover an immense area on the surface of the sun, but, since the sun lies 93,000,000 miles away, a spot large enough to contain the earth would appear to us about the size of a pinhead on a pincushion. Right here one should be warned again not to attempt to look at the sun without adequate protection (such as smoked glasses) for the eyes. A photograph taken through a large telescope is the most satisfactory. Although these dark blotches—which are only comparatively dark—were called "spots" and were later drawn as saucer-like depressions, modern research and increased power in the telescopes has revealed them as gigantic solar tornadoes. These tornadoes usually last from a few days to several months, and are especially numerous in cycles of 11 years. During sun-spot activity eruptive prominences rise to heights of many thousands of miles and streams of electrons are shot forth with such force that they may

possibly even penetrate deeply into our own atmosphere causing disturbances such as magnetic storms and auroras.



SUN-SPOTS.

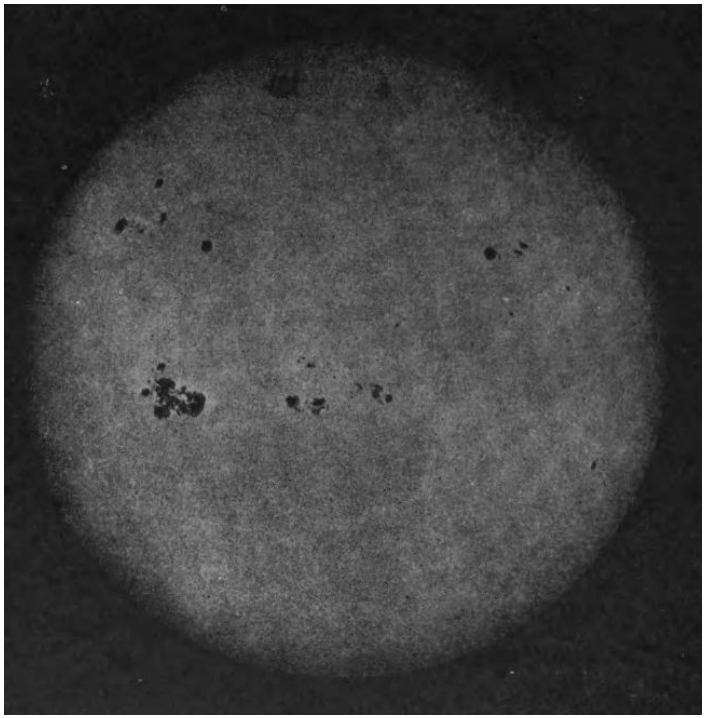
The earth is so small compared with the huge bulk of the sun that it would be lost in one of these "spots." Photograph by the Mount Wilson Observatory.

If a total solar eclipse occurs at a time when these great magnetic storms are raging in particular fury on the sun's surface, the corona always appears brighter and more intricate than when the sun is peaceful.

Sun-spots were very numerous in 1915 and 1916. The next spot maximum will occur about 1926, then in 1937 and so on. For three years or four years they appear with great frequency, then declining to a minimum for three or four years, rise to a maximum again; thus the period from maximum to maximum is about 11 years.

Through watching these black spots disappear around one edge of the sun and then reappear after an interval of time on the other side, Galileo discovered that the sun

turned completely around on its axis in 25 days.



SUN-SPOTS, DIRECT PHOTOGRAPH.

Compare with photograph on page 214, also made on same day by the Mount Wilson Observatory.

Further study disclosed the still stranger fact that the sun does not turn around in a solid body. Areas near the equator were found to complete a revolution in 25 days, but they were seen to forge ahead of those regions in higher latitudes; 45 degrees north and south latitude, the rotation period is 27½ days; 60 degrees north and south latitude, the period is 31.2 days, and in 80 degrees north and south latitude, the period is 35.3 days. This alone can be regarded as proof that the sun's apparent surface is not

solid but is either in a liquid or gaseous state.

AN ECLIPSE OF THE SUN

A *total* eclipse of the sun is caused by the moon passing between the earth and the sun, and since the moon is apparently the same size as the sun in the heavens, it hides the bright face of this luminary from our view; but the long shadow which trails behind the moon must touch the earth. The shadow moves along a narrow strip as the earth revolves and only those who are in this shadow can see the sun totally eclipsed.

If the shadow of the moon does not quite touch the earth, the moon's disk does not quite cover the sun.

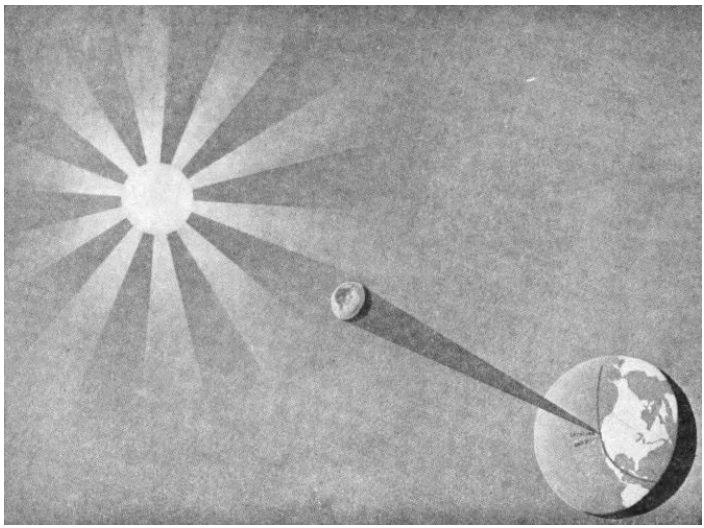


Then the dark body of the moon is seen surrounded by a ring of light. This is called an *annular* eclipse.

In a *partial* eclipse, the sun's disk suddenly becomes indented on one side, the indentation slowly increasing for some time, and then diminishing until it disappears altogether.

Total solar eclipses are extremely infrequent in any one place because of the smallness of the cone of the moon's shadow. This shadow draws a black streak across the earth, which, under favorable circumstances, may have a breadth of a little more than 160 miles and a length of 10,000 to

12,000 miles. The width of the shadow depends upon the nearness of the moon for if its shadow just touches the earth, the streak will have no sensible width. A partial solar eclipse is visible 2,100 miles or more on either side of the region where the eclipse is total.



RELATIVE POSITION OF THE SUN, MOON AND EARTH AT THE TOTAL SOLAR ECLIPSE OF SEPTEMBER 10, 1923.

(The two words at the point of the shadow's contact with the Earth are "Catalina" and "San Diego.") Drawing by Dr. Mars F. Baumgardt, Curator of Clark Observatory, Los Angeles, Calif.

Since the shadow of the moon passes across the earth at the furious rate of 1300 miles an hour, a total eclipse of the sun lasts for only a few minutes,—and for this length of time, short as it is, some thanks is due to the fact that the earth, in revolving upon its axis, carries the observer and the ground upon which he stands along the same direction in which the shadow is moving. Total eclipses are of extremely rare occurrence and only happen about once in every three hundred years for any selected spot on the

earth's surface.

An interesting description of a total eclipse may be found in Flammarion's "Astronomy for Amateurs":

> "The luminous disk of the sun is gradually corroded. Another disk, as black as ink, creeps in front of it and little by little invades it entirely. The atmosphere takes on a wan, sepulchral hue; astonished nature is hushed in profound silence; an immense veil of sadness spreads over the world. Night comes on suddenly, and the stars shine out in the Heavens. It seems as though by some mysterious cataclysm the Sun had disappeared forever."

Professor Moulton in his "Astronomy" gives another splendid description:

> "It always occurs precisely at new moon, and consequently the moon is invisible until it begins to obscure the sun. Steadily the moon moves over the sun's disk; and, as the instant of totality draws near, the light rapidly fails, animals become restless and everything takes on a weird appearance. Suddenly a shadow rushes across the surface of the earth at the rate of more than 1300 miles an hour, the sun is covered, the stars flash out, around the apparent edge of the moon are rose-colored prominences of vaporous material forced up from the sun's surface to a height of perhaps 200,000 miles, and all around the sun

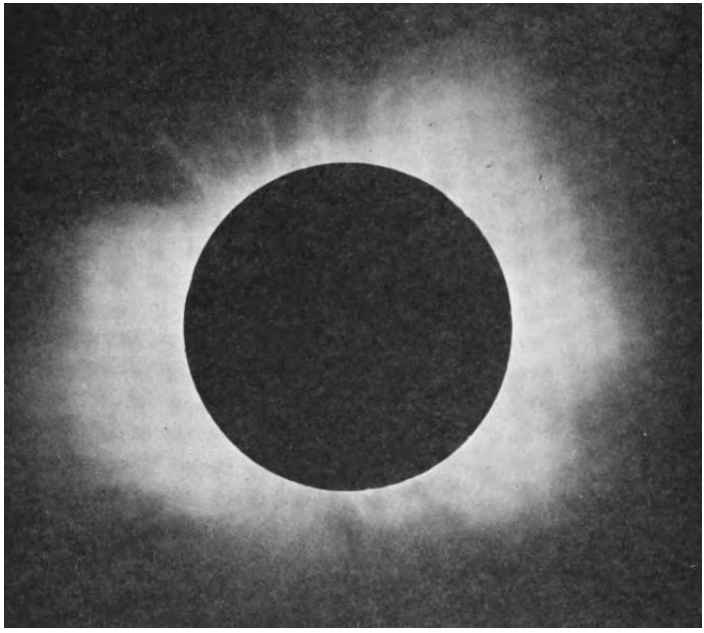
> extending out as far as half its diameter are streamers of pearly light which constitutes the sun's corona. After seven minutes at the very most, the western edge of the sun is uncovered and daylight suddenly appears."

In "New Astronomy," Langley tells of the sensations of an observer as the moon's shadow passes furiously on its way:

> "The bright cloud I saw distinctly put out like a candle. The rapidity of the shadow, and the intensity produced a feeling that something material was sweeping over the earth at a speed perfectly frightful. I involuntarily listened for the rushing noise of a mighty wind."

On June 8th, 1918, September 10, 1923, and on January 24th, 1925, many people in the United States were privileged to view the wonderful spectacle of a total eclipse. Scientists came from all over the world to witness the solar eclipse of 1923, for not only was it visible from an attractive corner of our country at a pleasant time of the year, but the sun was at a convenient altitude for observation. Many photographs were taken of the great flaming corona, some even from airplanes.

Although people now travel halfway across the earth in order to be able to witness an eclipse, in olden days such an occasion was marked by the greatest terror.



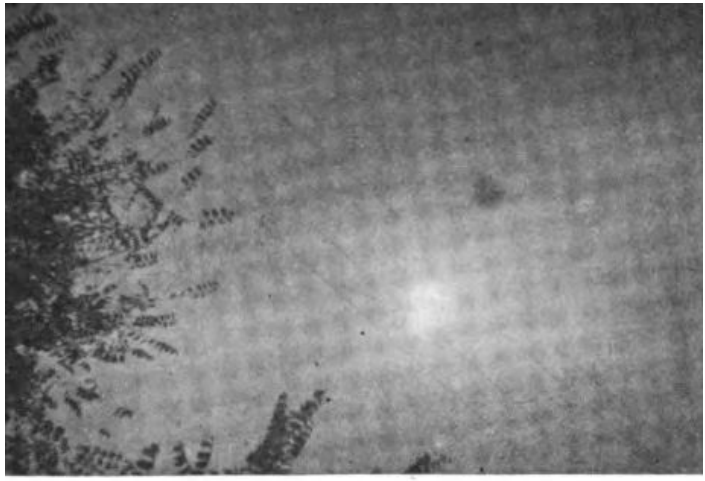
THE SOLAR CORONA.

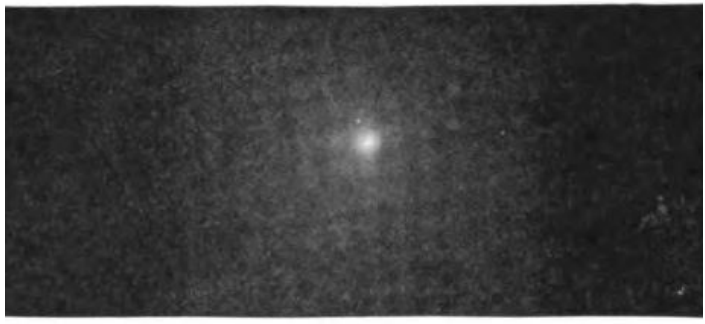
Photographed during the eclipse of June 8, 1918, at Green River, Wyoming, by the Mount Wilson Observatory Expedition.

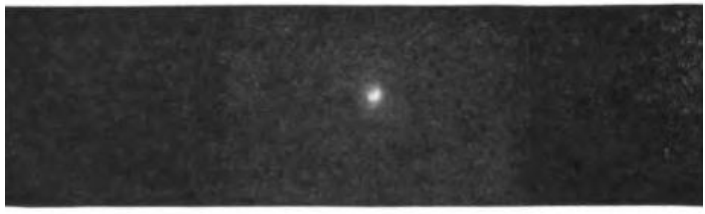
To the ancients they were without the order of nature, and in Rome, at one time, it was blasphemy, and punishable by law, to talk publicly of their being due to natural causes.

The Chaldeans believed the sun and moon to be black on the hidden side, and upon the displeasure of the Gods, the darkened side was turned to the earth thus causing an eclipse.

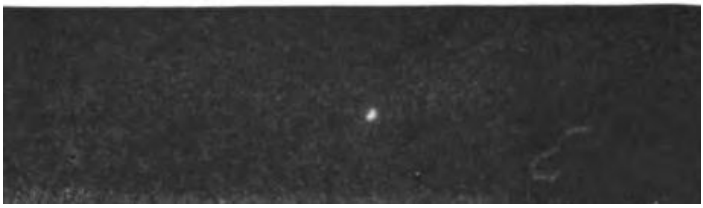












SUCCESSIVE STAGES OF AN ECLIPSE OF THE SUN, RECORDED WITH THE AID OF A KODAK.

Photographed by Edith Carlson at Palo Alto, California, September 10, 1923.

Many people among the European nations covered their wells and fountains for fear that the water would become contaminated by the poisonous, mists which arose during an eclipse. The notion was probably due to the fact that the drop in temperature is often accompanied by a fall of dew.

The Peruvians thrashed dogs during an eclipse so that their howling would keep evil spirits away, and for the same reason, the Romans beat their pots and pans, lifted up torches and fire-brands into the air. The people of the Northern nations also created a great din, for they imagined that the sun was pursued by fierce wolves (Skoll and Hati), who tried to swallow their brilliant prey so that the world would return to its primeval darkness.

Crooke, in "Popular Religion and Folk-Lore," says that

> "A high-caste Hindu will eat no food that has remained in the house during an eclipse, and all earthen vessels which are in the house at the time, must be broken. During an eclipse all household business is suspended, and eating and drinking is prohibited, even sleep at such times is forbidden, for it is then that the demons and devils are most active. The most effectual way of scaring the demon Rahu and releasing the afflicted planets is to

> bathe in some sacred stream and for protection, a Brahman should stand in the water beside the worshipper and recite the Gayatri."

It is said that at such times the rivers are covered with human heads.

Some barbarian tribes imagined that when the sun or moon began to lose its light, the orb was sickening under the arts of a wicked magician and they danced and screamed and beat their tomtoms in a wild frenzy so that the wicked one might become afraid and steal away. The well-known idea of the Chinese, however, is the most interesting of all, for there are records showing that for several thousand years these people believed that an eclipse was caused by the attempt on the part of a huge black dragon to seize the burning ball and swallow it. The dread of such a catastrophe so preyed upon the minds of the populace that it is reported in the "Tshu-King," one of the oldest chronicles in existence, that the ancient astronomers Ho and Hi had their heads laid before their feet for failing to predict an eclipse of the sun. Plenty of time to get out drums and kettles and to make the deafening noise which had always caused the monster to drop the sun was always given after this little incident. Douglas, in "History of China," relates that at this time, the intervention of every official in the country is called upon to save the sun from being destroyed.

> "Some months before the expected eclipse the board of astronomers notifies the exact date of its appearance to the officials of the board of rites, who in their turn announce its appearance to the viceroys and governors of the provinces. They transmit the message to all their

> subordinates, so that, when the time arrives, an army of mandarins stand prepared to avert disaster. Their procedure is simple and as neither the sun nor the moon have ever been devoured, it is regarded as efficacious. At the appointed time the mandarins assemble at the yamen of the senior official, and arrange themselves before an altar set up in the courtyard, on which incense is burning. At a given signal, they fall down on their knees and perform Ko-t-ow, after which the attendants beat drums and gongs to frighten away the oppressive monster, while the priests move in a procession round the altar chanting prayers and formulas. To assist the mandarins in their patriotic efforts, the people mount to the roofs of their houses, and add to the din which issues from the yamen by beating everything capable of emitting resounding noises."

The Grecians, however, ascribing all things to the gods, thought that the phenomenon was due to Jupiter, who, sometimes wishing to keep his business on earth secret from the other immortals on Mount Olympus, kept them from seeing him by hanging a little covering over the sun.

"The Olympian Father hangs a noon-day night

O'er the sun's disk and veils its glittering light,

Fear falls on man. Hence miracles, before

Incredible, are counted miracles no more."

—*Archilochus.* (*Trans. by* SIR CHAS. ABRAHAM ELTON.)

CHAPTER XII

THE CHILDREN OF THE SUN

THE PLANETS

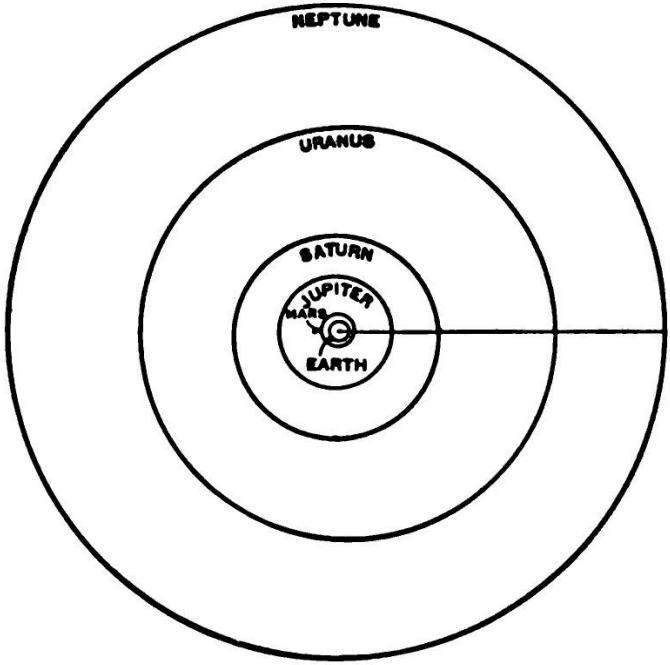
WE have just obtained a close view of one of the stars of the Galaxy,—the nearest star, our own sun,—and have gazed in admiration at the pearly setting of its corona, the turbulent waves of its crimson atmosphere, its black spots and moving belts, and our admiration increases as we visualize in our mind's eye, the eight fine planets which swing unceasingly around in its beautiful light.

In comparison with the sun, these planets are very small; either the earth, Mars, Venus or Mercury could be dropped into an average-sized sun-spot, or all four into an extra large sun-spot, while a thousand globes huge as Jupiter would scarcely balance the globe of the sun. Indeed, it has been computed that if the total mass of the whole solar system, with the exception of the sun, were called I, then the mass of the sun on the same scale would be 744.

All of the planets of the solar system roll as if on a great shield, one orbit set within the other at widely separated intervals. These orbits are not round but elliptical, with the sun shining at one focus of each elliptical orbit.

An unseen force called gravitation holds the planets in their pathways, always just so near and just so far from the sun. This is the same force that holds the stars in a Galaxy

and keeps the objects on the earth from sliding off into space. Since the attractive power of the sun is tremendous, the planets must travel around their pathways at a tremendous rate in order to develop enough centrifugal force to offset the gravitational pull, and the closer the planet the faster it must fly.



The orbits of the four outer planets, Neptune, Uranus, Saturn and Jupiter, and the orbits of Mars and the Earth, drawn to scale. (Within the orbit of the Earth would appear the orbits of Venus and Mercury, too small to be shown in this drawing.)

Mercury, for instance, travels at a rate of 35 miles a second while Neptune, seventy-five times as far off, has an orbital velocity of only 3.4 miles a second. The following table shows the distances of each planet from the sun and the

time it takes it to complete its journey around its orbit, beginning with Mercury, the nearest planet to the sun, and continuing outward.

	Distances from the Sun
Mercury	35,750,000 miles
Venus	66,750,000 "
Earth	92,500,000 "
Mars	141,000,000 "
Jupiter	457,000,000 "
Saturn	881,000,000 "
Uranus	1,771,000,000 "
Neptune	2,775,000,000 "

Mercury, Venus, Earth and Mars are sometimes called the inner planets because they form a group nearest the sun but more frequently are called the Terrestrial Planets because they all have solid crusts like the earth.

Jupiter, Saturn, Uranus and Neptune, forming a group called the outer or major planets, are more or less in a gaseous condition and are very huge in comparison to the first four.

The orbit of Neptune, the farthermost planet, encloses the orbits of all the other planets, and is so very large that it requires 165 years for Neptune to travel around it. This is quite a contrast to the time consumed by little Mercury who flies so close to the sun that he travels around it in 88 days. This, of course, means the length of the year on each of these planets.

