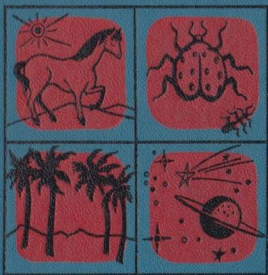
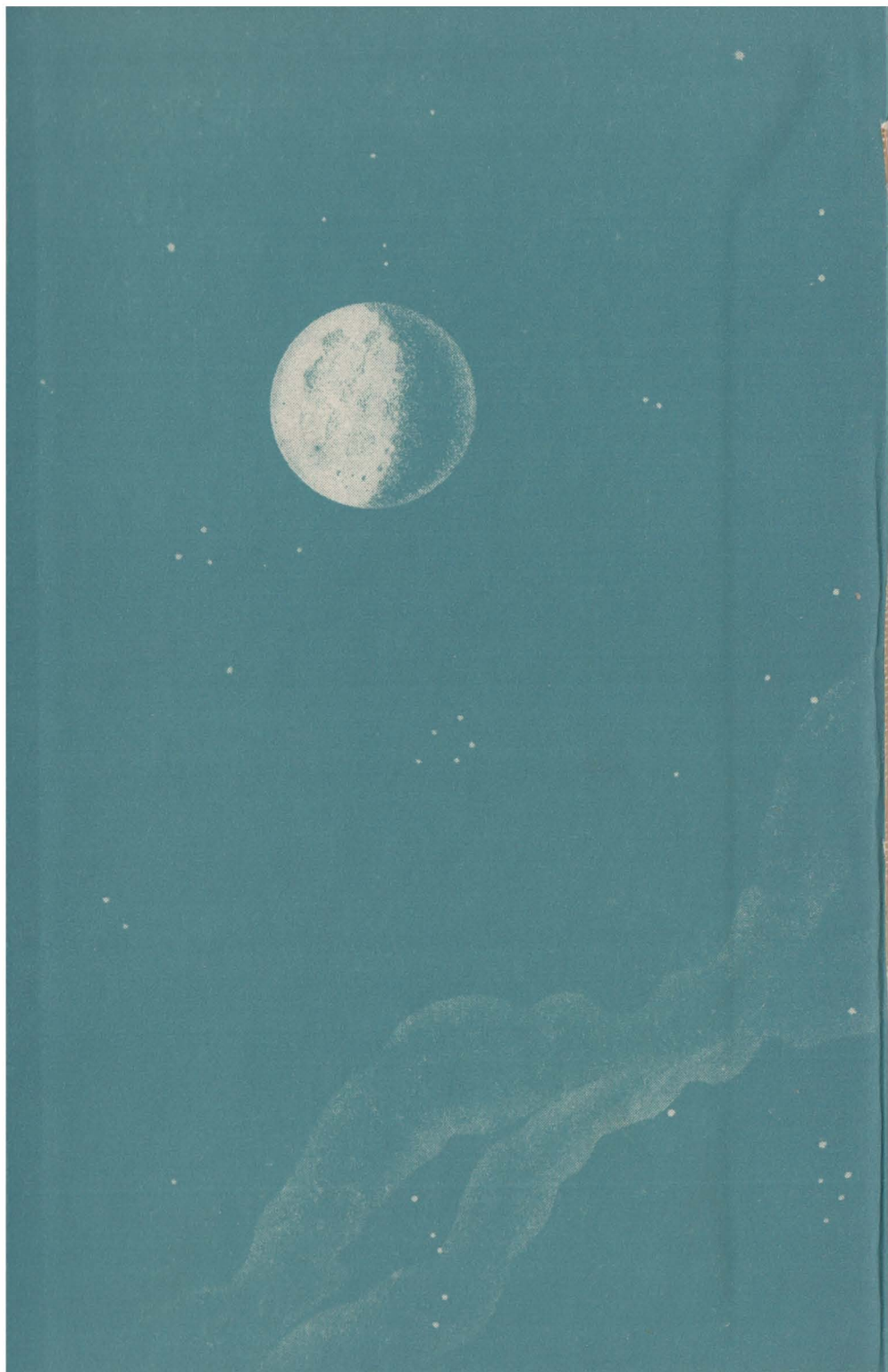