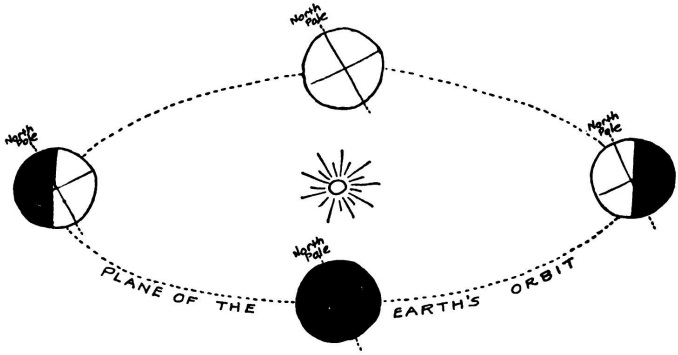
Since the planets shine by light reflected from the sun, half of their globes are always bright,—and the other half is always hidden in the darkness of the shadow which trails behind. Each planet, however, rotates on its axis, which

gives each side in turn a night and day. Exception to this must be made in the case of Mercury and Venus, their rotation with respect to the sun having been destroyed by the powerful tidal actions of the sun eons ago. Hence only one hemisphere in each of these planets is warmed by the light of the sun; the other forever faces the darkness and the cold of outer space.

The period of a planet's rotation is determined by watching its markings, just as the period of the sun's rotation was determined by watching its spots. The larger planets rotate much more swiftly than the smaller ones; a "day" on Jupiter or Saturn is not half as long as on Mars or on Earth.

The seasons of a planet depend on the angle at which its axis is tipped. The axis of the earth tips over at an angle of 23½ degrees from the perpendicular to the plane of its orbit, so its seasons are fairly well divided. Jupiter leans only 3 degrees and has little seasonal change but poor Uranus is inclined about 98 degrees and is subjected to the direst extremes. Since the year of Uranus consists of 84 of our years, each hemisphere has 42 years of darkness and 42 years of light.

The four inner planets are quite solid in comparison to the four outer ones, which are largely gaseous.



The Axis of the Earth tips from the Perpendicular to the Plane of its Orbit.

Mercury is the most solid planet of all, being more like metal than the earth; neither Jupiter nor Saturn have stable surface crusts while Saturn is so light that it would float on water.

Following are the diameters of the planets starting from Mercury, nearest to the sun, to Neptune, the farthest away.

Mercury	3,030 miles
Venus	7,700 "
Earth	7,927 "
Mars	4,230 "
Jupiter	88,300 "
Saturn	73,700 "
Uranus	32,000 "
Neptune	35,000 "

The planets that are relatively near the sun have few or no satellites, Mercury and Venus having none, Earth one, Mars two; those farther distant have a goodly number, Uranus possessing four, Jupiter nine and Saturn ten.

Mars has been studied in much detail and, of all the planets, has excited the most popular interest. Conditions are such that markings, mysterious at this distance, and colorful details, may be studied with comparative ease. The other planets that have been studied are too far away, too close to the sun, or are obscured by too cloudy atmospheres to permit detailed observations. The great planet Jupiter forms a magnificent picture, his broad face striped by colored bands which occasionally vary. This planet may be seen to turn completely around in 9 hours and 50 minutes, while four of its moons revolve about it in close attendance. Saturn is even more superbly magnificent than Jupiter, for the great, flat, shining ring which encircles this planet is the wonder of the whole solar system.

Because the planets are so much closer than the stars, they may be seen to change their places against the background of the constellations. An almanac will tell which of these worlds are visible in the evening during the different months and where they may be found. Since they lie nearly in the same plane as the orbit of the earth, they are always found within the boundaries of a pathway 16 degrees wide. This pathway circles the sky and is marked by the sun in the daytime and the moon at night. All the planets except Mars, Venus and Mercury travel nearly in the middle of this path which in ancient times was named the zodiac.

The constellations which lie along the pathway of the sun, moon and planets are called the constellations of the zodiac. The following are the Latin names of the signs of the twelve parts of the zodiac, with their English equivalents:

Spring:	Aries, the Ram ♈	*Summer*:
	Taurus, the Bull ♉	

Gemini, the Twins ♊

Autumn: Libra, the Scales ♎ *Winter*:

Scorpio, the Scorpion ♏

Sagittarius, the Archer ♐

When the winter months begin, the sun is in the constellation of Sagittarius, in the beginning of spring in the constellation of Pisces, in the beginning of summer, in Gemini, and at the commencement of autumn, in the constellation of Virgo. The zodiacal constellations are very important, and to the people in the olden days, the sun's position in front of them was a way to tell the season of the year. The words of Chaucer

"and the young sonne

Hath in the Ram his halfe cours y-ronne"

meant to any ploughboy in old England that it was April because during the first half of April the sun traverses the last half of Aries, the constellation of the Ram. Chaucer, by the way, wrote a book to teach "litel Lewis" his son, "to knowe every time of the day by the light of the sonne, and every time of the night by the starres fixed."

To locate a planet in modern days one has only to look up its position in the almanac or on a monthly sky map and then find it similarly located in the same constellation in the sky. The Monthly Evening Sky Map, an eight page journal for the amateur published by Leon Barritt, 150 Nassau St., New York, contains not only a map of the sky for every month, but also current astronomical news. With such aid, after becoming familiar with the belt of zodiacal constellations—which are easily learned by the following verse, it is not difficult to find the nearest planets.

"The Ram, the Bull, the Heavenly Twins

And next the Crab, the Lion shines

The Virgin and the Scales.

The Scorpion, the Archer and He-goat,

The Man that holds the Watering-pot,

The Fish with glittering tails."

Both Venus and Jupiter are brighter than first magnitude stars and will be recognized with but little difficulty. Mars and Saturn are as bright as first magnitude stars, although Saturn is not so easy to find unless its location is definitely known. Venus is a very white star, Jupiter a bright yellow, Saturn a pale orange, and Mars a fiery red. Mars wanders farther south than any other planet seen in the evening skies. Mercury may sometimes be seen after sunset in the spring or before sunrise in the fall, but only for a few days at a time and hence will seldom be seen by one who does not know just when, as well as where, to look for it. Uranus and Neptune are too far away and the planetoids too small to be of much interest to amateurs.

If examined with a glass the planets will show a bright round disk while a star is no more than a point of light. Mercury and Venus show phases just as our moon for their orbits lie between the earth and the sun. Venus is particularly beautiful as a crescent and is best seen in the west near the setting sun. Jupiter ranks second in popularity for even a field-glass discloses his round shining face and four of his principal moons.

THE PLANETOIDS

THE MINIATURE WORLDS OF THE SOLAR SYSTEM

Between Mars and Jupiter lies an immense lane of over 300,000,000 miles. This lane had been considered vacant until a century and a quarter ago, and since it was an exception to the general law of planetary distances, it had long been of interest to astronomers. Mercury, Venus, Earth and Mars are distant 35,750,000; 66,750,000; 92,500,000 and 141,000,000 miles, respectively, from the sun; then came this wide vacancy, with the order for the distances between the planets again resumed beyond Jupiter. When the great Kepler suggested that there must be an invisible planet revolving in this gap, many thought that the idea was only a dream of a great mind, for a planet so close would have been discovered long ago. Yet the suggestion was often considered, for the space had been to astronomers as a false note is to a musician, and they knew that if there were only a planet circling here, the spaces between every world would "increase with regularity in proceeding outward from the sun" and the solar kingdom would then be laid out in perfect harmony. The matter was left at this stage for many years, indeed it was not until 200 years after the suggestion was made that astronomers banded together, divided up the zodiac into twenty-four parts and, distributing them among an equal number of observers, began a systematic search. It is quite likely that during the 200 years previous to 1801, when the search began, not an astronomer lived but who had at some time wished to participate in such a search. Astronomers were, however, so few, the heavens so wide and life so short, that there was more than a load already on each of those earnest workers among the star fields.

Why is it, by the way, that more people are not curious about the sky? It sometimes happens that those who have

stars for a hobby, a rocking-horse Pegasus, unexpectedly find themselves transported by the Winged Horse to regions above. Thus, Piazzi, at Palermo on the island of Sicily, happened across the first of the little planets, or "planetoids," quite by accident, delighting not only himself but every scientist in the world, for order was now established in the solar system. Although this newly discovered planet was so tiny that its whole surface was no more than equal to the area of the United States, the very fact of its existence in what had seemed a wasted space, probably gave as much satisfaction as the discovery of Uranus ten years before. At the request of Piazzi, the new planet was named Ceres after the tutelary Goddess of Sicily, and ? as a symbol was appropriately given the sign of the sickle: ?

But a year later, Dr. Olbers, a physician at Bremen in Lower Saxony, discovered a second planetoid in the same region, with a mean distance and a periodic time so nearly identical with that of Ceres that they were almost within hailing distance. This second planetoid, which was named Pallas, was not greeted as joyously as the first, for now a situation was created that was harder to explain than the great vacant gap. But this was not all. In 1804, still another little globe was discovered, which was called Juno, and another in 1807, which was named Vesta,—four little planets in less than six years! Subsequent discoveries have brought the number almost up to 1000. An explanation by Olbers suggested that these minute bodies might be fragments of an exploded planet, but since they do not lie in the same plane nor do their orbits have a common point of intersection, this theory was discarded. It was then thought that the great attractive force of Jupiter would not allow a planet to form in the space. This theory was also discarded, and even now, a century and a quarter later, no one theory bearing on the origin of the little worlds has found general acceptance.

Following the custom of the ancients, the planetoids were given the names of Greek divinities, the next four being named Astræa, Hebe, Iris and Flora. But the names of Greek divinities at last ran out, and the planetoids were christened with more common names. Astronomers do not bother with any of these names, however, except in the case of a few. The rest they refer to by inclosing its number in a circle.

Although these little globes are very small, many of them have been found to possess distinct individuality. Vesta, for instance, is exceedingly bright, while Ceres, in contrast, is gray and dull. An explanation is that Ceres may be composed "of rugged and sombre rock, unclothed by any vestige of air, while Vesta displays a brilliant shell of clouds." Ceres is the largest of the planetoids, although even Ceres is less than 500 miles in diameter. Eros, which comes closer to the earth than any other known celestial body with the exception of the moon, exhibits a rapid variation in the brilliancy of its light. It is thought that this may be due to a rough, uneven surface with unequal reflecting power, for Eros is no more than a huge rock only 20 miles across. It has also been suggested that perhaps Eros consists of two bodies revolving close together so that one body eclipses the other in certain parts of its orbit, or again, it may be an angular body, not round at all! Many of the planetoids are smaller than Eros, some being only a few miles across.

Thus a thousand mysterious little worlds of assorted shapes and sizes roll along on their individual pathways in the great space between the orbit of Mars and the orbit of the earth. The bright light of Vesta, the dull glow of Ceres and the variable brilliancy of Eros lightly suggest the interest with which further observations and study may invest each tiny planet, as larger and more powerful telescopes are constructed.

COMETS AND METEORS

Comets

"Jove brandishing a star which men a
comet call."

A comet, in olden times, was an object of terror and dread and was regarded as an omen of pestilence and war. Searching through ancient records, incidents without number could be narrated to show that the malicious influence of some comet had caused—

"Fever, sickness, plague, and death,

Hard times, need and hunger's scathe,

Great heat, drought, and barren Nature,

War, murder, riots, fire and slaughter,

Frost, cold, storms, and want of water."

Josephus tells us that the destruction of Jerusalem in 69 A.D. was caused by no less than the sword shaped comet which pierced the heavens above the city!

A story is sometimes told of the great consternation caused in Europe in 1456 at the appearance of Halley's comet. This great shaft of light moving across the sky so disturbed the equanimity of Pope Calixtus that he instituted a form of prayer ("Lord, deliver us from the devil, the Turk and the comet") as a protection against its baleful influence. But the comet remained, and, with his people mightily afraid, the pope himself was forced "to interfere,

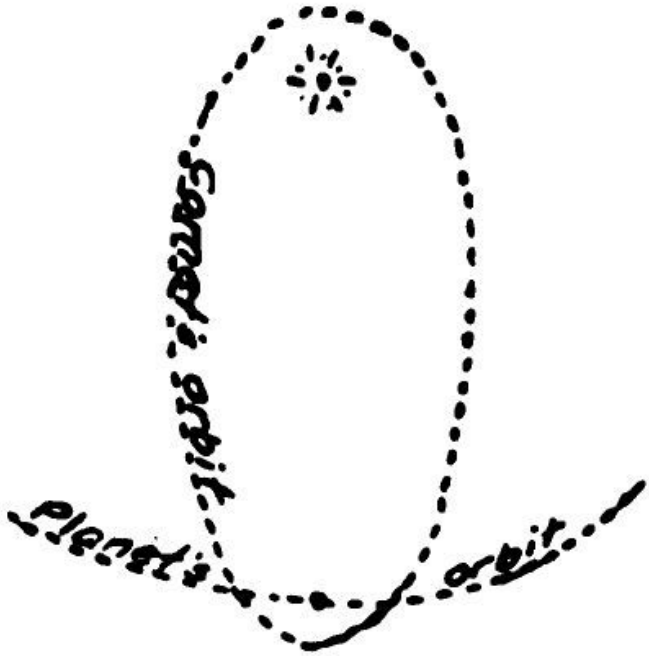
exorcise and expell" the malignant one from the skies.

Halley's comet has always been a most interesting comet. The last time that it appeared, in 1910, the earth rolled right through its beautiful, highly diffused tail, and although the experience was of interest to astronomers, it affected not a whit the affairs of the populace; indeed, but few people knew about it.

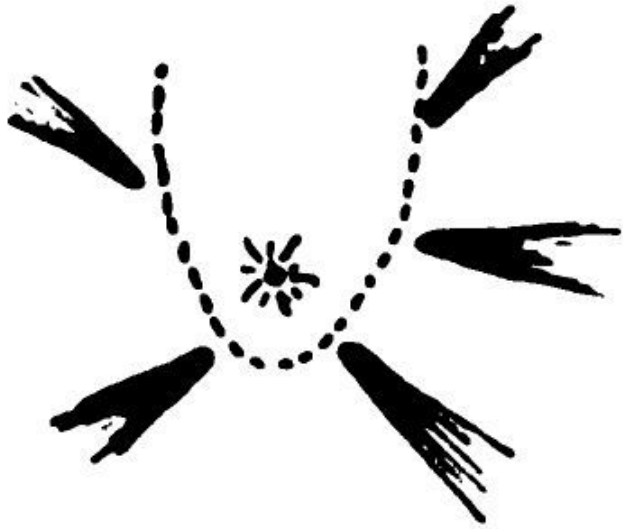
In 1680, Halley, an English astronomer and mathematician, while on a passage to France, was the first to observe this great comet, and later made observations with Cassini at Paris, where he observed its appearance with great care and painstakingly computed the elements of its orbit. From the nature of its orbit, he predicted that it would return at regular intervals of 75 years. He even traced this comet back on his historical table of comets, and found that the comets of 1607, 1531 and 1456 had the same orbit as the one which had appeared in 1680. Seventy-five years after, true to his prediction, the comet returned, thus proving that comets may travel in elongated orbits and appear periodically. Halley has the honor of being the first to predict the return of a comet.

It is now known that some comets require hundreds and even thousands of years to perform a revolution around the sun; Donati's comet, one of the most famous comets, which appeared in 1858 "like a plume of fire, shaped like a bird of paradise," travels on such a long circuit that it returns only every 2000 years. The brilliant comet of 1811, which remained visible for nearly ten months, has a period estimated as being around 3000 years. But the orbits of some comets are even longer than this, some traveling so far into space that they not only over-leap the boundary of Neptune but fly to a turning-post so distant that we may never see them return. More than 30 short period comets have been discovered and these have their orbits entirely within the solar system. Encke's comet, with a period of

3½ years, has the shortest period known.



Although it was discovered to the relief of mankind that comets have no influence upon the earth, it was also discovered that some of the planets with great mass and strong gravitational power, can exert considerable influence on a comet, in fact, enough influence to attract many of these celestial bodies out of their courses and force them to make their outer turn around a point near that planet's orbit. Jupiter has a larger family of comets than any other planet. If a planet once captures a comet it is his captive forever, unless the near approach of some planet of greater mass pulls the comet away and forces it to enclose its new master in the outer end of its orbit.



A large comet first appears among the stars as a dim spot of light. It may appear from any direction, for, although comets are considered members of the solar system, their orbits do not lie in the same plane as the planets. As it sweeps toward the sun with terrible velocity, which increases hourly, a long streamer of luminous gas gradually develops and floats backward from its head. A small comet often has no tail, but a large comet usually possesses a long and beautiful one, and has been known to possess two, and even half a dozen. This tail, or tails, are at their best when close to the sun, although at all times swung carefully away from the terrific flames of that luminary. Scientists almost hold their breath sometimes at the close call of comets, for the Great Comet of 1843 almost grazed the surface of the sun and many another has passed right through the outstretched banners of the corona. After darting swiftly around this brilliant center, the comet again heads into fathomless space, its long, bright tail gradually disappearing and its fierce speed

relaxing as it escapes farther and farther from the sun's control.

The word comet means a "long-haired" star. The star-like nucleus of the comet is called the head and the long nebulous streamer which trails behind, the tail. The head may be colossal, or it may be a mere shred; the head of Donati's comet would have more than filled the space between the earth and moon, while that of the comet of 1811 was considerably larger than the sun itself. The length of a comet's tail is equally amazing for it extends often for millions of miles. The comet of 1882 had 100,000,000 miles of tail while that of 1483 had one twice as long. The comet of 1680 extended below the horizon when its head touched the zenith.

The mean density of a comet is very small. Young states that it is nothing more than a sandbank—a swarm of solid particles of unknown size and widely separated. This light and airy object darts through space at a most hectic speed, often at the rate of a number of hundred miles per second, when close to the sun. It is of such flimsy construction that its light does not even obscure the stars although there have been comets so bright that they were visible in the daytime.

It is now believed that a comet derives its light, except that portion which is reflected sunlight, from electrical discharges between its particles. By some influence emanating from the sun, gas is emitted from the scattered swarm of meteoric particles which compose the head, and these stream out "like smoke from a locomotive" in a magnificent luminous trail. This only occurs when in the vicinity of the sun. Each time the comet comes back to the sun, it loses some of its beauty and its mass decreases—yet like a moth to a flame, it always returns. Newcomb describes the way in which a comet gradually loses itself in the following manner:

> "Altogether a good idea of the operations going on in a comet may be obtained if we conceive of a nucleus (or head) to be composed of water or other volatile fluid which is boiling away under the heat of the sun, while the tail is a column of steam rising from it. We do not see the same tail of the comet all the time because the matter which makes up the tail is constantly streaming outwards and constantly being replaced by new vapor rising from the nucleus."

In the course of time, the whole comet becomes disintegrated and its pathway scattered with debris. Astronomers now look upon meteors as the remains of worn out comets, for meteoric swarms follow along the same orbits as many of the comets. When the earth crosses the orbit of a disintegrated comet, or meteoric swarm, the fragments come in contact with our atmosphere where they blaze into incandescence and are seen as shooting stars.

The Biela comet is often mentioned as furnishing the best example of comet disintegration. This comet, which was discovered in 1826, had a period of 6.6 years. In 1846, after a lapse of twenty years, it was noticed to be considerably more elongated than usual and a month later it had separated into two comets, each developing a tail of its own. Before long these twin comets had become separated by 200,000 miles. On its next return, in 1852, the two halves of Biela appeared for the second time, with the distance between them increased to 1,500,000 miles. Once again they flew around the sun, but it was a farewell tour, for one streak of light followed the other out into space, grew fainter and fainter and finally disappeared, never to be seen again.



COMET 1910a.

Photograph with 6-inch Bruce Lens by Yerkes Observatory.

But just here is the best part of the story, for although the comets have completely vanished, in their place every year comes a radiant display of meteors! These meteors—the Andromids, coming on the 27th of November regularly—are believed to be the "fragments of the lost comet of Biela"! Thus, Serviss, with a touch of art, gives the shivery atmosphere of Poe to such an uncanny proceeding.

Although comets have here been placed with planets and planetoids under the heading of "The Children of the Sun," we are not sure, as yet, of the origin of comets. There is

one theory which suggests that comets may be the waste material of the solar system; the left-overs, as it were, after the planetary system was formed. Again, perhaps, a great comet may be material drawn in from outside space, perhaps flying back and forth between two stars until it becomes so exhausted that one of the stars is able to capture it. At least we know that the solar system now possesses a great number of comets who bow to the mastery of our star and never wander beyond the orbits of his planets. If these are not true children of the sun they are at least his adopted ones, and there is nothing that will ever lure them from his magnetic personality.

Meteors

Meteoric showers are popularly called "shooting stars." At least one shooting star may be seen every ten minutes but at certain times of the year they appear in showers. Three of the most profuse of these "star" showers appear from the

9th to 11th of August—Perseus (radiant point)
13th to 15th of November—Leo
27th to 29th of November—Andromeda

The Perseids, radiating from a point in the constellation of Perseus, are best seen about three o'clock in the morning. These meteors are called the "Tears of Saint Lawrence" and are noted in ancient legends as the "fiery tears" of this saint who was cruelly persecuted and burned at the stake. His festival is celebrated on the 10th of August, but his "tears" fall for three whole nights.

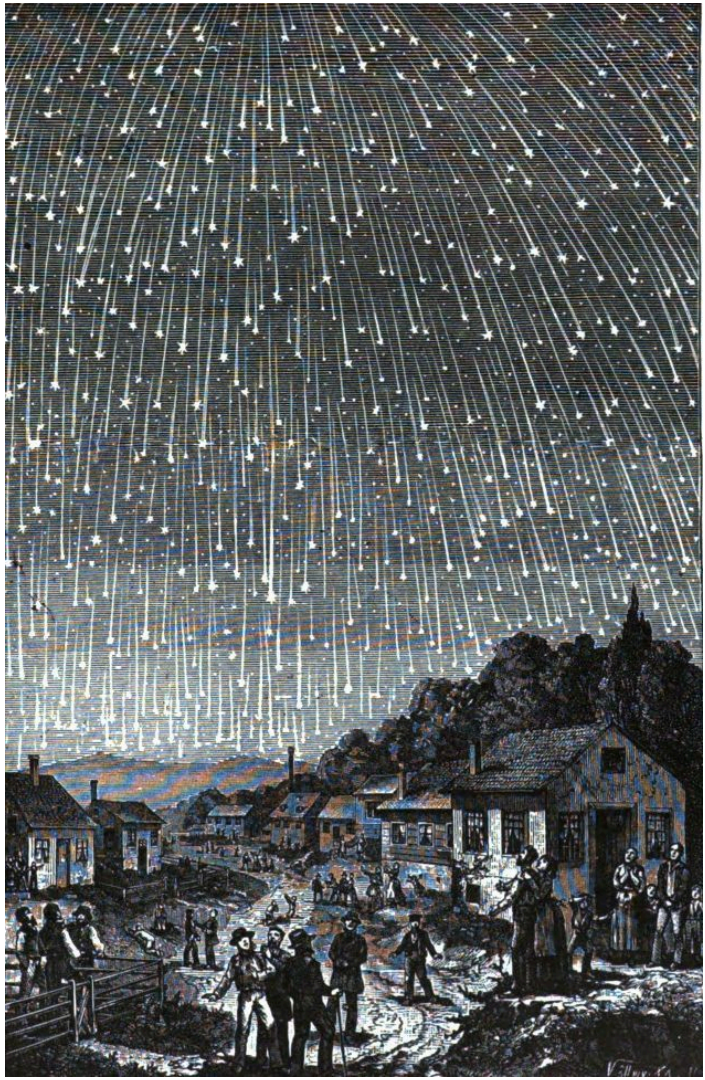
The Leonid star shower radiates from the vicinity of the star Y in the Sickle of Leo and rains most thickly in the early morning hours. On an average of every 33 years the

earth's orbit seems to cut through a denser portion of this meteoric swarm which causes especially beautiful displays. There is a record of this spectacular performance for a thousand years back, although it was not until after the brilliant displays of 1799, 1833 and 1866 that astronomers began a vigorous investigation of the subject of shooting stars. On the night of November 13th, 1833, "the stars fell like flakes of snow, varying in size from a moving point or phosphorescent line to globes of the moon's diameter." A witness of the spectacle wrote for the Christian Advocate and Journal of the following month, 1833, the following enthusiastic description:

> "It seemed as if the whole starry heavens had congregated to a point near the zenith, and were simultaneously shooting forth, with the velocity of lightning, to every part of the horizon; and yet they were not exhausted; thousands swiftly followed in the track of thousands, *as if created for the occasion*."

This shower was particularly well observed in the eastern part of North America. One eye-witness in the Southern States says that the negroes on the plantations were so unnerved that they "lay prostrate on the ground, some speechless and some with the bitterest cries, but with their hands upraised, imploring God to save the world and them." Another witness of the scene in the vicinity of Niagara Falls says that "no spectacle so terribly grand and sublime was ever before beheld by man as that of the *firmament descending in fiery torrents over the dark and roaring cataract*." Comstock tells of one illiterate observer being anxious to see how the heavens would appear the next evening, for he believed that there would be no stars left. In 1866 this shower was also a wonderful spectacle

commencing "about 11:30 P. M., with the appearance at brief intervals of single meteors; then they came in twos and threes, steadily and rapidly increasing in number till 1 h. 13 min. A. M. on November 14th, when no fewer than 57 appeared in one minute. From this time the intensity of the shower diminished gradually, wholly ceasing about 4 A. M. The total number of meteors which at that time came within the limits of the earth's atmosphere was estimated at about 240,000." This was not as brilliant a spectacle as when in 1833 the meteors fell like snowflakes, but it must have been very fine for, to continue with the description of an observer who witnessed it from Great Britain:



METEORIC SHOWER OF NOVEMBER 13, 1833.

"The stars from Heaven like rain-drops from a bough.

Like tears they poured adown creation's face."

—*Bailey*.

"The great majority were white, with a bluish or yellowish tinge; a considerable number were red and orange; and a few were blue; many surpassed the fixed stars in lustre and some were even brighter than Venus—Most of the meteors left trains of vivid green light 5 degrees to 15 degrees in length, which marked their course through the heavens, and endured for 3 seconds on the average, then became dissipated; though some of the trains were almost 40 degrees in length, and remained in sight for several minutes." The shower of 1899 was quite naturally anticipated with much eagerness but it fell far short of the brilliant displays seen in 1866 and 1833.

The third shower listed, the Andromids, radiate from the orange-gold star on the foot of Andromeda during the last week in November. These are best seen during the evening. They are also called the Biela meteors and bring to mind the interesting history of the late Biela comet.

Many hundreds of these radiant points have now been discovered. The meteors which appear in a direct line to the eye, appear as points or stars; those appearing farthest from the center, other things being equal, appear to have the longest trails but their paths are all parallel. The illustration in perspective of the trains coming forward from a point on the horizon of a desert illustrates this clearly.

Meteors, which represent the wreckage which comets strew along their orbits, are not visible until they strike our atmosphere, which causes them to glow. They "glow" because they become white-hot, and they become white-hot because they have been rushing through space at planetary speed, and striking our atmosphere is like striking a match against a stone wall. The friction thus

engendered causes the smaller particles to burst into flame and melt in a streak of fire, although the larger ones only melt on the outside, which is thrown off in a streaming tail of incandescent matter, the remainder of the meteor falling to the earth like a heavy rock. Thunders and visible explosions sometimes are heard as an accompaniment of the falling meteor. The meteors which fall to the ground are called "meteorites," or "ærolites," a literal translation of the latter term being "airstone." On an average, however, the individual bodies of a meteor swarm are very small, being represented by "a cloud of silver dimes each about 250 miles from its nearest neighbor." The smaller and lighter meteors called shooting stars which are consumed in our atmosphere probably number from 10 to 20 million daily.

Occasionally a meteorite found is very large, a few weighing several tons, but this is most unusual. The one brought by Commander Peary from Greenland is 11 feet long and 5 feet wide and weighs 36 tons. This is now on display in the Museum of Natural History in New York City. At Ensisheim, in Alsace, during the 15th century, a stone weighing 260 pounds which had descended from the sky was ordered by Emperor Maximilian to be suspended in the church where it hung for 300 years. A shower of nearly 3000 stones of various sizes occurred in Normandy within an elliptical area seven miles long and three miles wide. Nearly all the inhabitants of a large district saw the cloud and witnessed the rain of the stones.

The Greeks and Romans thought that casting stones upon the earth was some sort of pastime indulged in by the Gods and the Romans incorporated in a temple a shower of stones which fell on Alban Mount near Rome. A stone from Heaven was also reverenced in the masonry of the great Mosque of Mecca where it is annually kissed by thousands of pilgrims who begin holy rites by walking

seven times around the Kaaba starting from the corner where the black stone is fixed. The great stone in the pyramid of Cholula, in Mexico, and a black stone at Emesa, in Syria, have also been regarded with religious veneration. In India, the residence of a soul in heaven is believed to be proportionate to its charities on earth, and when its allotted period is over, it falls to earth as a meteorite.

If picked up soon after it falls, a meteoric stone is found to be very hot on the outside while the inside is cold. One constant characteristic by which it may be identified is the fused, black, thin and glossy crust, somewhat like varnish, which coats the surface of the meteoric stone. This surface crust is thin and sharply defined from the inner mass.

The predominating element in one class of meteorites is iron, generally combined with a small amount of nickel. Copper, tin, cobalt and other substances are also found, but never silver or gold. Stony meteorites are, however, more common than iron meteorites.

The velocity of meteors, or shooting stars, varies from 12 to 40 miles a second. Herschel estimates their average height above the earth at the time of their appearance as 73 miles, and 52 miles at the time of their disappearance.

CHAPTER XIII

VENUS AND JUPITER

THE BRIGHT PLANET OF VENUS, THE GODDESS OF LOVE

Diameter—7,700 miles

ALMOST every one knows Venus, the beautiful Evening Star, which is also, by the way, an equally beautiful Morning Star. In ancient times the Greeks believed these to be two different stars, calling the Morning Star "Phosphorus," the torchbearer who lights the way for the Dawn, and the Evening Star "Hesperus," leader of the stars of night. These names were translated into Latin as Lucifer and Vesper. The Morning Star was the son of Astræus and Aurora and the Evening Star a brother of the Titan Atlas. Pythagoras is said to have been the first to identify Hesperus with Phosphorus.

"Now glowed the firmament

With living sapphires: Hesperus, that led

The starry host, rode brightest."

—Milton.

The dates that Venus may be seen are announced in the

Almanac. Always look in the west after sunset for this lovely star, or in the east before sunrise, never in either case more than 48 degrees away from the sun. It follows the sun so closely that it is never seen more than four hours after sunset.

> "The Sun was sunk, and after him the Star of Hesperus, whose Office is to bring the Twilight upon the Earth."
>
> —*Milton.*

Every 584 days Venus appears in the west as an evening star, first appearing about 20 minutes after sunset, near the horizon.



VENUS.

Showing crescent phase. Photographed

with the 40-inch
refractor at the
Yerkes Observatory.

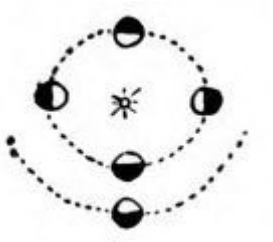
After being visible but a short time, it disappears from view not far from the point where the sun went down.

Every succeeding day this star appears at a higher elevation and glows brighter and brighter; this continues for several months until it appears like a great lamp, outshining every other object in the heavens, except the moon. It then begins to appear at a lower elevation each evening and to set a little earlier, until in the course of two or three weeks it disappears in the early twilight. About two weeks after her departure from the evening sky, Venus appears in the east shining brightly in the cool, gray hours just before Aurora opens the gates for the Sun-god.

Day by day, the Morning Star increases in brilliance just as did the Evening Star until it appears at the highest point above the horizon; then its light gradually declines as each day its stay becomes shorter and shorter, until finally it pales in the morning light and is immersed in the rays of the sun.

Venus passes through its period of greatest brilliance every eighth year. This last occurred in 1921 and will next occur in 1929. At such a time the planet is so bright that it may be seen in daylight, if one knows where to look for it.

The discovery through a telescope that Venus had phases firmly established the theories of Copernicus.



When this Polish astronomer, in 1543, announced the astounding theory that the sun was the center of our solar system, he said that if the planets between the earth and the sun could be clearly seen, they would show phases like the moon. When in 1610, Galileo turned his telescope on Venus and beheld the beautiful little crescent, the followers of the ancient system of Ptolemy—who claimed that the *earth* was the central body around which the sun and planets revolved—were, for the first time, silenced, for they saw that the orbit of the earth must enclose the orbit of Venus, and that they must both *revolve around the sun*. Even a small telescope will show the phases of Venus, the crescent being far more beautiful than one would imagine.

"Calm star! who was it named thee Lucifer,

From him who drew the third of Heaven down with
him?

Oh! it was but the tradition of thy beauty!

For if the sun hath one part, and the moon one,

Thou hast the third part of the host of Heaven—

Which is its power—which is its beauty!"

—Bailey.

When first seen through a telescope, in the evening twilight, Venus is gibbous, or nearly round. It has then just emerged on the farther side of the sun from us. After first becoming visible as a disk, it gradually assumes the figure of a half moon (this is at the point of its greatest elongation when it is at its highest in the sky); then as it again approaches the sun, it gradually becomes more and more like a slender crescent of light. When Venus is showing nearly a full face, it is the whole diameter of its orbit farther away than when it shows a slender crescent. In this position it is 160 millions of miles distant from the earth; when nearest the earth it is only 22 millions of miles distant. This is the reason why it appears much smaller when its full hemisphere is turned toward us than when it is seen as a small crescent. The proportion of this disk to the crescent is as 10 to 65. After becoming a "silver bow," Venus disappears from the evening sky, later to appear on the other side of the sun in the same guise, and gradually, as the days go by, changing to a half moon and on again through all its phases.

The orbit of Venus is tipped slightly from the plane of the earth's orbit; thus only on very rare occasions does it pass directly in front of the sun. Such a passage is called a transit. These transits occur in pairs—two transits being 8 years apart and the successive pairs being separated by 122 years. The last transit occurred on December 9th, 1874, and December 6th, 1882. They will not occur again until June 8th, 2004, and June 6th, 2012. There is only a slight possibility that some young reader may see this.

When passing before the face of the sun, Venus appears as a round, black spot surrounded by an illuminated ring of atmosphere. The spectroscope has shown that this atmosphere is about the same as the earth's, possibly a little more dense, and, strange to say, there is now strong evidence that water vapor and oxygen are conspicuous by

their absence.

The dense atmosphere on Venus causes it to reflect light most beautifully but it also obscures its surface so that it is very difficult to see any markings. From time to time, when Venus passes between the sun and ourselves, it approaches to within 25 million miles of the earth, and even less—which is about 10 million miles closer than Mars comes at its nearest approach—yet we can clearly see the surface of Mars for its atmosphere is very tenuous, while the surface of Venus is almost completely hidden under thick white clouds. At such a time, Venus is also a slender crescent while Mars shows a full round face. The spectroscope combined with observations made upon such surface markings as may be seen in full daylight has, however, enabled us to determine that Venus rotates so slowly upon her axis that one face is always turned toward the sun. Thus the day on Venus must last forever and its night-side has only one long night. It has been conjectured that this condition may cause storms of frightful intensity upon its surface, for high air currents on the light torrid side probably flow rapidly to the dark, cold side, with the cold air near the surface of the dark, cold side flowing with equal rapidity to the torrid side. This state of affairs may tend to equalize the intensity of the two extremes of climate. Being almost 30 million miles closer to the sun than the earth, Venus may have a higher temperature than the earth, although the heat may be somewhat modified by the clouds which are always in the sky.

Sometimes a faint, grayish light has been observed on the dark side of the planet when it is nearest the earth. This was at one time thought to be a reflection from a cold and frozen hemisphere, but a more likely suggestion hints that it may be an electrical manifestation in the planet's atmosphere, similar to our Aurora.

Venus completes its orbit in 7½ months, its year being

rather shorter than ours.

The question of the existence of life not only on Venus, but on the other planets, is always a subject of general interest. Professor Barnard of the Yerkes Observatory had the following convictions on the subject:

> "There are possibilities of life on some of our brother worlds, though that is not in any way a necessity, possibly on Mars and probably on Venus, with Mercury very doubtful but more probably lifeless. The moon we will not consider, for we believe that it is dead long ago—even if it ever had any form of life upon it. It may even be that some world of our solar system has ceased to bear life and it has been suggested that possibly Mars is such a world. This is in no wise unreasonable. It is entirely probable that some of them are not in a life-bearing condition, just as a tree in your orchard may not have obtained maturity yet. Their heyday is yet to come, perhaps this will be when the earth and all its present life are cold and dead—dead of old age! for a world must die just as a man must die."

Jupiter, Saturn, Uranus and Neptune are considered, he says, to be worlds of the future, their low density and other considerations leaving little doubt of their unripeness for life. Perhaps millions of years will pass before these giant worlds are in a condition to welcome life of any description.

Many astronomers believe that the conditions for life such as we know it on earth, are more likely to be found on

Venus than on any other planet; others think that Mars, being evolutionally older, may have even passed the stage in which we now find ourselves, or that it may have developed, to suit the conditions on Mars, along quite a different line. Life adapts itself to many extremes, it may live in intense heat and freezing cold, in the air, in the water and under the ground. Speculation on this subject has disclosed the most interesting data, but as yet we do not know, and may never know, if there is life on any of the planets.

THE GIANT PLANET OF JUPITER, THE KING OF THE GODS

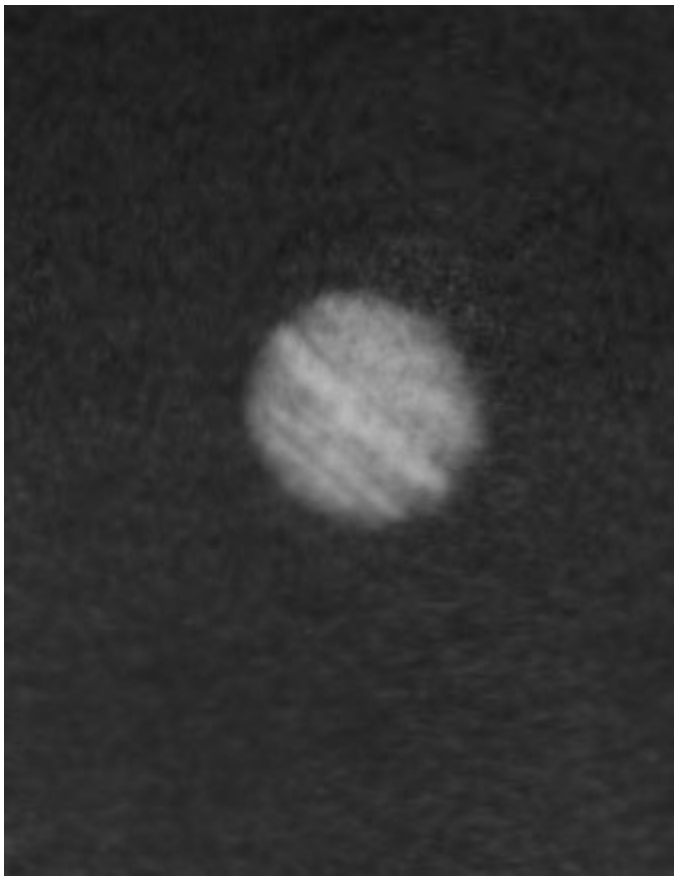
Diameter—88,300 miles

Jupiter is the largest planet in our solar system. With high magnifying power it is seen to be a great "orange-shaped" globe, larger than the full moon to the unaided eye, with a bulging equator and flattened poles. This polar depression is $\frac{1}{16}$th of its diameter causing the polar diameter of 84,400 miles to be several thousand miles less than its equatorial diameter, which is 90,200 miles.

This colossal world is favorably situated for observation three months out of every year, traveling eastward along the zodiac, and spending around twelve months in each zodiacal constellation. It requires twelve of our years for Jupiter to complete a revolution around the sun.

Even an opera-glass will give a view of Jupiter as a minute disk with two bands across its center and four luminous points on either side. These luminous points are satellites, three of which are larger than our moon and one almost as large. Jupiter has nine satellites in all but only four are visible in any but the most powerful telescope and three cannot be seen except in photographs. The four large

satellites may be seen to change their positions from hour to hour, occasionally disappearing in the shadow behind Jupiter, and then reappearing with startling abruptness on the other side.



THE PLANET JUPITER.

Photographed by Yerkes Observatory through the 40-inch refractor.

With a stronger glass they may be seen moving as bright spots across the face of the planet, followed or preceded by the dark disks of their shadows.

With a large telescope, various colored belts are seen to streak this globe like dark stripes from east to west, the most prominent ones being the two deep red bands some 7000 miles broad which lie on either side of a faint golden equatorial belt, some 6000 miles across. Besides these, there are lesser belts to the north and south which are red, green, brown, black and brilliant white. The spots on the equatorial belt move rapidly toward the west with a speed of over 270 miles an hour, with respect to the other markings on the planet. By watching these impressive colorings and markings the gigantic globe may actually be seen to turn around on its axis! It does this in only 9 hours and 50 minutes—less than half the time that it takes the earth to rotate.

With a still larger telescope, however, it was discovered that 9 hours and 50 minutes was only the average time that it takes Jupiter to rotate and that the day varies according to the location on the planet. Thus, like the sun, its surface is not a fixed one, for at the equator the rate of rotation is 9 hours and 47 minutes, a little distance at either side 9 hours and 56 minutes, and in higher latitudes over 10 hours. But Jupiter is not as hot a globe as the sun, which has been described as somewhat resembling "thick molasses," for if it shone by its own light it would not cast a shadow, nor would the shadows of its satellites be dark spots upon its surface.

Such facts have led to the general belief that Jupiter is still in an early stage of development with its globe probably in a semi-fluid condition so hot that the gases which will some day form its waters and be cradled in the hollows of its crust, now rise as hot vapor into its thick, warm atmosphere and fall as incessant rains. The surface visible to us on earth must therefore be in the nature of dense clouds and vapors while its real surface is probably in a "hot, muddy thickish liquid" condition, quite

unattractive to think about.

Yet there are some considerations that tend to disprove the cloud theory. Barnard mentions that the semi-permanent nature often shown by the markings is against it. The great Red Spot has been visible at intervals for a hundred years or more, and other markings may be traced with but little change of form for months, although these objects are free to drift around and their rotation periods are not constant. Professor Barnard, using the powerful Yerkes telescope, said that when seen under the finest conditions the appearance of the surface is more of a pasty nature.