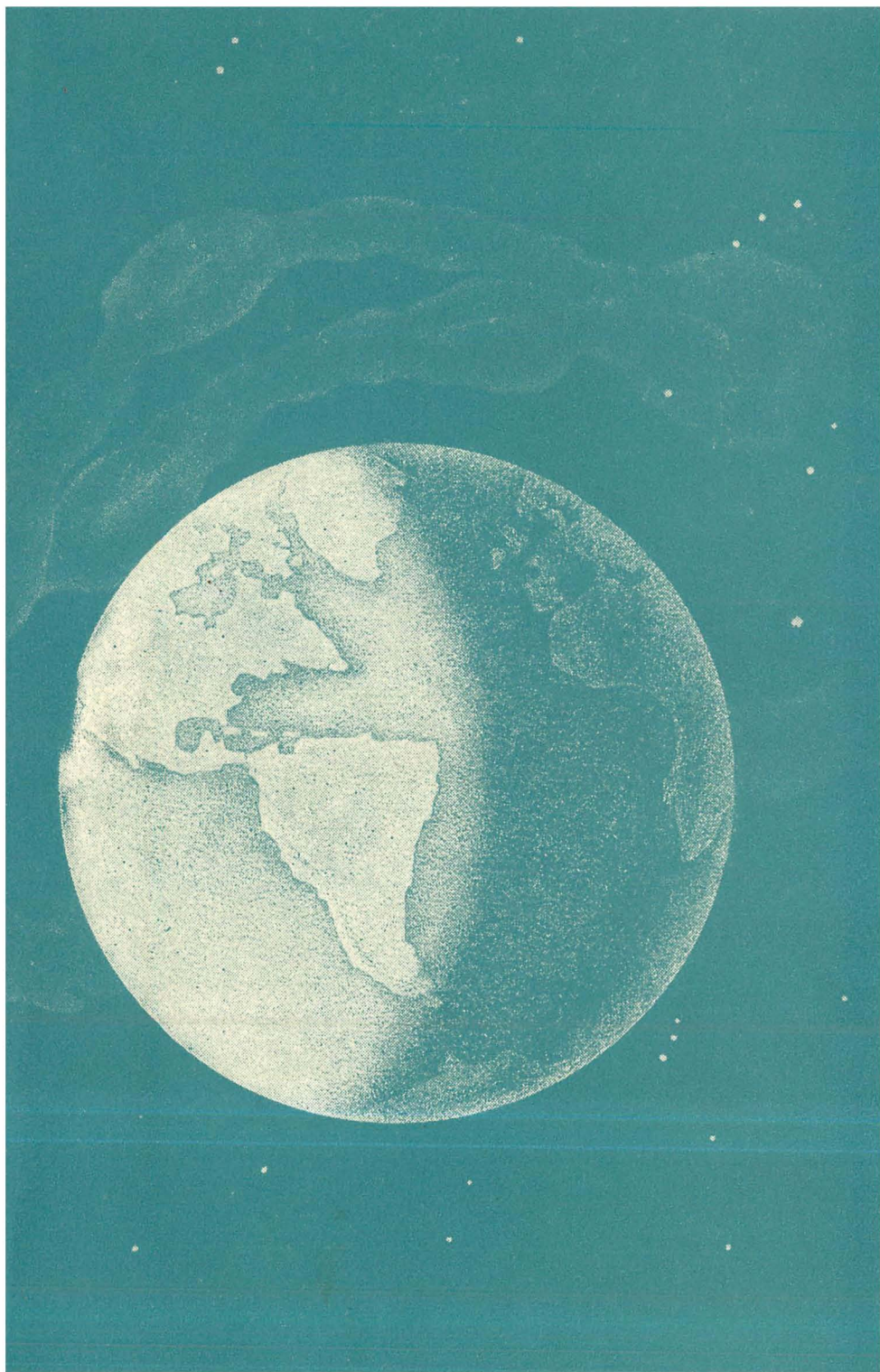