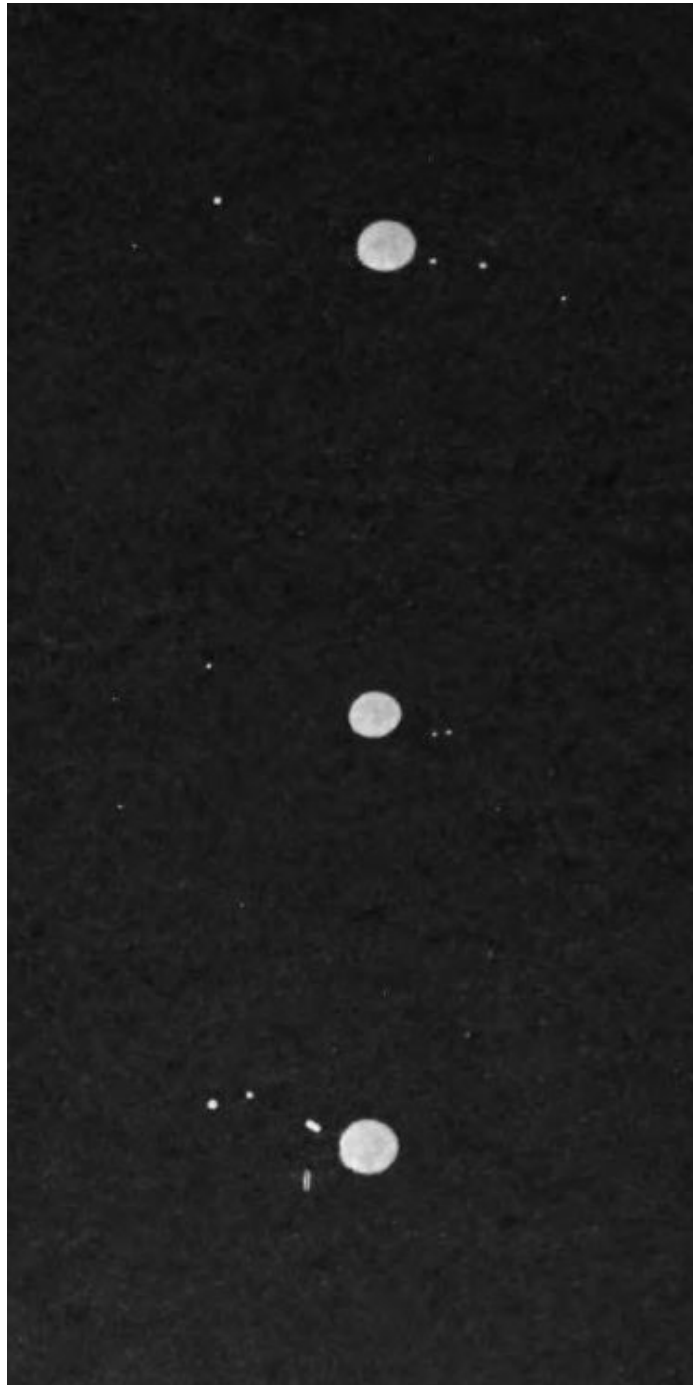
The great oval-shaped spot mentioned above and famed as the "Great Red Spot" appeared in the southern hemisphere in 1878, or at least it appeared more distinctly on that date, for early drawings show that traces of it had been observed long before that. It was at first of a very strong red color and stretched above the equator for a distance of 30,000 miles. It is now of a delicate pinkish tinge, extremely faint but still visible.

The cause of this prominent marking is not known. It has been suggested that it might have been a gigantic eruption. Gigantic indeed, if it covered 30,000 miles! It also has a curious repellent nature, for all the belts and spots that come near it, instead of passing onto it or over it, seem to be forcibly pushed to one side and held at a certain distance until they have completely passed this whatever-it-is.

It has also been suggested that a new continent may be forming here, but the fact that this feature like other features on Jupiter's apparent surface does not seem to have a fixed position has caused it to be likened rather to a vast drifting island. This "vast drifting island" sometimes moves fast, sometimes slowly and sometimes remains perfectly stationary! The last suggestion was brought

forward before the more or less irregular drift was noticed which seems to prove after all that it could not be a true part of the real surface of Jupiter.

If Jupiter were composed of materials as dense and solid as the earth, he would not be as large a planet as he now is. The materials of which this great world is composed are only about one fourth as dense as the earth or 1.25 as dense as water.





JUPITER AND FOUR OF HIS MOONS.

Photograph by the Yerkes Observatory.

The axis of the planet is nearly perpendicular to the plane of its motion, the inclination being only about three degrees from the perpendicular. Thus there is no great variety of seasons on Jupiter although his year is twelve times as long as our year. If his axis were inclined as much to his ecliptic as the axis of the earth, his polar regions would remain in darkness for six years at a time.

JUPITER'S SATELLITES

With a telescope magnifying thirty-three times which he had constructed himself, Galileo discovered the moons of Jupiter. Three of them were first seen on the 7th of January, 1610, and the fourth on the 13th of the same month. These moons, which are sometimes called the "Galilean quartet," were the first heavenly bodies which had not been known from time immemorial.

Delighted beyond measure, Galileo sent his drawings and an account of his observations to his patron Cosmo de' Medici, Great Duke of Tuscany, in honor of whom he called the moons the "Medician Stars." Equally anxious to show the world, Galileo set his telescope on the tower of St. Mark where the advocates of the Copernican system hailed them with joyful satisfaction for here was a miniature of the sun and its planets hung up in the heavens to demonstrate the truth of the new doctrines. But the stubborn followers of Ptolemy, viewing them argued that

such pretended discoveries were absurd, and that since we had seven openings in the head—two ears, two eyes, two nostrils and the mouth, there could be in the heavens but seven planets. He had therefore either bewitched them or the telescope, for which they threw him into prison.

After the moons had finally been accepted as a fact, they were given the names of Io, Europa and Callisto, three lovely maidens of whom the great Olympian God was fond, and Ganymede, his cupbearer, although astronomers usually designate them as I, II, III (Ganymede) and IV, in order of their distance from Jupiter. Their orbits lie in the plane of Jupiter's equator and as that lies always in the plane of our vision, the satellites seem to swing back and forth in their journey around him, sometimes in one position and sometimes in another—sometimes all four on one side, sometimes two on one side and two on the other, or perhaps one of them will be hidden by the planet. They present a different aspect and relation to each other every successive evening and even in a few hours may be seen to change. Frequently these moons may be seen as bright spots against the surface of the planet or their shadows appear as conspicuous round black spots traveling along one of the colorful belts.

Ganymede, satellite III, is the largest of all known moons in the solar system, having a diameter of 3560 miles, actually exceeding the planet Mercury in size. Satellite I exceeds our moon in diameter by a couple of hundred miles, satellites III and IV by over a thousand miles.

Io, the satellite closest to Jupiter (named after the maiden who was transformed into a cow and chased to the end of the world), is a very swiftly moving satellite, traveling completely around its orbit in 1 day, 18 hours and 28 minutes. This means that it must move at the tremendous speed of 320 miles a minute! Our moon takes

27½ days or nearly a month to travel around the earth in an orbit of almost the same size, but the attractive force of our earth is so much less than the attractive force of Jupiter that our moon does not have to travel so fast in order to keep from being pulled down on its surface.

Europa's period of revolution is 3 days, 13 hours and 14 minutes; Ganymede's, 7 days, 3 hours and 43 minutes and Callisto's 16 days, 16 hours and 32 minutes.

In 1892 Professor Barnard discovered through the Lick telescope a moon closer to Jupiter than Io. This little moon is only $\frac{1}{600}$th part as bright as the other satellites and is only 30 miles across.

In 1905 two other satellites were discovered by photography, still another in 1908 and another in 1914, making a retinue of nine satellites in all. These last two, which are very remote from the planet, were found to be revolving in the opposite direction from the other seven, which is from west to east, the direction that generally prevails throughout the heavens. Other exceptions to this rule are the outermost moon of the planet Saturn, the moon of Neptune and all four moons of Uranus. The ninth moon of Jupiter is about 15,400,000 miles from the planet and takes nearly 3 years to complete a revolution. Only 11 hours and 57 minutes for Barnard's satellite and nearly 3 years for the most distant one, is quite a contrast in periods. Although Jupiter's 5-hour night is rich in moons, he is not nearly as well supplied with moonlight as is the earth.

It has already been mentioned how Roemer, a Danish astronomer of the 17th century, discovered the finite velocity of light through the disappearance and reappearance of Jupiter's satellites within his shadow. This was later found true through direct experiment.

At least a peep at this mammoth and colorful world,

with its bands and spots and swiftly moving satellites, should be the privilege of every man, woman and child.

CHAPTER XIV

MARS AND SATURN

THE RED PLANET OF MARS, THE GOD OF WAR

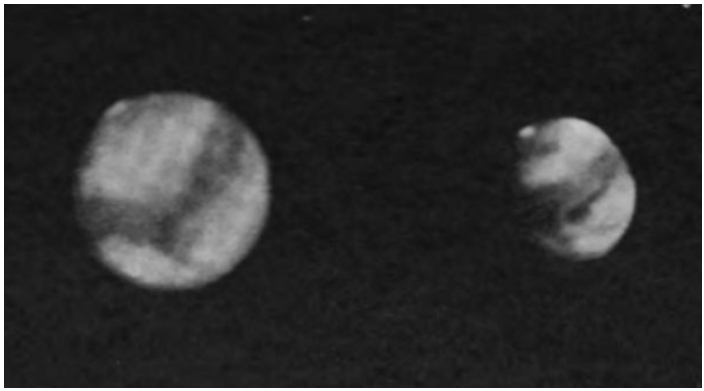
Diameter—4230 miles

THE orbit of the little planet Mars, 141,000,000 miles from the sun, encompasses the orbits of Earth, Venus and Mercury, and forms the boundary line between the four inner planets and the planetoids or minor planets. Beyond the planetoids are the four great planets, Jupiter, Saturn, Uranus and Neptune.

The orbit of Mars is very eccentric, more eccentric, in fact, than any other planet in the solar system with the exception of Mercury. At its nearest approach to the earth's orbit it is only 35,000.000 miles away, while at its furthermost point it is distant 62,000.000 miles. The two planets, however, when at different points in their orbits, may be over 200,000,000 miles apart. This eccentricity in the orbit of our neighbor Mars causes it to differ in brightness as we see it shining as a star, for, although it is always large and beautiful, at its nearest approach to the earth it shines with more than tenfold the brilliancy of a first magnitude star. At such a time its fiery light attracts the attention of everyone. Such extreme increase in light can only occur in the months of August and September and then only about every fifteen years. This was a much heralded astronomical event of the year 1924, when the

two planets were closer together than any other time during more than a hundred years. However, Mars was low in the sky and not in such a good position for observation as it will be two years from that date when at a higher altitude, even though it will be at a greater distance from the earth. During shorter periods at intervals of two years and two months, the earth passes between Mars and the sun; Mars then shines in our night-sky as an especially red and lovely star with a well-illumined face just right for observation.

Mars is a much smaller globe than either the earth or Venus, but it is larger than the planet Mercury.



MARS, SHOWING SURFACE MARKINGS AND POLAR CAPS.

Photographs by the Mount Wilson Observatory.

Its diameter of 4230 miles is only a little more than half that of the earth, although its period of rotation is almost the same, the earth gaining by two-thirds of an hour. Its day therefore is only about 40 minutes longer than ours. The seasons of Mars are twice as long as ours, and its year equals 687 of our days, or 669 of its own.

The atmosphere of Mars is very rare and thin, more rare

and thin than that surrounding the peak of Mount Everest, our highest mountain. Being less than one-fourth as dense as that found on the earth, one may see through it easily and discern the permanent markings on its surface. The first thing one notices through a telescope is the ruddy color of its surface and the dark belt across the equatorial regions. The ruddy color is presumed to be the characteristic color of its soil, five-eighths of which is in a desert condition; there are also regions of other colors which are subject to change, and a white cap marking either pole.

The two white caps about the poles increase greatly during severe months of winter and vanish to small spots during the warmth of the Martian summer. These are the reservoirs of moisture for the planet. A series of photographs illustrating the phenomenon of the increase and decrease of these caps is very interesting, for at the height of the Martian winter, for instance, the north polar cap extends to the temperate zone while during the summer it dwindles until it is but a tiny patch a few hundred miles across. As the polar caps melt, they are bordered by a blue belt and this blue belt is only visible as the brilliant caps disappear. Judging from the same phenomena which are manifest on our earth, these polar caps were supposed to be snow. Through the aid of the spectroscope, they are now known to be snow.

The ruddy areas on Mars are interpreted as desert regions—great unfertile tracts of land but little affected by changes in climatic conditions, while the large irregular dark or blue-green regions are regarded as marshes or areas covered with vegetation, since they invariably grow darker during the Martian summer and reveal themselves in massed colors changing from the initial blue-green to ocher and finally to chocolate-brown. These changes follow the melting of the polar caps and each hemisphere

undergoes the change in turn. Mars, however, is best known and famous for the theory of its so-called "canals."

The "canals" were first observed by Schiaparelli, the distinguished Italian observer, in 1877. Schiaparelli thought that the dark irregular areas were oceans and that they were connected by these narrow streaks which he called "canale" or "channels." Unfortunately the word was not translated as "channels" but as "canals," which implies artificial construction, and this latter does therefore not convey the idea which the astronomer sought to convey. These black lines, or "canale," are generally straight and although spoken of as narrow, must be at least 12 miles in width and from a few hundred to three or four thousand miles in length. Starting from points near the polar caps, they follow the arcs of great circles, proceeding to what seem to be centers in the middle of the continent where, most surprisingly, they meet other lines which have come to the same spots. Schiaparelli says that "every channel opens at its end either into a sea or into a lake or into another channel, or else into the intersection of several other channels." "None of them as yet have been seen cut off in the middle of a continent, remaining without beginning or without end ... by preference they converge toward the small spots which we have given the names of lakes." These lakes are sometimes several hundred miles in diameter, although many are very much smaller.

The late Dr. Lowell, splendidly equipped with an observatory 7000 feet above sea-level in the clear air of Flagstaff, Arizona, maintained that each "canal" marked the route of a waterway, and that the visible mark is not the "canal" itself, but a broad band of vegetation irrigated from a narrow channel. He studied and mapped 522 of these canals, 56 of which were double. He also mapped the "lakes" which he called "oases." Dr. Lowell wrote a very interesting book on "Mars as the Abode of Life" as a result

of his observations. He explains the "strips of vegetation" in this manner:

Since Mars is fast approaching a desert condition, there is a great scarcity of water, the only reliable source of supply coming from the melting of the snows at the polar caps. With the advance of spring the white caps begin to recede and a dark band appears around the edge. The water thus formed then flows away from the poles over the flat, dry surface, collects in the greenish areas (which are probably marshes) and from there is led into the canals. These canals do not begin to appear until the snows begin to melt and are always in the same position each season. The land is then moistened with water, the process starting near or around the melting polar caps and gradually moving down toward the equator. This water takes about 55 days to reach the equator, vegetation springing up along the way. At the end of the season, the fresh green withers and dies down. The spots, or oases, always connected by a canal to the rest of the dark area, appear and disappear, like the canals, with seasonal changes. These start faint in tone as large as they are to be, then darken throughout.

Since the vivifying water advanced from the south pole toward the equator and also toward the equator from the north pole, Lowell concluded that it must have some propelling force behind it, at least in one direction. This presupposes the directing influence of an intelligence.

Accepting the theory that Mars is inhabited by intelligent beings, it is presumed that the water resulting from the melting of the snow caps is consciously controlled and turned over certain designated portions of its surface, otherwise the tremendous floods "would prove more of a curse than blessing." The picture is one of a high order of intelligent beings realizing that their water is gradually disappearing and that their planet is rapidly becoming a desert, and who are struggling heroically to

prolong its life. There are many objections to this theory, but at least it is an interesting hypothesis presented by a noted astronomer who possessed a splendid telescope erected in the clear air of Arizona, and who spent his life in a study of this planet.

The entire surface of Mars is about equal to the land surface of our earth. The density of the planet is only 73% that of the earth and the force of gravity on its surface is 35% as great as on the surface of our world. The lesser force of gravity, also the lower temperature and rare atmosphere, would all have their influence on any life found on Mars with the result that beings found there might be constituted physically in a very different way from ourselves. The temperature of Mars was computed lately at the Mount Wilson and the Lowell observatories and the results obtained at the two observatories were in excellent agreement. Although it was found to be 94 degrees below zero at one pole and 96 degrees below zero at the other pole, the average temperature on other parts of the planet during the brightest parts of the day averages between 40 to 60 degrees F. This would be a livable temperature for life as we know it, although another fact is commented upon which might cause curious complications. Since the blanket of air surrounding the planet is not of sufficient thickness to hold the heat on the planet, most of it may escape during the night-time, thus causing the temperature to drop to over 112 degrees below zero. If intelligent life wished to survive from day to day it would have to hibernate, perhaps in heated underground galleries, during the night half of its existence. The question as to whether or not there could be life on this planet has been hotly disputed by astronomers for years. It is certainly one of the most interesting aspects of astronomy to the public at large. It is often argued that since Mars is smaller than the earth it must have cooled down millions of years before the earth reached a similar

stage, and that its organic life must therefore be proportionally farther advanced. Others have contended that it is past the age where it would be able to support life of any kind.

Professor W. H. Pickering has advanced a new speculative theory called "The Theory of Aerial Deposition." According to this theory the major canals are natural marshes fed by storm laden air currents. These marshes furnish Mars a substitute for our oceans. Without them "the water evaporated from the summer pole would find its way too rapidly, through the natural general atmospheric circulation of the planet, to the southern polar regions, where, wrapped at this season in the long winter night and subjected to the cold of space, it would quickly be withdrawn from further use in support of vegetal and perhaps animal life. The function of the so-called canals or marshes in the economy of the planet is in short to furnish a substitute for our oceans, and to furnish by evaporation during the Martian summer a steady and continuous supply of water after that derived from the northern snows has appreciably diminished." The above is quoted from a report on Mars by Professor Pickering in the January number of *Popular Astronomy*, 1918. Professor Pickering believes that the "canals" "are either bands of moistened soil or vegetation growing on moistened soil" and that they cannot be anything else "for we know of no solid in the mineral world that darkens and then fades out in the sunlight." He does not think that the major canals are necessarily the work of intelligent beings, but they do serve the purpose of furnishing the northern hemisphere with a supply of water in the form of natural marshes during the long northern summer until the southern polar cap starts to melt at the coming of the autumnal equinox.

Professor Pickering, who has written a book called "Mars," gives the following interesting information as to

how the planet appears through the telescope at Flagstaff: "We may examine the moon some night through a small opera-glass. The sharpness and amount of detail visible in the two cases will be similar, although the appearance of the two bodies is quite unlike."

General public interest in Mars is probably keener than in any other planet and since the great event of August 23rd, 1924, when Mars shone like a lantern in the sky, this interest will probably grow greater than ever. This small matter of 34,648,000 miles—not much over a third of the distance to the sun away from us—is almost as near as the earth and Mars will ever approach one another.

An association of observers interested in Mars who are stationed in different parts of the world has recently been formed. All parts of the planet are now kept under inspection and regular reports are sent to a central bureau which publishes the results in an astronomical magazine.

THE SATELLITES OF MARS

The following story is often related in connection with the satellites of Mars: Many years before the satellites were discovered, Swift, in "Gulliver's Travels," described the little planet as having two moons, one of which flew across the Martian sky three times a day! The thing seemed absurd, for never during all the explorations of the solar system had a moon been found which behaved in such an erratic fashion. Nevertheless, in 1877. Professor Asaph Hall, of Washington, discovered two tiny attendants to the planet of the War-god weaving "like golden shuttles" around the Martian orb, and one of these made three revolutions in its orbit while the planet itself turned once on its axis! Thus the month of this surprising moon is less than eight hours long.

This little rapid-transit moon flies only 3700 miles above the planet's surface, and, on account of the curvature of the globe it would not be visible beyond 69 degrees of latitude on each side of the equator. As seen from Mars, it rises in the west and sets in the east, changing from new to full one and a half times every night! With the constantly recurring metamorphoses of this tiny moon, which is scarcely 7 miles in diameter, and its most exceedingly rapid flight, it would seem that there would be some reason in naming it Phobos (Fear), after one of Mars' attendants. On account of its nearness to the surface of Mars, Phobos would appear to a Martian about the same size as our moon does to us.

The other moon, which was named Deimos (Terror), is about 14 miles in diameter and is 12,500 miles from the planet. Its period is also very short, being only 30 hours and 18 minutes. Since this period is only a few hours more than the rotation period of Mars, the moon moves very slowly across the sky, remaining continuously above the horizon of any given place on the planet for more than 60 hours. It has been computed that these two small moons would cause 1400 eclipses of the sun a year, as seen from Mars. They are the smallest objects visible in the sky, as seen from earth.

Our month of March, as well as this fiery-hued planet, was named after the War-god. Since Tuesday was also named after the War-god, it might be well to mention here how the other days and months obtained their names.

In the early days of Astrology, a "science" which was based on legends and myths, the names of the five planets then known were given to the days of the week. Apollo, the Sun-god, gave his name to Sunday, and his sister, Goddess Diana, to Monday, and these two days retained their names, but the days which followed those named for the sun and moon later became Germanized, as it were, or the names of the originally imported gods translated into

those of the Germanic divinities. Thus the name of the Northern Sword-god Tyr, who resembles the Roman War-god Mars, was given the day of the week held sacred to Mars, now known as *Tuesday*, or Tiu's day, Mercury's day became Wodan's or *Wednesday*, Jove's day was called Thor's or *Thursday*, and the day of Venus transformed into *Friday*, the day of Freya, the wife of Wodan. The day of Saturnus, retained under this name in some northern tongues, became a *langardage*, or a bathing day, in others. As for the months—*October* and *February* were names derived from Roman festivals; a horse named October was sacrificed to the War-god Mars during this month, while February derived its name from the Roman festival Februalia, from *februare*, to purify. April, meaning Aprilis, from *aperire* to open, obtained its name because it was the season when the buds began to open. *September* (septem, seven), *November* (novem, nine), and *December* (decern, ten) were the 7th, 9th and 10th months of the year of the Roman calendar when the year consisted of 10 months. *January* was named after Janus, the porter with the double head which enabled him to look back into the past and forward into the future; *May* after Maia, one of the Pleiades; and *June*, after Juno, Queen of the gods and the Goddess of Marriage. Quintilis, the 5th month of the Roman year, which began in March, was named *July* in honor of Julius Cæsar, while the 6th month, which was originally styled Sextilis, received its present name, *August*, from the Emperor Augustus.