A REAL BOOK







William George Willis  
Christmas 1957  
from Mummy

THE *REAL BOOK* ABOUT

STARS

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# STARS

*by*

HAL GOODWIN

*Illustrated by Paul Wenck*



EDITED BY HELEN HOKE

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THE *REAL BOOK* ABOUT  
STARS

## CHAPTER I

# *Countries in the Sky*

WHEN you go out of doors on a clear night and look up at the sky, you are doing something that men have done for countless thousands of years. But you're much luckier than those who have lived before you, because you can know things about the stars overhead that your grandfathers only guessed. You have, at your fingertips right now, the knowledge collected over hundreds of years, by hundreds of men and women. This knowledge can help you to understand what you see in the night sky.

When you look up at the stars and find them all scattered, with few neat patterns, with different brightnesses, and even different colors, it is easy to be confused. It seems impossible to tell one star from another. However, as you study the sky a bit, you begin to find groups of stars that make squares, oblongs, or triangles. You find three or four in a straight line. The sky begins to seem somewhat more orderly.

A little more stargazing and you can see differences

in the stars. Sometimes what at first seemed to be a faint star turns out to be a tiny patch of mist. Other times, you find that a star really is a twin.

Nowadays, even the stargazer who uses only his eyes has an advantage over his ancestors, if he has learned a few things about the stars. Astronomers have inspected with telescopes the things we can see with the naked eye, and they have told us what these objects are.

Thus, when the stargazer sees the misty patch of light in the group of stars called Andromeda, he can thrill to the knowledge that he is looking at a galaxy: a whole universe of billions of stars in that one patch.

When the stargazer finds Algol, the Demon star, he knows that it changes in brightness because of the darker companion star that regularly blocks out some of its light.

The ancients, long before Galileo invented the first telescope, had the sky pretty well charted. Just by observing the skies with the unaided eye, they recognized that some of the heavenly bodies behaved differently than others. They named these bodies "planets," which means wanderers, because they seemed to wander through the heavens while the other stars stayed in place. They recognized individual stars and named them. They noted clusters of stars, and groups that seemed to form regular patterns. They learned a lot about the behavior of the stars, and the movement

of the planets along certain paths, and about the changes in the sky at different seasons of the year.

Very early, people began drawing imaginary pictures in the sky. They took groups of stars that seemed to make the outlines of people or animals and gave them names. One group of stars seemed to have the outline of a ship's sail, so they named it Vela, which in Latin means the sails. Another group looked very much like the poisonous creature called the scorpion, so they named it Scorpius. And, of course, they named the individual stars that made up the groups.

Each group, or picture, is called a constellation, which means studded with stars. Today the entire sky, from the south pole to the north pole, is divided into constellations. Thus the sky is all mapped out, just as the earth is divided into countries. There are maps for each season of the year. On these maps the constellations form regions, and each region has its own boundaries. People all over the world agree on these boundaries so that, when a French astronomer speaks of a certain group of stars, a Chinese astronomer knows exactly which group he means.

The names of all the constellations in the sky are in Latin. The names of individual stars may be Arabic, Latin, Greek, or more ancient Persian and Egyptian. The names are interesting because they were chosen to describe the star or the constellation, so the name itself, when we understand it, gives us a good deal of

information, as well as stirring our imagination. The names are not difficult to pronounce, and after you have learned the first few, you will feel quite at home with them. A pronouncing dictionary at the back of this book will help you as you go along.

In addition to being divided into constellations, the sky has a north pole and a south pole, just as the earth has. These are called celestial poles and are directly over the earth's poles. The sky also has an equator, just like the earth's—an imaginary line around its middle. This is called the celestial equator.

Our ancestors noticed that the moon and the planets always stayed in the same band in the sky. By watching the stars right after sunset, and noticing where the sun went down in relation to the stars, they found the sun also stayed in the same band as the moon and the planets. They called the sun's path the "ecliptic."

Along this band were many constellations, forming a kind of road in the sky. The constellations inside this road, or band, seemed to be outlines of various animals, and so the band is named the "zodiac," which means band of animals. We get our word zoo from the same root. The constellations in this band are called the signs of the zodiac. There are twelve of them, so there is a sign for each month of the year.

Although the constellations are named for people, animals, or things, they seldom really look like what they are named for. First of all, the star maps are a little

misleading—even the ones in this book. Just the brighter stars usually are shown. The very brightest are made a little larger than the fainter ones. Another difficulty is that maps are printed on flat paper, and the sky is like an upside-down bowl. A perfect star map could be made on a big plastic bowl which we could hold over our heads, but it would be pretty expensive. Besides, it really isn't necessary. The constellations can be found, if you're patient.

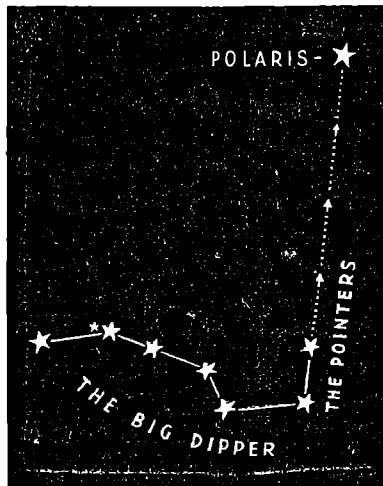
There are a lot of different ideas on how to start learning to locate the constellations. One of the best ways is to start by finding the Big Dipper. This is the most important part of the constellation Ursa Major, the Great Bear. Then you can find Polaris, the North Star, and the Little Dipper, which is part of Ursa Minor, the Little Bear. Polaris is at the tip of the smaller bear's tail.

This is a good way to begin because, once you know these groups, it is easy to find the stars which circle the celestial north pole and never set.

After finding the constellations around the pole, it is supposed to be easy to find the other constellations. However, it isn't so simple as that. The sky is a vast place and there is much to learn. It helps a lot to follow a regular system, so here is one that is sure-fire if you follow it pretty consistently.

On a good clear night, locate the Big Dipper, the North Star, and the Little Dipper. Then, using the

star map made for this particular time of year, try to get some idea of where the very bright stars are located with reference to the North Star. Don't be impatient if you find it hard to locate whole constellations at first. Once you know the bright stars, the constellations can be found with a little study.



*The pointers (Merak and Dubhe) show the way to Polaris, the North Star, which is located at the tip of the Little Dipper's handle.*

Then continue studying on a night when there is a little bit of haze. You'll find that the dim stars can't be seen, only the bright ones. So the sky looks more like the star map. Even so, it won't look exactly like the map, because the stars are much farther apart than they seem on the map.



Watch the skies at about the same time every night, around eight o'clock or perhaps an hour later in the summer, and pay special attention to the eastern half of the sky. Month by month new constellations will rise above the horizon, and you will have time to learn them really well, so that you will know them again from wherever you are. But a warning: in order to do this, you must keep watching the constellations as they appear to move to the west. Remember that, when setting, they will be in a position different from the way you first saw them. You want to know the constellations as seen from any direction.

This system takes patience. If you aren't that patient, start with the constellation Ursa Major, then learn the ones near it. Keep moving from one constellation to the next. Sooner or later, you'll find that the stars suddenly seem to be in neat patterns—and that you know where they are. You'll know the names of most of the important stars, too.

A particularly good time to start studying the stars is in the winter when Orion, the Hunter, is in the eastern half of the evening sky. Orion is one of the easiest constellations to trace out. What's more, the celestial equator runs right through Orion's belt, so you begin to have a feeling of knowing where you are in the sky world. And, starting with Orion, it is really quite simple to trace out the other constellations one by one. Chapters XVII and XVIII of this book give

you a month-by-month description of the skies. If you start studying the stars in the summer, other constellations than Orion will be above the horizon right after dark, but the same system of observing them will work. Learn what the constellations just above you are, then identify the new ones that rise as the seasons move on.

Learning to know the stars is well worth the time it takes. Besides being fun, this knowledge has a practical value; you will know your directions and be able to use the stars as guides. Sailors, through the ages, have depended on the stars to get them home safely.

Perhaps the biggest thrill of all is to look up and see only a single bright star and, without thinking, say, "There's Spica." Suddenly you realize that you've named a star without even seeing the other stars around it. That will happen sooner than you think, because the stars soon become old friends, just as they've been the silent friends of man for countless thousands of years.

## CHAPTER II

### *Night's Thousand Eyes*

|| IF YOU look up at the sky on a good, clear night, you can see between 2500 and 3000 stars from any one place on earth. How many, and which ones you see, depends on the time of year; the weather; your own eyesight; and particularly on where you are on the earth.

There seem to be more stars than 3000 overhead, and there are, but that is all we can see at any one time without a pair of binoculars or a telescope.

When you look at the Big Dipper, you see only the handful of stars that form its bowl and handle. But if you could look at the bowl of the Dipper through a telescope—and it wouldn't have to be a very big one—you could see over a hundred stars.

Even without a telescope, you can see that some stars are brighter than others. The brightness of a star is called its "magnitude." The brighter the star, the lower the number of its magnitude.

Betelgeuse and Aldebaran, two bright stars which

appear in the same part of the sky, are about first magnitude in brightness.