THE RINGED PLANET OF SATURN, THE GOD OF TIME

Diameter—73,700

Although Jupiter is the largest planet and Mars the most interesting planet, the planet Saturn, as seen through a

large telescope, is the most uniquely beautiful creation that man has ever beheld. The spectacle of a huge silvery ball surrounded by an equally huge and silvery ring suddenly disclosed in the midst of the darkness, is such an astounding surprise that one can never forget the strange sensations experienced when first beholding it.

Saturn moves very slowly through the sky, traveling on the average only about one degree a month and spending two or three years in each zodiacal constellation. This is because its pathway lies millions of miles beyond that of Jupiter's, and is so large that it takes the planet 29½ years to complete its circuit around the sun.

Saturn is believed to be composed mainly of gases and vapors or to be at least in a fluid condition with no solid crust. Its density is less than that of any other planet in the solar system, being only 0.70 as compared with water as unity. This is only about one-half as great as the density of Jupiter, which is somewhat greater than that of water. The weight of the earth is five and one-half times that of water. If the earth and Saturn were two balls immersed in an ocean large enough to hold them, the earth would sink like a ball of metal while Saturn would float like a ball of wood.

A white belt may usually be seen near the equator of Saturn and curious pale gray caps cover both the poles. Between these are faint colors and other dim belts. Its colors as markings are not as pronounced as in the case of Jupiter, on which they are far more distinct as this latter planet is 400,000,000 miles closer to the earth. The mysterious gray color of the caps at the poles of Saturn remain an enigma and the spectroscope shows that Saturn contains some substance which has not yet been identified.

Saturn's equator is inclined to the plane of its orbit at an angle of 27 degrees—a direct contrast to the axis of Jupiter which is almost perpendicular. This would cause Saturn to

have very marked seasonal changes and very long seasons for one of its years is equal to almost 30 of ours.

Day and night on Saturn are very short for this huge planet turns completely around in 10¼ hours. With only 5⅛ hours of daylight (and Saturn receives only $\frac{1}{90}$th as much light per unit area as that received by the earth), one would hardly get up before it was time to go to bed. But perhaps the future Saturnian will be so constructed that he does not have to spend so many hours in sleep, or perhaps, as in the Golden Age when the god Saturn ruled on earth and the needs of man were brought forth without labor, this length of day would be quite enough for general entertainment. Again, they might be such quick-witted creatures that they could accomplish a thing while we were thinking about it, or, yet again, they might not care to slave all their days in order to indulge in such foolishly complex lives as we do here and 5⅛ hours would prove a great plenty. How we do ramble on! Yet is it not a little fun to stop a moment and conjecture about folks on a distant world? Perhaps they could never be—perhaps Saturn may never mature into a habitable globe—but then, who knows?

THE RINGS OF SATURN

John H. Thayer in his interesting article on Saturn in *Popular Astronomy*, March, 1919, says: "If you want to see a picture painted as only the hand of God can paint it, go with me to Saturn." He then beautifully describes the scene of the wonderful band of silvery light which arches the sky near the equator, and the bewildering panorama of many moons, full round disks, quarter phases and thin crescents displayed in the Saturnian nights. Not only would the nights be startling to an earth-being; during the daytime their tiny sun would skim across the sky at the rate

of about the distance of the diameter of the moon in every minute, and then after the sun literally dropped below the horizon, the stars and crescents and disks and quarters of moons would shoot across equally fast.

Suppose all the inhabitants of the solar system were forced to exist in a medium like the ocean, for instance, to know nothing of such celestial scenes; perhaps the unfortunate inhabitants of Venus can see no more clearly through that dense atmosphere which surrounds their globe.

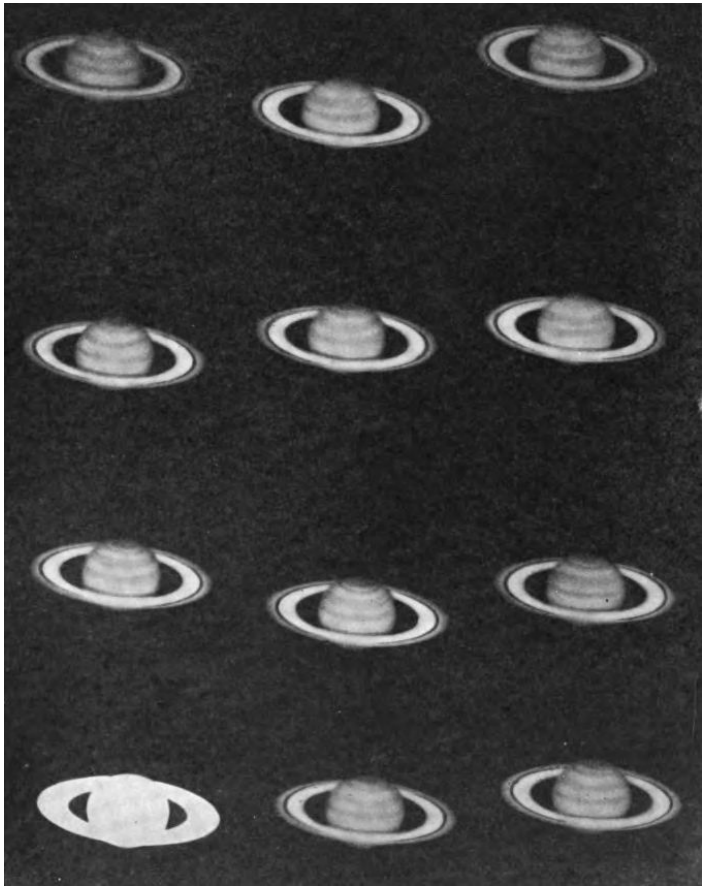
> "One might think that the atmosphere was made transparent with this design, to give man in the heavenly bodies, the perpetual presence of the sublime. If the stars should appear one night in a thousand years, how would men believe and adore; and preserve for many generations the remembrance of the city of God which had been shown! But every night come out these envoys of beauty, and light the universe with their admonishing smile."
>
> *—Emerson.*

The crowning glory of Saturn, its thin flat ring, is poised above the huge body without in any way touching it. Although this ring appears as a solid piece, it is now known positively that it is made up of swarms of meteors or exceedingly minute satellites, all whirling round and round Saturn in the same plane. It may easily be seen why a brightly swirling mass of these shining moons would seem as one object at such a distance.

Through a large telescope it becomes apparent that Saturn's ring is really composed of three rings lying one

inside of the other, the two outer rings, which are about 11,000 and 18,000 miles in width, being separated by a dark, narrow clean-cut space of about 2200 miles.

The third ring is a thin, faint inner ring, so transparent that the planet may be seen shining through it. It is about the same width as the outer ring, 11,000 miles, and its inner edge lies only 6000 miles above the surface of the planet. This inner ring is called the "crape ring" because it has a dusky look. It is believed to be the inner ring thinning off toward the planet. It has been suggested that the crape ring may have originated from collisions of particles in the bright ring, thus reducing their orbits, and that the rings of Saturn are slowly shrinking down upon the planet and will sometimes in the future have entirely disappeared.



TWELVE PHOTOGRAPHS OF SATURN, MADE WITH A 60-INCH REFLECTING TELESCOPE.

Photographs by the Mount Wilson Observatory.

The first individual to gain a glimpse of Saturn's rings was Galileo. To Galileo, whose telescope was not much superior to the field-glass of today, the planet appeared triple with two outer stars touching the middle star "like two servants assisting old Saturn to complete his journey." A few years later when he again turned his telescope upon

Saturn, these attendant orbs had disappeared. "It is possible some demon mocked me," he exclaimed, and would look no more.

"But for these news I know not what they be,

Some one perhaps has lit on a new vein

Of stars in Heaven:"

—Bailey.

Later the side features reappeared and became larger and larger, until they fitted the globe "like a pair of handles."



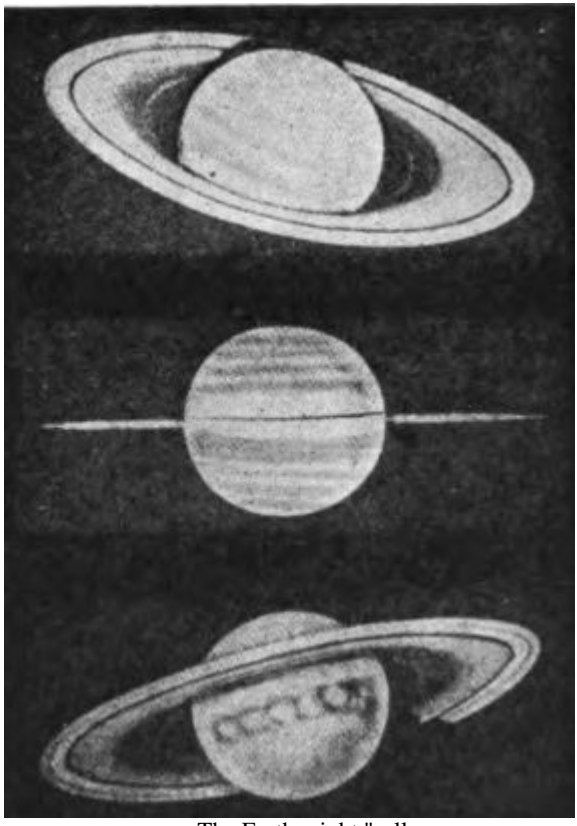
This drawing shows the rings of Saturn opened to their fullest extent, as seen on July 7, 1898, by Prof. E. E. Barnard through the 40-inch refractor at the Yerkes Observatory.

The drawings of those days look very strange to us now, for some pictured a bar run through the planet or a ball with ears. Fifty years later, in 1656, Huygens, with his 123-foot tubeless telescope, solved the mystery and proved

the existence of a thin, disconnected ring, which was as astounding a phenomenon as the ears or bars or handles.

Proof by direct observation that the ring was neither liquid nor solid but a multitude of very small bodies journeying close together, was made by Professor Keeler when he applied the spectroscope to determine the velocity at which the rings rotate. It was then discovered that the inner parts revolved more rapidly than the outer parts and the only way in which such a phenomenon can be explained is to accept the hypothesis that the rings are composed of separate independent bodies.

Every 15 years the plane of the ring passes through the plane of the earth and hence it is seen edgewise to the earth. It then almost disappears, being so thin as to be seen only in the larger telescopes.



The Earth might "roll
upon this ring like
a ball upon a road."
(Aspects of Saturn's
Rings.) From Comstock's
"Textbook on Astronomy,"
by permission of publishers,
D. Appleton & Co.

Seen edgewise through the 40-inch Yerkes telescope, it is scarcely more than a streak of light "like a pair of illuminated needles piercing the ball on opposite sides." This is because all of these tiny moons which fly about Saturn are moving in the same plane. We obtained this

edgewise view in 1907; in 1915 the ring was opened at its widest extent while in 1921 it was again almost invisible.

The reason that this ring may be observed at so many angles is because it is inclined about 27 degrees to the plane of the planet's orbit and about 28 degrees to the plane of the ecliptic. In the course of the earth's journey and Saturn's journey around the sun, we sometimes look up at this ring and sometimes down upon it, but when the earth lies exactly in the same plane, we look only on the edge which is so thin that it becomes almost invisible. The thickness of the ring is, indeed, scarcely anything at all in comparison to its width for, although the distance from one side to the other of the entire ring is about 172,000 miles, its edge is estimated as only about 62 miles.

When the rings are open, the dark shadow of Saturn's planet may be seen against the light of these rings.

"While Saturn whirls, his steadfast shade

Sleeps on his luminous ring."

—Tennyson.

This shadow proves that the dull, yellowish glow on the planet is reflected sunlight, and that the planet does not shine with its own light, as a star.

THE MOONS OF SATURN

Besides all the tiny moonlets in the beautiful ring, ten large moons whirl about the planet Saturn. These give Saturn a system with a radius of 8 million miles, which is quite extensive compared to the earth and moon system which has a radius of 240,000 miles.

The moons of Saturn range in size from about 200 miles to nearly 300 miles in diameter but being so far away only Titan, the largest, can be seen except in a large telescope. These satellites were given the names of the brothers and sisters of the God of Time and are called Mimas, Enceladus, Tethys, Dione, Rhea, Titan, Hyperion, Japetus, Phœbe and Themis.

Titan, the largest satellite, is 771,000 miles distant from the planet. The nearest one is only 117,000 miles away but there are also three others which are closer to the planet than our moon is to us. Phœbe, the most distant one, is almost 8,000,000 miles away and takes nearly 18 months to make a revolution. It appears as a full moon only once in a year and a half—quite a contrast to Mars' little Phobos who goes through his phases one and a half times every night! Phœbe seems to be possessed with a streak of contrariness for she moves in her orbit around Saturn in the opposite direction from all of the other moons.

Japetus, the second largest satellite, has the interesting peculiarity of appearing three or four times as bright when on the western side of Saturn as when on the eastern side of it. This is explained by the supposition that one of its sides has a greater reflecting power than the other and, like our moon, always has the same side toward its planet. We would, therefore, see one side of it when east of Saturn and the other side of it when west of it.

Themis, the tenth moon, was first recognized by W. H. Pickering in 1905 but it is only recently that its discovery was fully confirmed. Professor Pickering also discovered the ninth moon of Saturn.

CHAPTER XV

MERCURY, URANUS AND NEPTUNE

THE TINY PLANET OF MERCURY, THE MESSENGER OF THE GODS

Diameter—3030 miles

MERCURY, the smallest and fleetest and hottest of the planets, shines as a star of the first magnitude. It lies closer to the sun than any other planet, which increases the difficulty of studying it. Most of the time it is either hidden behind the sun or is passing between us and the sun, and the only time when it is observable is when it is to the east or the west of the sun. Indeed it is so often hidden or lost in the brightness of the sun that it is rarely seen except by a professional astronomer.

Like Venus, Mercury is seen first on one side of the sun and then on the other. In the early spring it appears in the west almost invisible in the twilight; in the early autumn, in the east as a morning star just preceding or mingled in the rays of the dawn. It is always seen very close to the eastern or western horizon, never more than two hours before the sun in the morning nor more than two hours after it in the evening.

Because of the great inclination of the orbit of Mercury, it is seen in a transit across the face of the sun not more

than thirteen times in a hundred years. This transit may only be seen in a telescope. If it so happens that it travels across the center of the sun, the journey consumes about eight hours, although the little black dot is skimming across the big, bright disk at the rate of 100,000 miles an hour. The next five transits will occur on November 8th, 1927; May 10th, 1937; November 12th, 1940; May 13th, 1953, and November 6th, 1960.

The eccentricity of the orbit of Mercury is so pronounced that its greatest and least distance from the sun varies nearly 15,000,000 miles. This causes considerable variation in the speed of this planet, for as the sun does not lie in the center of the orbit but at one focus, it is not compelled to go as fast on the far side as on the side nearest to this tremendous mass. Being so close to the great attracting force of the sun, it is however, forced to move faster than any other planet in the solar system in order that the right balance of speed may be obtained to counteract the gravitational pull which would otherwise draw him instantly to the burning surface. Mercury's average rate of speed around its orbit is 35 miles a second. Neptune, seventy-five times as far off, feels so much less this relentless pull that it can roll leisurely along at the comfortable rate of 3.4 miles a second with no fear of being drawn to destruction.

Mercury completes his orbit in 88 days and this is, of course, the length of his year. During this journey he always turns the same face to the sun. The heat on this side must therefore be terrible and the surface unmercifully scorched and possibly cracked. Moreaux, a French astronomer, thinks that it may even be so hot that it has oceans of lead and molten tin. A few features are discernible, and although faint, these features are fixed. The general impression gained is that the tiny planet is barren, rough and mountainous, bleak, seared and desolate,

with one side sweltering in terrific heat and the other numbed with dark and cold. Since there is no appreciable atmosphere on Mercury, there must be no wind—no warm currents of air to flow from the hot side to the cold side, nor from the cold side to the hot side,—thus making what is already drear seem motionless and dead.

Yet there is often some alleviating quality to make the drear seem less drear. For instance, a slight exception may be taken to the statement that the day side of Mercury is always day and the night side always night. As an effect of libration, an oscillatory movement of the planet on its axis, there is a strip of ground on either side, where the dark and light hemispheres meet, upon which the sun rises and shines for 44 days and then sets, leaving it in 44 days of darkness. This strip of ground is 23½ angular degrees in breadth and enjoys a true day, although its "day" is as long as its year, and is equal to 88 of our earth-days.

THE STRANGE PLANET OF URANUS, THE ANCIENT GOD OF THE HEAVENS

Diameter—32,000 miles

Mercury, Venus, Mars and Jupiter have been known since antiquity but Uranus was the first planet to be discovered with the aid of a telescope. This planet was discovered in 1781 by William Herschel while mapping stars, and the very fact of its existence astounded the world. Because Galileo had named the satellites of Jupiter the Medician Stars after his patron, Herschel wished to name his newly discovered planet Georgium Sidus, in honor of George the Third. But foreign astronomers would not agree to this and until a name was decided upon, called the planet Herschel. Later, the planet was called Uranus after the most ancient of all the deities, and its sign was the

sign of the world hung on the initial of Herschel. H In appreciation of the fact that he had discovered a planet, Herschel was made private astronomer to his king and later knighted.

Uranus is the smallest of the major planets and ranks next to the earth in size, which is the largest of the minor planets, yet there is a great difference in the size of these two planets, for the diameter of the earth is only 7927 miles, while that of Uranus is 32,000 miles. There is also as great a difference in the nature of these two worlds.

Uranus travels through space in an orbit at an average distance of 1,771,000,000 miles from the sun, encompassing the orbits of Saturn, Jupiter, the Planetoids, Mars, Earth, Venus and Mercury; an orbit so large that it takes the planet 84 years to complete its journey around the sun. It has only been a year and a half, according to time figured on Uranus, since Herschel first introduced this planet to earth-dwellers.

Although the year of Uranus is 84 of our years long, which causes long and remarkable seasons, its day is very short, for the planet turns so rapidly on its axis that it sees both day and night in 10 hours and 50 minutes. Even the few hours of daylight it enjoys are not very bright ones, or warm ones either, for the planet is so far from the sun (which appears as an intense point of light), that it receives only $\frac{1}{370}$th as much light and heat as we do on earth.

The axis of Uranus is tipped 98 degrees from the perpendicular which causes not only extreme but peculiar seasonal changes. Since the axis of the planet is always pointing in the same direction and at one place in its 84-year journey points almost directly at the sun, each pole in turn is bathed in 42 years of dim daylight and then, when on the other side of the orbit, sleeps through a night that is just as long. Bürgel remarks that "an inhabitant born at the beginning of winter and dying at the age of forty, would

never see daylight, or the sun, but live in everlasting darkness like the pit-ponies in coal mines. The contrary would be the case with the summer-born, who would know of night and the stars only from hearsay." Quite different from what life might enjoy on Jupiter, for Jupiter's axis is inclined only 3 degrees from the perpendicular and its year would be almost a perpetual spring.

Careful observations seem to indicate that Uranus is a gaseous body, although cooler and more solid than Saturn and Jupiter. This planet is immersed in an exceedingly dense atmosphere quite different in constitution from the light, diaphanous covering of air which encloses the ball of the earth. This is indicated by the broad absorption band in its spectrum.

Uranus is attended by four moons but these are too far away for us to observe in any detail. Herschel discovered two of these soon after the planet was discovered, and they were given the names of Titania and Oberon. In 1851, Lassel of Liverpool discovered two more which were called Ariel and Umbriel. Two of these moons are seen with great difficulty even with the aid of the most powerful telescopes. The orbits of these moons are tipped nearly perpendicular to the plane of the orbits of the earth and Uranus, and their movements are retrograde as regards most of the known movements of the solar system.

This strange planet of the most ancient God of the Heavens is now visible during the spring and summer months as a faint, greenish star of the 6th magnitude, but it is rather difficult to locate unless the observer is an experienced astronomer.

THE BOUNDARY PLANET OF NEPTUNE, THE GOD OF THE SEA

Diameter—35,000 miles

After the discovery of Uranus in 1781, its pathway among the stars of the sky was carefully noted and geometers were not long in fitting it with an orbit. In a few years, however, it was noted that the planet was out of its computed orbit by a distance as great as the moon's distance from the earth. The deviations attracted general attention and popular opinion feared that the new planet, being so far from the center of the solar system, was breaking away from the sun's control. But a young mathematician, J. C. Adams, and a few months later an older and experienced mathematical astronomer, Leverrier, conceived a more logical solution of the mystery, and decided that they would search beyond Uranus and see if there was not a planet which was attracting Uranus and causing irregularities in the great world's motion. This was a tremendous task, for not only was it necessary to calculate the orbit of the hypothetical planet, but also the weight and speed that such a planet would have in order to pull Uranus in exactly the way that it was being perturbed. After much hard work the problem was satisfactorily solved by each man independently.

Challis at Oxford, following the computations of Adams, first commenced to search in the place where these indicated that the planet might be found, and on August 4th, 1846, actually saw and mapped the star but did not recognize its planetary character. On the 23rd of September, 1846, Galle of Berlin, searching at the place indicated by Leverrier, found the new world at almost the exact place indicated by the computations! This should satisfy the most skeptical as to the validity of the great Newtonian law of gravitation and the accuracy of the mathematical deductions therefrom. To prove the existence of a planet and to determine its position before it was ever seen, is considered by scientists to be among the most

amazing intellectual achievements ever recorded in history.