Polaris and Mizar, in the northern sky, are about second magnitude in brightness. This means that they are  $2\frac{1}{2}$  times *less* bright than Betelgeuse and Aldebaran. A third-magnitude star is  $2\frac{1}{2}$  times *less* bright than a second-magnitude star, and so on. The faintest stars we usually can see with the unaided eye are of about the sixth magnitude.

Two stars are brighter even than first magnitude, so when their magnitude is given they have a minus sign in front of the numbers. These stars are Sirius and Canopus.

Magnitude is the measure of the way the star looks from the earth—how bright it appears to be. But some stars are much farther away than others, so there is another kind of magnitude which astronomers use. This is “absolute magnitude.” Absolute magnitude is a way of expressing how bright the star really is.

For example, take two first-magnitude stars, Regulus and Deneb. They look almost exactly the same from the earth. But Deneb is over six times farther from the earth than Regulus. So you can see that Deneb must have a much, much greater real brightness, or absolute magnitude, than Regulus.

To put it still another way, a flashlight five miles from us and a great searchlight fifty miles from us might look about the same in brightness. But the

searchlight would, of course, be many times as powerful as the flashlight.

As you learn the stars and get to know them by name, you will notice that they have different colors. Some are definitely reddish like Betelgeuse and Antares. Aldebaran is sort of orange. Sirius and Vega are bluish, and very bright. Capella is yellowish. Castor seems to have a greenish tinge. Their color depends on what kind of star they are.

There are several different kinds of stars, although they all get their energy from the same source—subatomic energy. Some are brilliant, very hot stars. These are usually bluish or blue white in color. The slightly cooler ones are just white. Slightly cooler again, and they become yellowish. The coolest ones are the red ones.

Then, besides color, there is size. The stars are not the twinkling little lights they seem. By comparison our earth is very small. There are great red and yellow giant stars, thousands of times bigger than our sun. Then there are white dwarfs which are little stars so densely packed with matter that a cubic inch from one of them would weigh tons. Sirius, our brightest star, has a white dwarf for a companion. We can't see this dwarf star with the unaided eye. It is not much bigger than the earth, but it contains as much matter as there is in our sun, all compressed in a way that is hard to imagine.

There also are red dwarf stars, and stars so cool and faint that we know about them only by their effect on stars we can see, and by special instruments.

These instruments the astronomers use to find out about objects so unbelievably immense and far away are pretty complicated. But it helps us in our stargazing to have some idea of how they work.

One of these instruments produces a kind of scientific rainbow. When sunlight hits droplets of water, it sometimes breaks up into colors and forms a rainbow. The colors are called the "spectrum." They range from red to violet.

Of course, a real rainbow could not be used for a scientific instrument, but it was found long ago that a prism, which is a special kind of glass triangle, would also break light up into its spectrum. Prisms can be fitted on telescopes.

Also, a long time ago, a scientist named Fraunhofer found that the spectrum had strange lines in it. By experiment, he found that every single element which exists in a source of light makes a line or group of lines in its spectrum. These lines are always found in exactly the same place in the spectrum. They are called Fraunhofer lines, and they help us to know exactly what elements are in a source of light. In astronomy, stars are the light source. So by using an instrument called a "spectroscope," which is built around a special grating that acts like a prism, astronomers can tell the elements

in a star's spectrum. Once the elements are known, we know what the star is made of.

Helium is a rare gas which is used to fill dirigibles and some other balloon ships. Helium was discovered on the sun, by the spectroscope, before it was discovered on the earth. That's why the gas was named helium, which comes from the Greek word for sun.

The same Greek word has given a name to the instrument called a spectrohelioscope, which is made just for studying the sun.

There is another way, besides finding elements, that a spectroscope helps us to know about the stars. It can also tell us their speed through space.

To understand how, we have to come back to the earth for a bit. Have you ever noticed how the sound of an automobile horn changes when a car toots at you as you're driving along?

If you get two people with cars and a friend to help, you can make an experiment. Start the cars toward each other from a distance of about half a mile. (Each car stays on its own side of the road, of course.)

Then, have each driver press down on his horn and hold it until the cars have passed.

Your own horn will be steady. It will keep blasting on a single note. But the car coming toward you will not have a steady-sounding horn. As you come close, then pass, the other car's horn will seem to rise in tone, then suddenly slide down the scale in a very strange way.

Ask your friend in the other car and you'll find that his own horn seemed steady while yours acted strangely. This change in sound, or pitch, is caused by a natural law.