Neptune requires 165 years to complete a revolution around the sun. The boundary line of the solar system, which is the planet's orbit, is a tremendously long pathway on which to travel, for it lies at a distance of 2,775,000,000 miles from the sun.

The length of a day on Neptune is not known as it lies too far away to permit an observer to distinguish any permanent surface features even with the largest telescopes.

It has been estimated that as Neptune is so far away from the sun, it receives only $\frac{1}{900}$th as much light and heat as our earth.

"When the keen north wind with all its fury blows,

Congeals the floods, and forms the fleecy snows,

'Tis heat intense to what can there be known;

Warmer our poles than is its burning zone.

Who there inhabit must have other powers,

Juices, and veins, and sense, and life, than ours.

One moment's cold, like theirs, would pierce the bone,

Freeze the heart's blood, and turn us all to stone."

—Baker's Universe.

The sun, as viewed from Neptune, would look very small,

not much larger than Venus does to us when she is nearest the earth, although he gives to Neptune 250,000 times more light than Venus gives to us at her best.

Neptune possesses only one known satellite. This satellite has the peculiarity of whirling much as if it had been tipped over through an angle of 150 degrees, which causes it to move in a direction opposite to that in which the planets travel around the sun.

CHAPTER XVI

THE EARTH

A PLANET AT CLOSE RANGE

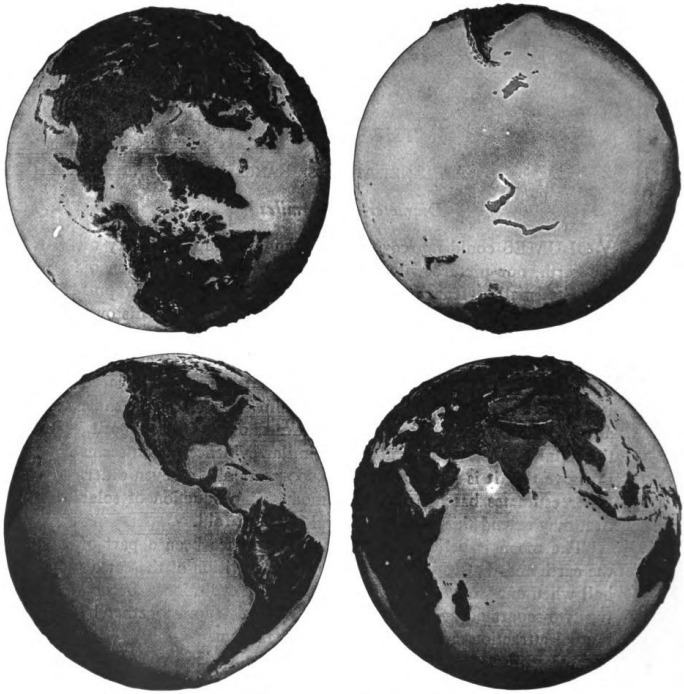
Diameter—7927 miles

VOLUMES could not cover the extremely complex history of the earth, nor picture with justice the exquisite construction of even its smallest features. It is here that the astronomer puts away his glass and turns detective with the geologist on his own home ground.

Astronomers, basing their computations of the earth's age upon the rate at which the sun is shrinking or contracting, have placed it at 25,000,000 years, but geologists claim that this is too short a time to account for the enormous thickness of stratified deposits, the salinity of the ocean, and other similar evidence which seems to prove that it is probably 100,000,000 years old, or even older. Later estimates based upon other modes of production of solar heat may extend this estimate several hundred fold.

The moon is believed by some to have once been a part of the earth and that it was formed through a division of the earth's ball when our world was in an early stage of evolution. Becoming two separated bodies, they have remained bound together by mutual attraction, and thus move around the sun.

According to the Nebular Hypothesis expounded by La Place, the earth and moon once shone like stars but, through the long ages of time they have gradually cooled, and, their lights extinguished, two cold-surfaced globes now wend their way around the sun.



THE EARTH, SEEN FROM A DISTANCE.

(Used by permission of the publishers, Rand McNally & Company, from Dodge's "Elementary Geography.")

The smaller of these two globes is now scarred and old but the other is still fresh with sparkling waters, green verdure, and is teeming with life.

According to the later and more generally accepted Planetesimal Theory of Moulton and Chamberlain, these

globes were cold in the beginning but became hot through compression as the material of which they were composed was drawn toward their centers by the pull of gravitation.

The four outer planets are mostly gaseous; the four inner ones have hardened crusts. Let us scan for a moment the various surface features of the third one in order from the sun,—the Earth, our own globe, and consider the unique and marvelous manner in which its various features have come to be.

In the course of millions of years, the earth, through the pull of gravitation, became gradually more and more dense. Different elements in its gases (which according to the later theory were squeezed out by pressure), combined to form rock, water and atmosphere. Hydrogen united with oxygen formed water; nitrogen, oxygen and small quantities of carbonic acid gas formed the atmosphere; oxygen mixed with silicon made quartz, the earth's first rock. This rock, called granite, rose to the top of the molten liquid material and formed a thin film of crust, for it was lighter than the metallic substance which sank to form the earth's core.

This thin, rocky film of crust which covered the hot liquid matter was at first so hot that the gases which had formed the water could not stay on its surface but rose in the air as steam. After the temperature became lower and the rocks cooled, rain poured down in sheets of water, remained on the crust and formed a warm sea.

For a long time this film was but a slight obstruction to the raging fiery forces confined beneath it and again and again these forces tore the crust asunder and made the surface of the earth a scene of wild commotion. But each time the cooling gained a slight mastery over the heat, and by cooling the earth's film was continually shrinking thus forming a thicker and more solid protective crust. After an heroic struggle between these mighty forces the crust was

at last strong enough even to sink down in places to fit the inner core; the sea then ran into these hollows and into the wrinkles formed from the shrinking, and the first ridges or islands appeared above the surface of the water.

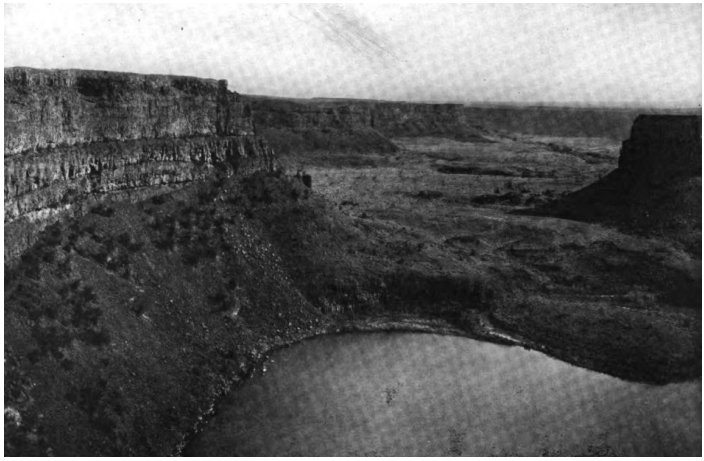
These ridges or islands were then attacked by the elements, eroded by the weather and the rains, and the granite which formed them was crumbled into quartz, feldspar and mica. The torrents of rain formed rivers, and these, seeking a level, carried the debris down to the shores of the ridges,—the finer sediment, the feldspar and mica, being washed far out from the rocky land where it settled to the bottom of the sea and in time formed which under pressure turned to clay, while the clay under greater pressure, turned to slate. The quartz of the granite, ground to fine particles, stayed near the shore and formed sandy beaches, which if covered under great pressure, became sandstone. Thus were some of our various rocks formed from the original rock of granite, and no matter where one sees sandstone or claybanks, even if on top of a mountain, such a place was once under water, for that is the only place where such sedimentary material could form.

"The sound of streams that swift and slow,

Draw down Æonian hills, and sow

The dust of continents to be."

This slow disintegration of the earth's first land continued for millions of years, the waste accumulating along the shores, and as far out as the finer sediment could be carried. Finally the pressure on the edges of this land caused the thin crust to soften and break, the molten magma poured forth in great masses, and the thick sediments were smashed together, folded up and thrust upward to form the earth's *first hills*.



A PORTION OF THE COLUMBIAN LAVA FLOW IN THE STATE OF WASHINGTON.

Photograph by Asahel Curtis, Seattle.

The crust was then so thin and easily broken that only low hills appeared but after it became thicker it was not so easily rent and *mountain ranges* were born with an accompanying roar of tremendous volcanoes. Geologists, studying the ages of the different ranges in the United States, have concluded that the first to appear were the Appalachian mountains; later the Rocky mountains in the west, and still later the Coast ranges. Mountain ranges are invariably found along lines of very thick sediments. The same strata which along the Appalachian range are 40,000 feet thick, thin out, when traced westward, to only 4000 feet at the Mississippi River.[1] The high tablelands in portions of Idaho, Oregon and Washington were formed by great streams of lava which poured through many of the fissures of the coast ranges and buried the whole country above the hill tops. This lava cooled into thick massive layers of solid rock—an interesting sight to this very day.

Although mountain ranges appear amid violence and their growth, in a geologic sense, is rapid, *plains* and *plateaus* are illustrations of sea-bottoms which have been covered with sediment carried down from the mountains, —mainly pebbles, sand and clay,—pressed and cemented together under the water and then gently raised to the surface. Sometimes the sea-bottom is exposed as a vast plain; again the strata are upheaved, bent or broken, forming faults and ridges. Many of the elevated plains and plateaus are later sculptured into hills by rains, winds, frosts and rivers. The hills are then gently torn down, the valleys filled up and the sediment again deposited by the rivers upon the bed of the ocean.

> "For every valley shall be exalted and every mountain shall be laid low."

A few million years passed by and these same deposits may again be raised and become dry land. *The great stretches of land between the mountains of the eastern and western portion of America* were formed from the sediment washed down from these mountains and deposited in the sea which lay between.

The crust of the earth is still rising and sinking, the land gaining on the water, but as this is usually such a slow movement, it can only be traced through a period of many years.

> "The notion that the ground is naturally steadfast is an error. The idea of terra firma belongs with the ancient belief that the earth was the center of the universe. It is, indeed, by their mobility that the continents survive the increasing assaults of the ocean waves, and the continuous down-wearing which the rivers and

glaciers bring about."

—*Professor Shaler.*

Nearly the whole of Sweden and Norway, for instance, has been rising for thousands of years. This is proved by the fact that old sea-beaches full of shells of species now living in neighboring seas, are found from fifty to seventy miles inland, and several hundred feet above the present sea-level on both sides of the Scandinavian peninsula.[2] Such sea-beaches are found high above the present water level in Chile and Patagonia, and the chalk cliffs of England were formed under the waves of the ocean. Le Conte says that one of the most evident proofs of crustal movements in ancient geologic times is the great thickness of shallow water sediments (sandstones, shales and limestones) over the greater portions of all of the continents, which represent areas of slow subsidence; and the great breaks or unconformities between the series of strata, which represent areas of uplift and atmospheric erosion.

Although sand and gravel are distributed over the bottom of the ocean near the land, dredging expeditions reaching down their metal cylinders for samples of the sea-floor at greater depths in various sections of the globe, have discovered that it is of a different composition, one-third of its area being covered with red clay. *Red clay* is composed of iron and silica and represents all that is left of the minute shells which cover the tiny sea-animals which flourish in such countless multitudes throughout the ocean. These shells, after the animal dies, drift downward in ceaseless showers and the lime, of which they are largely composed, is dissolved during the long journey to the bottom. "*Ooze*" is found in water less deep and is formed by the accumulation of minute shells of different species. Minute shells of the same species have formed great thicknesses of limestone or of chalk even as grains of sand

build in time their banks of sandstone. Such information as this is, of course, disclosed by the penetrating eye of the microscope. Chalk cliffs, now dry land, form thousands of miles of habitable land in Europe, while coral sand pressed into rock forms the unique foundation of the Bahama Islands, the Bermudas, many islands of the Pacific, and the Great Barrier Reef extending for a thousand miles along the shores of northern Australia!

Looking again about our own country on the land that lies cradled between the eastern and the western mountains of the United States, one cannot help but regard with awe the magnificent stretches of time it must have taken for this great area to have been formed beneath the sea. This alone proves the great age of the earth. Because it was raised slowly, the strata lie there little disturbed, one over the other, "like the leaves of a great stone book," containing the history of the earth. A good view of the river strata may be obtained in the canyon of the Colorado river, for this mighty river has carved a bed through the stratified deposits to a depth of from 3000 to 6000 feet.

"To quarry the heart of the earth

Till, in the rocks red rise,

Its age and birth, through an awful girth

Of strata, should show the wonder-worth

Of patience to all eyes."

The elevated sea-bottom is a fertile field for the fossil hunter, affording evidence that enables the geologist to reconstruct the evolutionary development of life on our planet in its divinely ordained stages. There is often but little resemblance in the fossils found in the lower strata to

the plants and animals now in existence, but traced from stratum to stratum, the connection is obvious. The "fire-formed" rocks of the Archæan Age, which support all the other strata, contain no evidence of life; neither do the first sedimentary rocks which were deposited above them. The first fossils are found in the strata overlying the first sedimentary rock.

Geologists have divided the history of the earth into seven ages:

1. *The Archæan Age*, represented by the Archæan system of
   rocks.
2. *The Age of Invertebrates*, represented by the Cambrian,
   the Lower Silurian and the Upper Silurian rocks.
3. *The Age of Fishes*, represented by the Devonian rocks.
4. *The Age of Amphibians*, represented by the Carboniferous
   rocks.
5. *The Age of Reptiles*, represented by the Mesozoic rocks.
6. *The Age of Mammals*, represented by the Cenozoic rocks.
7. *The Age of Man*, represented by recent rocks.

All of these Ages, which represent the life history of the world, left their impression on the rocks of their times, and each Age is connected with the preceding and the succeeding Age like links in a long, long chain.

In regard to the distinctness and importance of the last great era, the Age of Man, Le Conte, in "Elements of Geology," says that there are two views which will ever

divide geologists, depending on the two views regarding the relation of man to Nature:

> "From a purely structural and animal point of view, man is very closely united with the animal kingdom. He has no department of his own, but belongs to the vertebrate department, along with the quadrupeds, birds, reptiles and fishes. He has no class of his own, but belongs to the class Mammalia, along with the quadrupeds. Neither has he an order of his own, but belongs to the order of the Primates, along with the monkeys, lemurs, etc. Even a family of his own, the Hominidae, is grudgingly admitted by some. But from a psychical point of view it is simply impossible to overestimate the space which separates man from all lower things. Man must be set off not only against the whole animal kingdom, but against the whole book of Nature besides, as an equivalent: Nature the *Book*—the revelation—and man the *interpreter*. So in the history of the earth: from one point of view the era of man is not equivalent to an era, nor to an age, nor to a period, nor even to an epoch. But from another point of view it is the equivalent of the whole geological history of the earth besides. For the history of the earth *finds its consummation, and its interpreter, and its significance, in man*."

Ah—how exhilarating the thought! Once again with the astronomer, we gaze out on the huge planets of the solar

system,—the groups and great galaxies of stars. Does the earth really seem so insignificant in its smallness?

The beautiful little earth-ball, with its precious freight of human beings, softly flies about the sun. Amply protected in a transparent case of atmosphere, it completes its tremendous journey of 576,000,000 miles once every year. During this year its temperature is varied by four seasons which are caused by the earth being inclined 23½ degrees on its axis.

"Some say, he bid his angels turn askance

The poles of earth twice ten degrees or more

From the sun's axle; they with labor push'd

Oblique the centric globe."

—Milton's Paradise Lost.

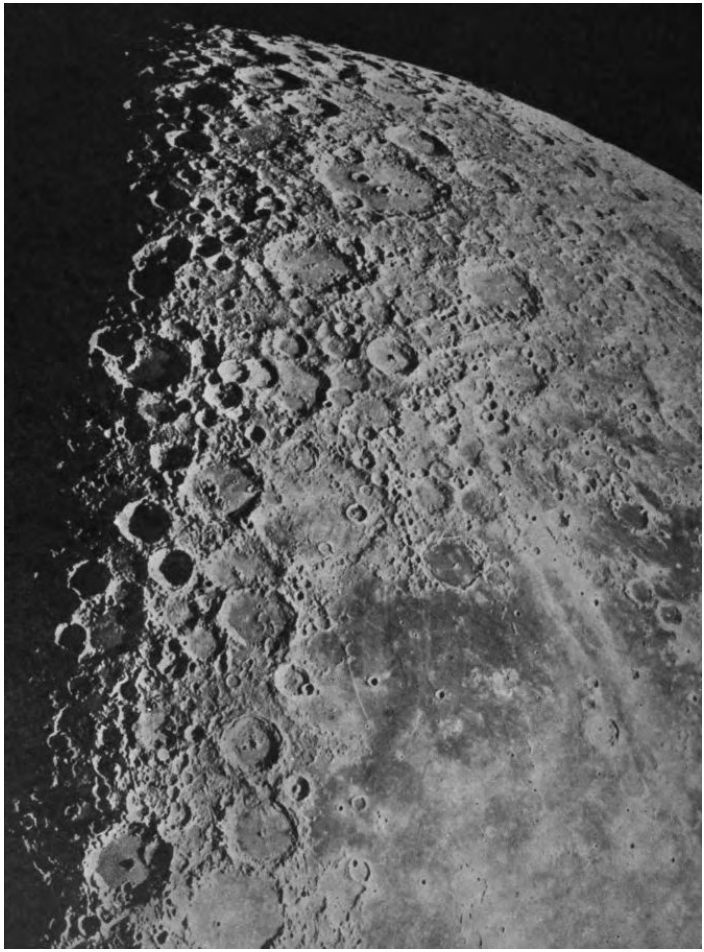
During this journey around the sun, the earth rotates 366¼ times on its axis, making one revolution every 23 hours, 56 minutes and 4.09 seconds. This causes each side to be alternately warmed and lighted every few hours. Cupped close to the darkened hemisphere lies a huge cone of shadow which extends out in space past the moon. When the moon rolls through this shadow it is eclipsed for it has come into our night.



This cone of the earth's shadow is our personal night and ours alone, and, although the stars seem enmeshed in its velvet sides, it is not the night of earth that holds the stars, —its darkness merely shuts out the glare of the sun and the stars of the universe therefore become visible. This remarkable view gave to man a science set in beauty so keen that in the world's young days it was thought that it was music too sweet to be heard by any but the gods. But now we know that all Nature is like that, and there is not a cliff, rock, shell, mountain, valley, water, land or any living thing in the botanical or zoological kingdom, no matter how common or how lowly, which does not carry, even as the stars, its quota of science and song.

[1]Le Conte.

[2]De Greer, Bulletin of the Geological Society of America, vol. III, 1892.



THE SOUTHERN PORTION OF THE MOON AT LAST QUARTER.

Photograph by Mount Wilson Observatory through the 100-inch Hooker telescope.

CHAPTER XVII

THE EARTH'S MOON

A NEAR VIEW OF A SATELLITE

Diameter—2163 miles

THE moon's diameter is equal to one-fourth that of the earth. As viewed from a nearby planet—neighbor Venus, the planetoids, or neighbor Mars—the moon and the earth would appear as two close stars.

Both Jupiter and Saturn have moons larger than ours, but Jupiter, for instance, is over a thousand times larger than the earth, and Saturn ranks next to Jupiter. The moons of Mars are exceedingly tiny, and Mercury and Venus have none at all. Neptune has one moon, Uranus four, Jupiter nine and Saturn ten. Of all these moons, it is most natural for us to want complete information on the moon that lies nearest to us, the moon of the earth, which travels around us as we journey around the sun, at a distance of only 240,000 miles. With the aid of the greatest of telescopes, through which the accompanying photograph was taken, the moon can be brought within a clear range of 60 miles, and even closer. However, an opera-glass reduces the distance to one-half, and such a glass, or a very small telescope, is much better in every way for the amateur.

With the nearest planets millions of miles in the distance and the nearest stars millions of millions of miles away,

the short distance of 240,000 miles to the moon seems almost no distance at all; in fact, the moon lies so close to us that it not only rolls through the shadow of the earth, but we may also see the various features, and even the shadows of those features, upon its surface.

The moon and the earth form a little system of their own and are bound together by a strong attraction.



EARTH-LIT NEW MOON.

Showing a slender crescent embracing the earth-lit night portion of the moon. Photograph through 40-inch refractor by Yerkes Observatory.

This strong attraction, called the force of gravity, has

resulted in a strange thing happening to both the earth and the moon, for the earth pulls so hard on the moon that it has long since destroyed the moon's axial rotation with reference to itself, and the moon pulls so hard on the earth that it moves the great fluid body of the ocean. Thus the moon has always the same face toward the earth for it cannot turn around and show us the other side, while the pulling of the earth by the moon causes the ocean's waters to rise and fall every 12 hours and 26 minutes, or twice a day. When the Greek and Roman travelers first ventured to the ocean, they could not understand why great stretches of beaches were left dry, and with equal regularity covered up; where did the water go, and why? It seemed a hopeless mystery to people who had lived around a landlocked sea where the tide, with few exceptions, rises but a few inches. When the sun and moon are in line with the earth they co-operate in their pulling and hauling at the sea. The moon is then either "new" or "full" and it is then that the highest tides occur.

"The silver Moon o'er briny seas presides,

And heaves huge ocean with alternate tides."

—*Lucan's Pharsalia* (ROWE'S *Trans.*)

At exactly new moon (the moon is called new when it lies between the earth and sun), the moon comes above the horizon at the same time as the sun and sets with it. A few days after new moon we sometimes see what is called the old moon in the young moon's arms, the dimly lighted portion being illuminated by light reflected from the day side of the earth. This earthlight at the moon is at least 50 times greater than moonlight at the earth. Its somewhat ruddy color is caused by the sunlight having passed twice

through our atmosphere. The bright crescent, which is the young moon's arms enclosing the old moon, is the sun-illuminated portion of the moon.