Everything that vibrates, whether it is sound, electricity, or light, has a frequency, or pitch. The number of times it vibrates per second is its frequency and determines what kind of radiation it is or what kind of sound it makes.

To put it another way, a beam of red light is just a vibrating wave of energy. If it vibrated faster it would be violet light. A bass drum is just a sheepskin that vibrates rather slowly when struck and gives a low tone. A snare drum is a smaller piece of sheepskin that vibrates faster and gives a higher tone.

You may wonder how all this business about horns and vibrations has anything to do with astronomy. It has, because light has vibrations, and these vibrations are affected by speed. They are also affected by whether the source of the light is coming or going—just as the pitch of a car horn is affected by its speed and whether it is coming or going.

Astronomers look for the position of the lines in the star's spectrum. The shifting of lines toward the red part of the spectrum, called the red shift, means that a star is moving away from the earth. When a star is approaching, the lines shift toward the violet part of the spectrum. This is called the violet shift.



Another instrument, which has been used to measure the heat of a star, is called a "thermocouple." Thermo means heat. We have the same word in thermos bottle and thermometer. A thermocouple is made of two pieces of different kinds of metal. When heat strikes them, they work together to make a little electricity. The more heat, the more electricity. The electricity is measured, and that gives the amount of heat. So the heat of a star can be found by putting its light on a thermocouple which is attached to the eyepiece of a telescope.

Thermocouples are not really sensitive enough for very delicate measurement, so they have been replaced, except for special purposes, by other instruments. These are made of special kinds of things which are sensitive to light, such as a photoelectric cell which is not very different from the light meters photographers carry.

All together, these instruments tell us a lot about the stars. They explain why some stars behave as they do; they tell us what the stars are made of, and how hot they are.

Delicate measuring instruments tell us how far away stars are through the kind of mathematics called trigonometry, which has to do with triangles. If you know two of the angles and the length of one of the sides of a triangle, it is easy to figure out the length of the other sides, using trigonometry.

The stars are so far away that from any two places on the earth there just wouldn't be enough of a difference in the angles to figure out the star's distance. But astronomers have a longer line than there is on earth. It is the distance from one side of the earth's orbit to the other. The earth's orbit is the path it travels around the sun.

For example, an astronomer can measure the angle of a star when the earth is on one side of the sun. Then he waits until the earth is exactly on the other side of the sun and measures the angle of the star once more. Now he has two angles. Since he already knows the distance across the earth's orbit, he can figure out how far the star is from the earth.

Of course it takes a lot of study to use astronomers' instruments, and beginners never use them anyhow. But it is interesting to know how astronomers collect information about stars, because what they find out helps us to understand more about the things we see as we study the skies with no telescope and no instruments.

### CHAPTER III

## *Worlds of Outer Space*

LET'S SEE if we can get some idea of the size and space of the sky.

Try to imagine yourself way off in space, beyond our earth and sun. Imagine a sky without stars, sun, or moon. All around you is blackness, except for a few faint, distant, misty patches of light. The patches are so far away that you can't see their shape or what they're made of.

Each of the patches is a galaxy. One of the grandfathers of the word galaxy is the Greek word *gala*, meaning milk. This name was given because of the streaky look of a galaxy, like a glass that has had milk in it.

If we choose the right galaxy and move toward it, we will see it grow gradually larger, as we approach, until it becomes like a great wheel. The wheel looks like a solid mass of pale light. Then, as we get closer still, we will see that the wheel is made up of stars—billions of them.

As we get very close, we find that the stars are millions upon millions of miles apart. Here and there we might see a small group pretty close together. And quite often we see two or even three stars all bunched up. But mostly the stars are so far apart that they look just about like the stars we see from the earth, except that their positions are not the same.

We steer for one edge of the giant galaxy wheel. There, just inside, like a speck on the side of a tire, we find a medium-size star. That star is the sun—our own sun.

As we look up now, toward the main part of the galaxy, we see the stars so close together that they look like a white river. The ancients named that The Milky Way. This is the Milky Way galaxy.

From where we are out in space, we can see that our sun has a family. Whirling endlessly around it are worlds that look like stars but are not. They are the planets. The earth is one of them.

This part of our galaxy is called our solar system. Solar comes from the Latin word *sol*, which means sun. It is called a system because the movement of the planets around the sun is a very exact system, indeed.