"I saw the new moon late yestere'en,

Wi' the auld moon in her arms."

—Old Scotch Ballad.

After "new moon" the moon appears a little to the east of the sun as a thin semicircle, the horns of which *always* point to the cast. The horns point to the east because the sun sets in the west and the illuminated part of the moon is on the side nearest to the sun, a fact sometimes forgotten by artists. The thin crescent of the moon gradually becomes broader as the moon moves away from the sun and in the course of four or five days increases to a semicircle.

"The Moon her monthly course had now begun,

And with increasing horns forsook the Sun;"

—Lucan's Pharsalia.

The semicircle then increases to an oval and by the time the moon is behind the earth with the earth between it and the sun, the oval has increased to a full circle. Each day the moon rises about 50 minutes later than on the preceding day and in the course of a month changes from a crescent —a quarter—a full shining face, to a quarter, a crescent and again a slender new moon. It has now traveled completely around the earth. Since the moon has always the same face toward the earth (if one will walk around a

table with the eyes always toward the center, this journey will be well illustrated), it will be seen by us in all its phases before it completes a day and night, or, in other words, although the earth turns all sides to the sun in 24 hours, the moon must travel all the way around the earth, which takes almost 30 of our days, before it completes a day and night. This means a continuous stretch of 14¾ times 24 hours of daylight, which is about equal to 29 of our days, of daylight, followed by 14¾ times 24 hours of night, when the sun is below the horizon. It would be a strange experience to travel to this country where the day and night each last half a month.

If a journey to the weird, rough country of the moon were possible, one would experience even greater surprises than the length of the day and the night, for the sky, as seen from this airless sphere, would be strangely different from anything that we are accustomed to. Here the sun hangs like a big gold jewel edged with a tiny fringe of scarlet, the pearly petals of its delicate corona far outstretched against the star-filled sky. The brilliant ball of the earth, which would appear almost 13 times as large in area as the moon, rests immovable and ever present, its great globe turning completely around every 24 hours. Also, as the moon does to us, it would exhibit to an observer on the moon an interesting variety of phases, mammoth crescents, quarters and disks. Such a sky!—a huge white planet, a flower-like sun and multitudes of unwinking stars. And even more, for stretched from horizon to horizon of that black dome, even though the sun shines brightly, is the misty arch of the Milky Way glowing in a glory quite unknown to mortals on earth. All this would happen for the simple reason that the moon has no appreciable amount of atmosphere to diffuse the sun's rays, make the sky seem blue and render the stars invisible. This would also unveil many of the smaller stars that are not seen here without optical aid—and every star would

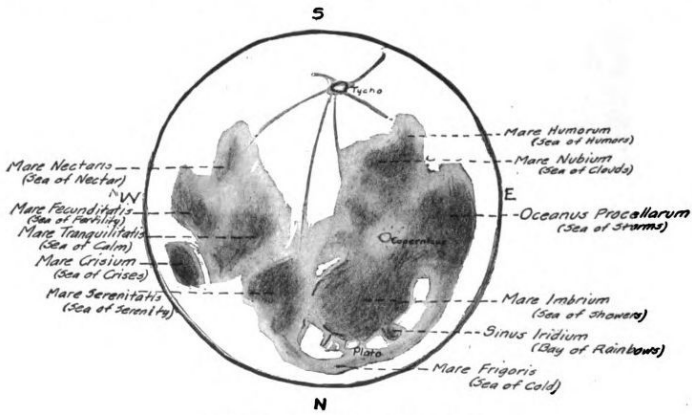
"burn" but none would "twinkle." In the morning of that long lunar day of 354 hours, the yellow face of the sun would slowly push its gayly bedecked head above the black rim of the horizon unheralded by a dawn; neither would twilight trail behind it when it sank beyond our sight after the long day was done, for these phenomena are due entirely to the light-reflecting and refracting power of an atmosphere.

The absence of an atmosphere on the moon, or at least the presence of only a very rare one, is proved by the suddenness with which a star will disappear when the moon passes between the star and us. Also surface features would not otherwise stand forth with such clearness nor shadows be so sharp and inky-black. When the moon passes in front of the sun at the time of an eclipse, its outline shows perfectly sharp against the yellow disk, even showing, like jagged saw-teeth, the "mountains of eternal light" which tower near the southern pole. When Venus makes a transit across the sun its whole edge is illuminated instead of being merely sharply defined, for Venus is enclosed in a wrapping of atmosphere.

The spectroscope has proved that there is no water on the moon. If it is airless and waterless it consequently must be lifeless. But hold, a moment. Perhaps we go too fast with our this anti that and therefore, for here come reports from Pickering, one of our most tireless observers, who declares that there is a considerable amount of dampness still lodged in the deep cavities of the circular mountains, and that this dampness ascends in mists when the sun rises. These mists do not seem to float freely but cling to ridges and higher levels and later dissolve there. The outlines of these cavities are slightly blurred until the mist is banished.

THE GRAY LAND ON THE MOON

The curious gray areas which extend over two-fifths of the surface of the moon are the most conspicuous features to be seen with the unaided eye. These areas are comparatively smooth and level and invariably lower than the surrounding country.



THE GRAY LAND OF THE MOON.

The rest of the moon is extremely rough, the southern hemisphere in particular presenting the most singular circumambient scenery of thousands of round pits fringed by lofty ramparts of circular mountains.

With the aid of a small telescope, the grayish spots on the moon somewhat resemble seas as they might appear at a great distance. Thus old astronomers, believing that they might at least be ancient sea-bottoms from which the water had evaporated, named them accordingly—although rather romantically. These names are still retained, disguised in Latin on the map of the moon and referred to in Latin by present day astronomers. Translated, however, they add a quaint glamour to the Gray Land and the eye wanders interestedly over "The Sea of Showers," "The Sea of Tranquillity," "The Sea of Clouds," "The Sea of Nectar,"

"The Gulf of Dews," "The Ocean of Storms," "The Bay of Rainbows," "The Marsh of Sleep" or "The Lake of Dreams."

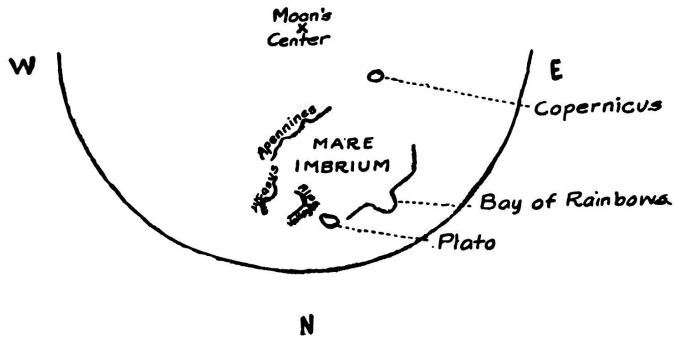
Since the days of Galileo, improved telescopes and continued research have constantly increased our knowledge of the moon. The curious so-called "seas" are not, seemingly, old sea-bottoms; they are dark plains on the lunar surface much more likely to be great lava plains than sea-basins, according to the evidence that has been collected. Many scientists now regard these areas as a part of the surface where the thin crust became weakened and succumbed in an early stage of the moon's development; the lava then welled forth from the interior and flowed out in great molten sheets over the surrounding country. Since over 100,000 craters have also been observed on this side of the moon, all in fairly good condition, and since there has been no weathering, it is sometimes said that the moon presents a picture of the volcanic age petrified.

The gray patches are best seen when the moon is full. Under a telescope these areas appear darker with occasional traces of yellow or green tints. The colors may be due to some form of vegetation or masses of colored volcanic material.

MOON MOUNTAINS

The most prominent mountains on the moon are the Apennines. These extend in a continuous curve for 450 miles a little north of the center of the moon, forming an impressive "shoreline" for Mare Imbrium, the "Sea of Showers." Running northward, just above the Apennines, is the Caucasus range, and east of the Caucasus, lie the Alps. The Alps and Caucasus mountains are far less conspicuous than the Apennines, for not only do these

latter mountains reach into a higher altitude but they also are crowned along their 450 miles with some 3000 steep and rugged peaks.



The Alps are noted for a remarkable flat-bottomed valley which cuts in a straight line through these mountains for a distance of 80 miles. This valley is from to 6 miles wide and at least 11,000 feet in depth. Such a long, level strip bordered by gigantic mountains is as unique a formation as the mammoth craters with the towering rims.

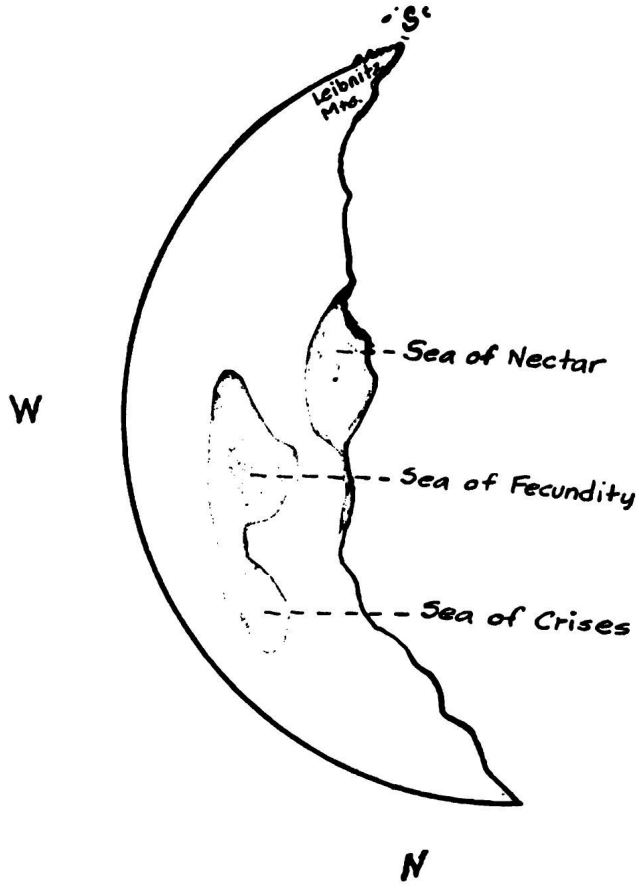
The Leibnitz and the Doerfel mountains are on the southern part of the moon near the pole. These mountains are so situated that the light of the sun always shines from their summits, and even during an eclipse they are visible in profile. Some of the peaks on these "mountains of eternal light" are very high, their needle-like points reaching upward for 26,000 to 27,000 feet. It has been estimated that if our mountains on earth were comparatively as high as the mountains on the moon, our earthly mountains would rise to the height of about 15 miles! The height and sharpness of the moon mountains is due partly to the low surface gravity, which is only about ⅙th that of the earth, and to the fact that there is no leveling influence such as is caused by frosts and rains.

Isolated mountains rising up like a huge lump, or a pen point, from a flat surface, are commonly found on the moon. These often stand several miles high and are particularly interesting as seen in the northern hemisphere of the moon, when the long shadow of such a solitary mountain stretches in inky-blackness against the smooth gray plain. Several of these may be seen in Mare Imbrium just above the crater Plato, the loftiest of which is Pico, rising about 8000 feet. Isolated mountains are very frequently found in the center of craters. This would seem a strange formation close at hand—a large crater, or a ringed plain, miles in extent, with a tall slender mountain standing in its center.

The oddest and most common mountains, however, are the circular mountains which surround a plain or a large sunken cavity, like a mighty wall. Such mountains appear on almost every part of the moon's surface and in some places they appear in such profusion that their rings frequently touch and even overlap one another. The peaks of the circular mountains are often two or three miles in height and their shadows sometimes cover a large portion of the plain which they surround. These shadows are continually varying, for during the increase of the moon they are thrown in one direction and during the decrease, in the direction exactly opposite. During full moon they disappear altogether and the plains are filled with light, but lunar scenes are much more interesting when the sunlighted portions are accentuated by the long, queer shadows, for these shadows are black and clear-edged and stand out like silhouettes done in ebony, even at this distance of 240,000 miles. Because they have no light reflected into them from an atmosphere, these shadows are actually so densely black that if one stepped into such a shadow he would instantly be blotted from view.

On account of the vividness of the shadows, moon-

mountains are best observed during the first and last quarter of the moon. A good time to begin observing with a glass is when the moon is a narrow crescent in the western sky.



The most prominent object in the narrow crescent is the Mare Crisium or the Sea of Crises, 380 miles long. South of Mare Crisium is Mare Fecunditatis, the Sea of Fecundity and Mare Nectaris, the Sea of Nectar. When

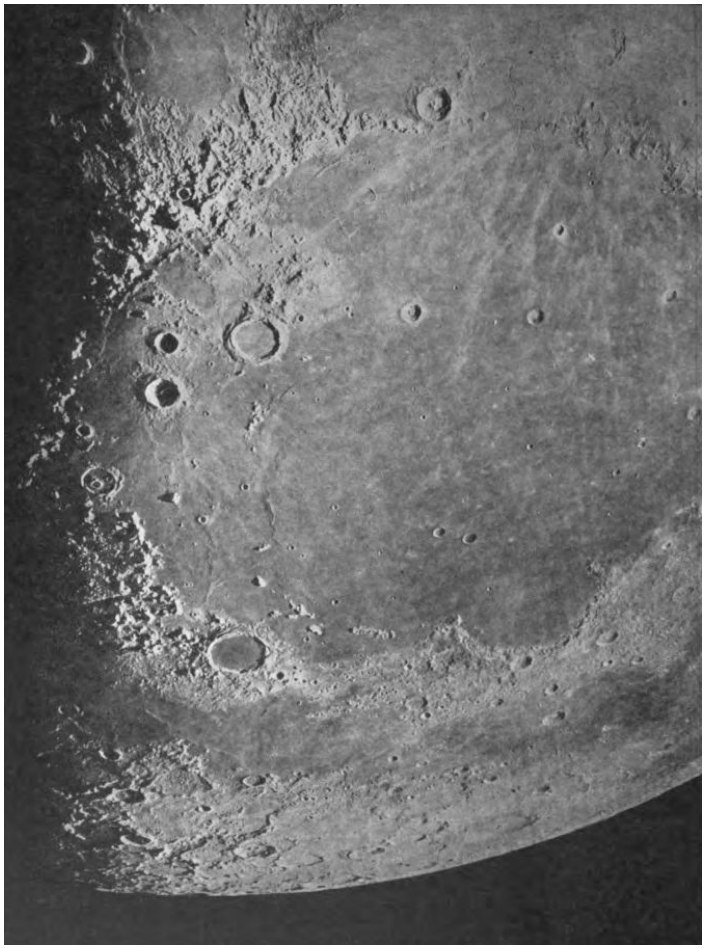
these three "Seas" are visible with Mare Tranquillitatis just coming into view, the moon is between 5 and 6 days old, that is, 5 or 6 days after new moon. The Leibnitz mountains may then be seen near the southern pole. Watch carefully evening after evening as the light creeps over new regions and brings them into view. The best place to select for observation is the boundary line between the illuminated and unilluminated portions, called the "terminator," for the shadows that are cast make the irregular features stand out more distinctly and bring out the individual beauties of the lunar scenes. Since we are looking down upon the moon, a mountain peak, at this distance, resembles a point of light, and a mountain range whose base is still in the shadow, but whose peaks are lighted by the rays of the sun, a straight or curved row of lights. Besides beautifying the country of the moon and revealing to us the peculiar sharpness of the mountain peaks, the shadows have proved of great practical value to astronomers, for by measuring the length of their shadows, the heights of the mountains are calculated.

THE CRATERS ON THE MOON

Craters are so numerous in some localities on the moon that one might walk for hundreds and hundreds of miles and step on nothing but crater rims. On the earth a crater is usually a rare object situated on the top of a mountain, but on the moon they are scattered all over the lunar plains, a state of landscape which permits of no short cuts. If, however, in the dim, distant past, life had ever developed on the moon, a moon-being would have been %th as heavy and able to jump six times as high as an earth-being for the surface gravity of the moon is only about ⅙th that of the earth. Thus if a lunarian had no other mode of transportation, he might at least have been able to

surmount many of the minor obstacles by jumping over them.

A map of the moon resembles a big mud-ball with all the little pebbles picked out.



NORTHERN PORTION OF THE MOON.

Note the "Sea of Showers," the "Bay of Rainbows," Copernicus and Plato, the three craters north of the lunar "Apennines," the Caucasus Range, the Alps and the Valley of the Alps. Refer to the maps. Photograph by Mount Wilson

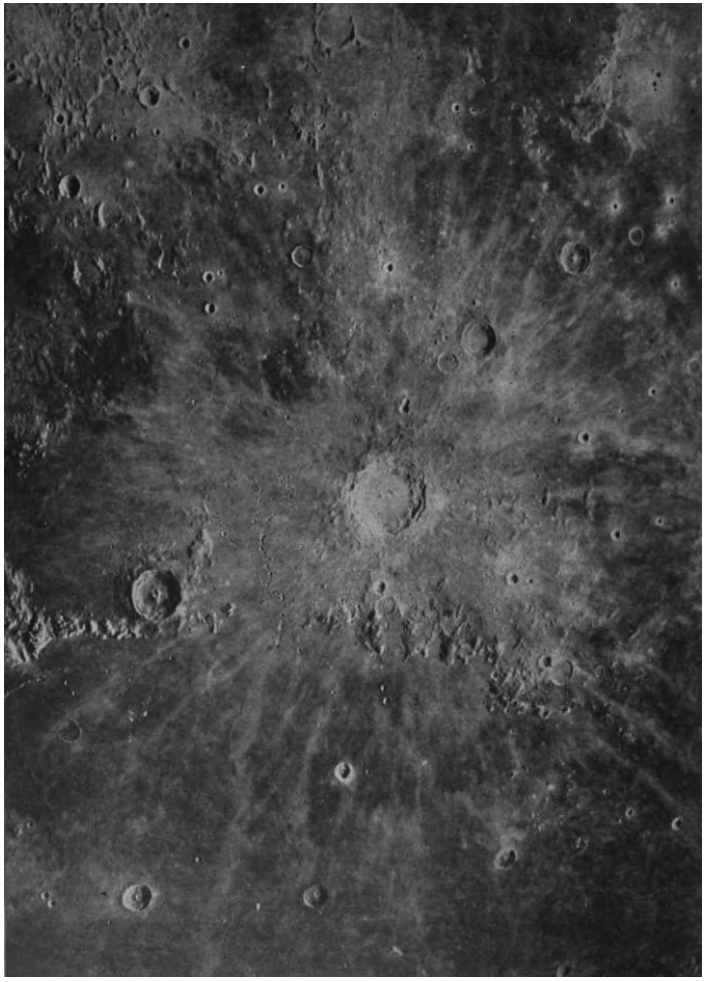
Observatory through the 100-inch Hooker telescope.

A crater only six miles in diameter may be easily seen in a small telescope, although there are thousands less than a mile in diameter which may be seen in a large telescope. Craters from 16 miles to 60 miles in diameter are common and a few even measure as much as 100 to 150 miles. These craters have deeply sunken floors and are usually surrounded by gigantic mountain walls which rise like a fringe of rock above the general level of the region outside. Near the center of many of the craters with the largest brims, one and sometimes two or three sharp-peaked mountains tower, casting a long, weird shadow over the crater's floor. The surrounding brim is almost invariably higher than the central mountain, yet many of these central mountains are a mile or so high.

Probably the deepest of the moon's craters is *Theophilus*, on the edge of the circular "sea" Mare Nectaris, and it is best seen while the moon is still a slender crescent. The encircling walls of this crater rise from 14,000 to 18,000 feet above its floor, the floor itself being 10,000 feet below the general level of the moon outside the wall. The walls of this amazing cavity, in the main, slope gently to the outer plain but rise very steeply from the depths of the inner floor which measures 64 miles across. Three lofty cone-shaped mountains rest in the center of this floor, their sharp, black shadows stretching to the left. One of these mountains rises 6000 feet, yet its summit is some 4000 feet lower than the level of the outside plain! Imagine standing on the rim of Theophilus and watching the darkness flow into its huge bowl until the mountain peaks in the center look like sunny isles in a dense, black sea! This is a *real* crater, for the word "crater" means "cup."

Most of the large craters on the moon, however, are not so "cup-like," but, to pursue the simile still farther, are

more like platters and saucers and individual butter plates, for their diameters range from five times to more than fifty times their depth.



THE LUNAR CRATER COPERNICUS, FIFTY MILES IN DIAMETER.

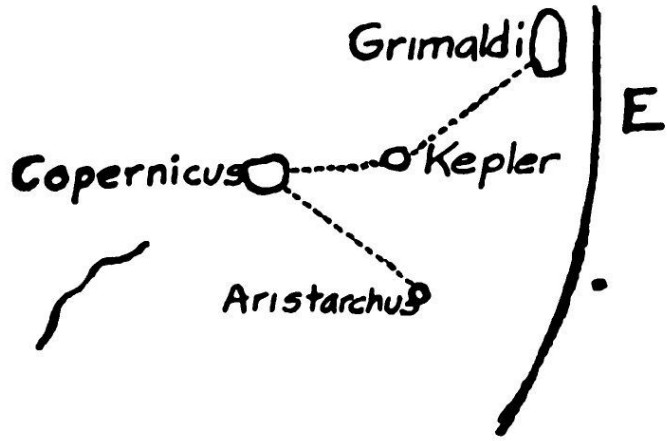
Photograph by Mount Wilson Observatory through the 100-inch Hooker telescope.

Chacornac mentions a walled-plain called *Schickard*, on the southeast portion of the moon, which is 134 miles in breadth, and, although encircled by a mountain wall which in one place is nearly 10,000 feet high, a spectator centrally located on the floor of the crater would think himself on a boundless desert, for this encircling wall, due to the curvature of the surface of the moon, would lie entirely beneath his horizon.

One of the most magnificent craters on the moon is the great crater *Copernicus*. Copernicus lies in an isolated position a little southeast of the range of the Apennines, on the darkened space called Mare Imbrium. Being not far from the center of the lunar disk, it is an easy object for the eye to find and to use as a guiding point from which to locate other craters. A circular range of mountains much terraced on the inner side surrounds the great plain of Copernicus, while in the very center of its 56 miles of floor stands a solitary mountain with an altitude of 11,000 feet. It is believed by many astronomers that such terracing as is shown in the interior of Copernicus, is mainly due "to the repeated alternate rise, partial congelation, and subsequent retreat" of a great flow of lava which rose up from the floor during a period long past. A number of other craters also show such terracing. The bright appearance of Copernicus is caused by an interesting system of bright streaks which radiate from the circular rim of its mountains. Tycho, near the southern pole, has also such a system of radiating streaks, but so enlarged and intensified are the rays of Tycho's system that they run for hundreds of miles and dominate the whole scene when the moon is full.

Aristarchus, northeast of Copernicus, is the brightest single point on the moon. The peak in the center of its 29 miles of brilliant interior shines so brightly that it has often been seen on the dark side after new moon. Indeed, when Sir William Herschel first observed it through a telescope

he mistook it for a volcano in action. The walls of Aristarchus are also conspicuously terraced and rise about 4000 feet above its floor.

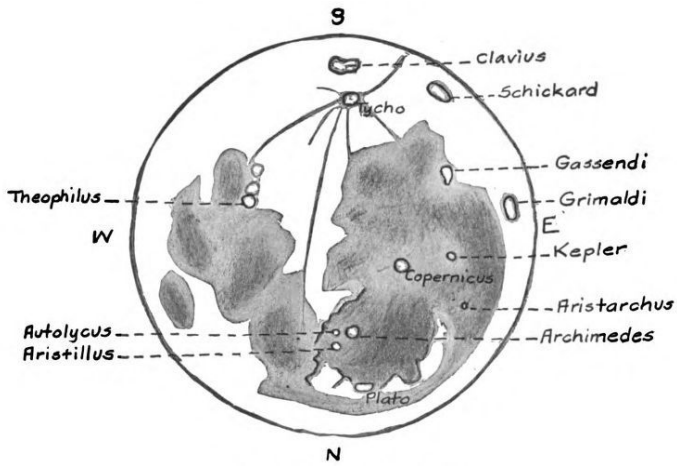


South of Aristarchus and east of Copernicus may be seen *Kepler*, a 22-mile crater noted for its extended system of glistening streaks. Its surrounding wall, like that of Tycho and Copernicus, seems to be covered with the same shining substance. The wall of Kepler is very low but its crater is about 10,000 feet below the exterior plain.

Southeast of the two bright craters, Kepler and Copernicus, and almost at the edge of the moon, lies the darkest and also one of the largest of the moon's craters, or walled-plains, as the large craters are now more frequently called. This huge crater, *Grimaldi*, extends north and south for a distance of 148 miles and covers an area of 14,000 square miles. It is very noticeably dark in comparison to all surrounding objects.

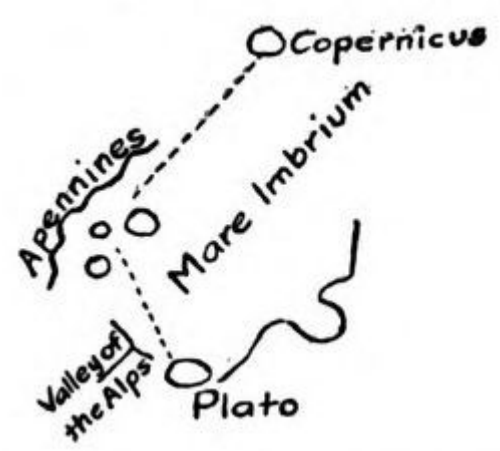
Gassendi, a little southwest of Grimaldi, contains a great variety of detail both on its rim and on its floor. Its plain is 54 miles in diameter and includes a number of central peaks.

Again starting from Copernicus and letting the eye travel northwest along the Apennine mountains almost to the Caucasus, one arrives at a group of three beautiful craters which rest conspicuously on the level floor of Mare Imbrium. The largest of these craters is named *Archimedes* after the most celebrated of ancient mathematicians. It is to be noted that lunar craters have been given the names of great men—Copernicus, Tycho, Kepler, great astronomers; Aristotle, Plato, great philosophers,—a very fine recognition of scholarly worth. Archimedes, 52 miles in diameter, has no interior mountain, but the shadows of its tall rim are imposing as they fall across its plain.



Some Interesting Craters on the Moon.

Aristillus is about 34 miles in diameter, and 10,000 feet deep. In the center of this deep cavity rises a massive many-peaked mountain whose base is often lost in the darkness of the crater's shadows. *Autolycus*, south of Aristillus and somewhat smaller, is 23 miles in diameter with a floor somewhat depressed below the country which surrounds it.



Some interesting Craters on the Moon.

On the "shore-line" of Mare Imbrium, north of Archimedes, Aristillus and Autolycus, and not far from the "Valley of the Alps," lies *Plato*, one of the most easily found craters on the moon. Plato is a very huge oblong crater, 60 miles in diameter and containing an area of 2,700 miles. Its floor is exceptionally dark and flat and forms a striking contrast with the bright border of mountains which surround it. Quite a number of minute craterlets have been distinguished on its floor.

The southern hemisphere of the moon, particularly as one approaches the region about the southern pole, is pitted with such a bewildering number of both large and small craters that astronomers say that it is relief to the eye to study the comparatively smooth, shaded portions of the globe after having gazed for any length of time at the crowded mass of detail in this wild and rugged region. The two craters in the southern hemisphere that are perhaps the easiest for the amateur to locate are *Clavius*, an enormous crater near the mountains at the southern pole, and *Tycho*, just below it, with its wonderful streaks, or rays.

Clavius is a crater of gorgeous depth and has an area of 16,500 miles. Around its walls and on its floor are many secondary craters, while from its center rise tall mountain peaks, one of which reaches 24,000 feet above the bottom of one of its included craters.

Tycho is called "The Metropolitan Crater of the Moon," because its brilliant rays stand forth so prominently when the moon is full that all other craters are lost in obscurity. This magnificent crater measures 54 miles from rim to rim with its floor over 3 miles below the highest ridge of the massive mountains which surround it. These mountains are diversified by a series of terraces on their interior slopes while a peak 6000 feet in height rises in the center of its floor. The ray system of Tycho is wholly invisible at the time the sun rises or sets, which is the time when most of the objects on the moon are seen at their best. However when the sun has attained an altitude of 30 degrees, they mysteriously make their appearance, extending for hundreds and some even for several thousands of miles. These rays are never irregular because of interposed obstructions but stretch straight and true in a most remarkable way over mountains, pits and plains. So numerous are these bright rays about the brilliant crater of Tycho that at full moon they may even be located as a patch of light to the unaided eye, although an opera-glass, which brings the moon down to 120,000 miles instead of 240,000, greatly improves the seeing. William H. Pickering, in his book on "Mars," gives some of the latest information concerning Tycho:

> "The white radiating lines or bands are seen to be due to numerous minute craterlets each giving out a triangular white streamer producing the general effect of a white band. It is probable that this observed regular distribution of the

> craterlets is due to their lying along invisible cracks radiating from the inner crater. It is much the same as the great volcanoes of the Andes, which stretch in a straight line for over 2000 miles between Peru and the strait of Magellan. The Alaskan volcanoes lie upon a uniformly curved line of nearly equal length.... This line formation is generally considered by geologists to be due to subterranean lines of weakness or cracks in the earth's crust."

The moon is considered to be a matured globe, evolutionally old, and it has even been referred to as being nearly dead. Lacking, air, water, life and even the diversion of sound, it surely is at least in but a semi-conscious stage, as worlds go. Mars is also called an old world, but Mars has air, its snow-caps melt in sheets of water, and we view the colors which mark its seasons, across a distance of 50,000,000 miles. The moon looks as it is, seared and old. There have been many theories advanced to explain the abundance of its craters and their peculiar construction, but some modified form of the volcanic action is the only tenable one. No one theory has as yet met with universal approval.

A great telescope with a 100-inch lens has lately been erected at Mount Wilson, near Pasadena, California. The telescopes which have mirrors, like this one, are called reflecting telescopes. The largest reflecting telescope before the one now mounted on Mount Wilson became available, was the splendid instrument at Little Saanich, Victoria, B.C., which has a 72-inch mirror. A telescope in which the light rays pass through a series of lenses fixed in a long tube pointed directly at the object is called a refracting telescope. The Yerkes telescope at the

University of Chicago is an unusually fine 40-inch refractor.

With the greatest of telescopes the moon may be brought to within 60 miles of the earth and a lunar object a mile or so in diameter is easily discernible. The imagination is entranced. All success to astronomers!

PRONOUNCING DICTIONARY

Acrisius—a-crish'-e-us
Ægean—ee-gee'-an
Ægeus—ec'-juce
Æsculapius—es-cu-la'-pe-us
Albireo—al-bi'-re-o
Alcyone—al-si'-o-ne
Algenib—al-ge'-nib
Algol—al'-gol
Alioth—al-i'-oth
Almach—al'-mach
Alnilam—al-ni-lam'
Alnitak—al-ni-tak'
Alpha Centauri—al-fa sen-ta'-re
Alphard—al-fard'
Alpheratz—al-fe'-ratz
Altair—al-tar'
Alwaid—al'-waid
Ambrosia—am-bro'-zhia
Amphitrite—am-fe-tri'-te
Andromeda—an-drom'-e-dah
Andromids—an-drom'-ids
Antares—an-ta'-rez
Aphrodite—af-ro-di'-te
Aquarius—a-qua'-ri-us
Aquila—ak'-wi-la
Aratus—ara'-tus
Arcas—ar'-cas
Archimedes—ar"-chi-me'-des

Arcturus—ark-tu'-rus
Ares—a'-rez
Argonauts—ar'-go-nawts
Ariadne—a"-ri-ad'-ne
Aries—a'-ri-es
Arion—a-ri'-on
Aristarchus—ar"-is-tar'-chus
Aristillus—ar"-is-til'-us
Asterope—as-ter-o'-pe
Astræa—as-tree'-ah
Atlas—at'-las
Atergatis—a-ter-ga'-tis
Auriga—aw-ri'-ga
Aurora—aw-ro'-rah
Autolycus—au-to-ly'-cus

Bacchus—bac'-cus
Bellerophon—bel-ler'-o-fon
Berenices—ber"-e-ni'-ces
Beta Centauri—be'-ta sen-ta'-re
Betelgeuse—bet'-cl-gooz
Boötes—bo-o'-tez

Caduceus—ca-du'-she-us
Canopus—ka-no'-pus
Canis—ca'-nis
Canes Venatici—ca'-nez ven-at'-i-si
Capella—ca-pel'-la
Castor—kas'-tor
Cassiopeia—cas"-se-o-pee'-ah
Caucasus—caw'-ca-sus
Centaurus—cen'-taw-rus
Centaur—cen'-tawr
Ceres—ser'-reez
Cepheus—se'-fus
Cerberus—cer'-be-rus

Cetus—se'-tus
Chaos—ka'-oss
Chromosphere—kro'-mo-sfer
Chimara—ki-mee'-rah
Chiron—chi'-ron
Constellation—con-stel-la'-tion
Coma Berenices—co'ma ber-a-ni'-ses
Copernicus—co-per'-ni-cus
Cor-Carolli—kor-kar-o'-li
Corona—ko-ro'-na
Crete—cre'-te
Cyclops—si'-clops
Cycnus—sik'-nus
Cygnus—sig'-nus

Danae—dan'-a-e
Dadalus—ded'-a-lus
Danaides—dan-a'-i-deez
Deimos—dei'-mos
Delphi—del'-fi
Diana—di-an'-a
Demeter—de-mee'-ter
Deneb—den'-eb
Delphinus—del-fin'-us
Dolphin—dol'-fin
Doerfel—doer'-fel
Draco—Dra'-co

Electra—e-lek'-tra
Elysian—e-lizh'-e-an
Erechtheus—e-rek'-thuce
Eridanus—e-rid'-an-us
Etanin—et'-a-nin
Eurydice—u-rid'-i-se
Europa—eu-ro'-pa

Formalhaut—for'-mal-o

Galileo—gal"-i-le'-o
Ganymede—gan-i-mee'-de
Gassendi—gas-sen'-di
Gemini—jem'-i-ni
Gorgons—gor'-gons

Hades—ha'-deez
Hecatoncheires—hec-a-ton'-sheires
Helicon—hel'-i-con
Hellespont—hel'-les-pont
Hercules—her'-ku-leez
Hesiod—he'-she-od
Hesperides—hes-per'-i-dees
Hesperus—hes'-pe-rus
Hyades—hi'-a-deez

Isis—i'-sis

Janus—ja'-nus
Juno—ju'-no
Jupiter—ju'-pe-ter

Leda—le'-dah
Leonids—le'-o-nids

Maia—ma'-ya
Markab—mar'-kab
Medusa—me-du'-sa
Merope—mer'-o-pe
Minotaur—min'-o-tawr
Minos—mi'-nos
Mintaka—min'-ta-ka
Mirfak—mir'-fak
Mizar—mi'-zar

Naxos—nax'-os
Neptune—nep'-tune
Nemean—ne-me'-an
Nebula—neb'-u-la
Nebulæ—neb'-u-lë

Oceanus—o-see'-a-nus
Ophiuchus—o-fi-u'-kus
Ossa—oss'-sah
Orion—o-ri'-on
Orpheus—or'-fe-us

Parnassus—par-nas'-sus
Pegasus—peg'-a-sus
Pelion—pee'-le-on
Perseus—per'-se-us
Phaethon—fa'-e-thon
Phœbus—fo'-bus
Photosphere—fo'-to-sfer
Phlegethon—fleg'-i-thon
Phœbe—fee'-be
Pirene—pi-re'-ne
Pleiades—ple'-ia-deez
Pleione—ple'-io-ne
Pluto—plu'-to
Polaris—po-lar'-is
Pollux—pol'-lux
Prometheus—pro-me'-the-us
Proserpine—pross'-er-pine
Præsepe—prë-se'-pe
Procyon—pro'-cy-on

Regulus—reg' u-lus
Rigel—ri'-gel

Sagittarius—sa-jet-ta'-ri-us
Saturn—sat'-urn
Schickard—schick'-ard
Scheat—she-at'
Sirius—sir'-us

Tartarus—tar'-ta-rus
Taurus—taw'-rus
Taygeta—tay-ge'-ta
Thuban—thu'-ban
Tycho—ty'-cho

Uffizi—oof'-fid-ze
Urania—u-ra'-ne-ah
Uranus—u'-ra-nus

Vega—Vee'-ga
Venus—Vee'-nus
Vindemiatrix—vin-de"-mi a'-trix

Zeus—zuce

BIBLIOGRAPHY AND LITERATURE CITED

Text Book of Astronomy—GEORGE C. COMSTOCK; D. Appleton and Co., New York, 1903.

Descriptive Astronomy—FOREST RAY MOULTON; American Technical Society, 1923.

Popular Astronomy—SIMON NEWCOMB; American Book Co., New York, Cincinnati, Chicago, 1892.

Manual of Astronomy—CHARLES A. YOUNG; Ginn and Co., 1904.

Uranography—CHARLES A. YOUNG; Ginn and Co., 1897.

Astronomy—CLERK AND OTHERS; D. Appleton and Co., New York, 1898.

New Astronomy—SAMUEL PIERPONT LANGLEY; Boston, 1900.

Popular Astronomy—NICOLAS CAMILLE FLAMMARION; trans. from the French by J. Ellard Gore, London, Chatto and Windus, 1907.

Astronomy for Amateurs—NICOLAS CAMILLE FLAMMARION; trans. from the French by Frances A. Welby; D. Appleton and Co.,

New York, 1904.

Astronomy for All—BRUNO H. BÜRGEL; trans. from the German by
Stella Bloch; Cassell and Co., New York, 1911.

Pith of Astronomy—SAMUEL G. BAYNE; New York, 1896.

The Dawn of Astronomy—J. NORMAN LOCKYER; Macmillan Co., New York,
1897.

The New Heavens—GEORGE ELLERY HALE; Charles Scribner's Sons, New York,
1922.

Astronomy without a Telescope—EDWARD WALTER MAUNDER; Knowledge
Office, London, 1903.

In Starland with a Three-Inch Telescope—WILLIAM TYLER OLCOTT; G. P.
Putnam's Sons, New York, 1909.

Pleasures of the Telescope—GARRETT P. SERVISS; D. Appleton and Co., New
York, 1901.

Celestial Objects for Common Telescopes—T. W. WEBB; Longmans, Green and
Co., New York, 1904.

Half Hours with the Telescope—R. A. PROCTOR; Longmans, Green and Co.,
New York, 1896.

The Story of the Heavens—SIR ROBERT S. BALL; Cassell and Co., New York,
1901.

The Call of the Stars—JOHN R. KIPPAX; G. P. Putnam's Sons, New York,

1919.

Friendly Stars—MARTHA EVANS MARTIN; Harper and Brothers, New York, 1907.

Starlore of All Ages—WILLIAM TYLER OLCOTT; G. P. Putnam's Sons, New York, 1911.

Star-names and their Meanings—RICHARD HINCKLEY ALLEN; G. E. Stechert, New York, 1899.

Half Hours with the Summer Stars—MARY PROCTOR; A. C. McClurg and Co., Chicago, 1911.

Stars in Song and Legend—JERMAIN G. PORTER; Ginn and Co., Boston, 1901.

Beginner's Star Book—KELVIN McKREADY; G. P. Putnam's Sons, New York, 1923.

Astronomy with an Opera-Glass—GARRETT P. SERVISS; D. Appleton and Co., New York, 1912.

The Constellations—WILLIAM PECK; Silver, Burdett and Co., New York, Boston and Chicago.

Astronomy from a Dipper—ELIOT C. CLARK; Houghton, Mifflin Co., 1909.

Earth and Sky—JULIA E. ROGERS; Doubleday, Page and Co., 1910.

Splendors of the Sky—ISOBEL MARTIN LEWIS; Duffield and Co., New York, 1920.

The Moon—NASMYTH AND CARPENTER; James Pott and Co., New York, and
John Murry, London, 1903.

The Moon—THOMAS GWYNN ELGER; George Philip and Son, London, 1895.

By Starlight and Moonlight—Warner and Swasey Co., Cleveland, 1909.

Mars and its Canals—PERCIVAL LOWELL; Macmillan Co., New York, 1906.

Mars as the Abode of Life—PERCIVAL LOWELL; Macmillan Co., New York,
1908.

Mars—WILLIAM H. PICKERING; Richard G. Badger, Boston, 1921.

"Popular Astronomy"—*Astronomical Magazine*.

Ovid's Metamorphoses—Trans. by English Authors, Sir Samuel Garth.

Prose translation of Ovid's Metamorphoses—HENRY T. RILEY; G. Bell and
Sons, London, 1912.

Phaenomena—Aratus, trans. by G. R. MAIR; G. P. Putnam's Sons, New York.

Hesiod and Theognis—REV. JAMES DAVIES; J. B. Lippincott, Philadelphia.

Festus—PHILIP JAMES BAILEY; Morton and Griswold, Louisville.

Paradise Lost—JOHN MILTON; Houghton, Mifflin Co., Boston, New York,
Chicago, 1896.

Popular Religion and Folklore—WILLIAM CROOKE; 1896.

The Religions of the Ancient World—GEORGE RAWLINSON; United States Book Co., New York.

Student Mythology—C. A. WHITE; A. C. Armstrong and Son, New York, 1900.

Manual of Mythology—ALEXANDER S. MURRY; David McKay, Philadelphia, 1895.

Grecian and Roman Mythology—M. A. DWIGHT; A. S. Barnes and Co., New York.

Mythology of Greece and Rome—ARTHUR FAIRBANKS; D. Appleton and Co., New York, 1912.

Myths of Greece and Rome—H. A. GUERBER; American Book Co., New York, Cincinnati, Chicago, 1893.

Age of Fable—THOMAS BULFINCH; David McKay, Philadelphia, 1898.

Famous Men of Greece—JOHN HARVEY HAAREN; University Pub. Co., New York, 1904.

Greek Poets—NATHAN HASKELL DOLE; Thomas Y. Crowell, 1904.

Studies of the Greek Poets—JOHN ADDINGTON SYMONDS; Adam and Black, London, 1893.

Mythology—THOMAS KEIGHTLEY; D. Appleton and Co., New York, 1836.

Classic Myths in English Literature—CHARLES MILLS GAYLEY; Ginn and Co.,

Boston, N. Y., Chicago, London, 1893.

Myths of Northern Lands—H. A. GUERBER; American Book Co., New York, Cincinnati, Chicago, 1895.

Myths and Legends of Japan—F. HADLAND DAVIS; G. G. Harrap and Co., London, 1912.

Mythologies of Ancient Mexico and Peru—LEWIS SPENCE; A. Constable and Co., London, 1907.

Romance of the Milky Way—LAFCADIO HEARN; Houghton, Mifflin Co., Boston and New York, 1907.

Textbook in General Zoology—LINVILLE AND KELLY; Ginn and Co., Boston, New York, Chicago, 1906.

Physical Geography—Ralph S. Tarr; Macmillan Co., New York, London, 1901.

Geology—JOSEPH LECONTE; D. Appleton and Co., New York, 1908.

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