We think of our earth as a big place. But in space, our whole solar system of sun, moon, earth, and other planets is so small that we can compare it to an ant. This makes the earth smaller than a speck of dust.

Our galaxy, on the other hand, is so tremendous that

we can't even begin to understand much about it. To get some idea, though, let us imagine our solar system as an ant perched on one side of the Empire State Building. The Empire State Building is our galaxy. The nearest building is two miles away, except for two little sheds nearby. These sheds are the Magellanic Clouds, described in Chapter XVI. But we have a powerful telescope, so we can look through it and see that many hundreds of other buildings also exist, each many miles apart. As far as we can see with our telescope, the buildings continue. These buildings, or galaxies, look like dim, misty patches of light.

We get very interested, of course. We want to know how far from us there are buildings. So we build a more powerful telescope. We look through it and see more buildings. Out to the very limit of power of the telescope the buildings continue, even though we now can see straight ahead for over two hundred miles.

The universe is like that. We are a very tiny part of a huge galaxy. Our sun is one star among many millions of stars that form our galaxy. Yet, as far as the most powerful telescope on earth can see, there are other galaxies, each made up of its billions of stars. No one knows where the universe ends. No one knows if it *does* end.

The ant and the Empire State Building may give us some idea of size, but they don't help us much in talking about distance. In space, the distances between

stars can't be measured in miles. If we tried it, it would be like measuring the distance between the north pole and the south pole in inches.

Miles are made up of a lot of inches. In the same way, astronomers use a measurement which is made up of a lot of miles. The measurement is a "light-year."

Light is the fastest thing known to man. It is so fast that we have a hard time trying to understand it. It goes at a speed of 186,000 miles *per second*.

Think of what this means. The distance around the earth at the equator is about 25,000 miles. A ray of light could travel completely around the earth about  $7\frac{1}{2}$  times in one second—the length of time it takes you to say Alpha Centauri.

A light-year is the distance light can travel in one year, at a speed of 186,000 miles per second. You can figure out the number of miles yourself, using 60 seconds per minute, 60 minutes per hour, and 24 hours per day—if you want to. It comes out to about six million, million miles.

The nearest bright star is Alpha Centauri. It is about four light-years away. This means that the light you see from Alpha Centauri left the star over four years ago, traveling at 186,000 miles a second, and only now is reaching the earth. If Alpha Centauri blew up right this minute we wouldn't know it for four years!

Still, Alpha Centauri is a close neighbor. The brightest star in the sky is Sirius, the Dog Star, about

eight light-years away. The second brightest star, Canopus, is about 650 light-years away.

The distance from one edge of the Milky Way galaxy to the other is over one hundred thousand light-years. And the nearest galaxy to ours is about eight hundred thousand light-years away.

The giant 200-inch Hale telescope on Mount Palomar, California, can see into space for a billion light-years, and there are galaxies at even that distance.

We know that the galaxies are made up of billions of stars. But in addition to the stars, they include great clouds of dust and gas. These clouds are called galactic, or planetary, nebulae. They are sometimes millions upon millions of miles across. Nebula comes from the Latin word for mist, but no earth mist ever was so thin as these space clouds. If you pumped all the air out of a bottle with the best pump on earth, the vacuum inside would still be denser than a nebula. Yet, some of them, called the dark ones, block out light just as dust in the air stops sunlight. Others, called the bright ones, shine by reflected starlight.

Of the many nebulae in our galaxy, there are only two light ones and two dark ones that we can see well without a telescope. The easiest one to find is the nebula in the constellation Orion. Directions for finding it are given in Chapter XVII: Stars from January to June.

Only one galaxy outside our own can be seen without a telescope. This one is known as the Great Nebula

in Andromeda. Since it is outside of our galaxy, it is known as an extragalactic nebula. Don't be confused by the use of the word nebula. It was given both to galaxies and to clouds inside our own galaxy before astronomers knew there was a difference. Directions for finding the Great Nebula in Andromeda are given in Chapter XVIII: Stars from July to December.

Finding the Orion nebula is interesting. We can look at the dim, misty patch of light and wonder about the tiny particles of dust or gas that seem to fill that corner of space.

But seeing the Andromeda nebula is different. Here is one of the universes of outer space. It is almost a million light-years away. Remember that the nearest star is four light-years away. You may wonder, as you look at that faint patch of light, if somewhere in the billions of stars clumped together above you there may be suns with planets like ours, and if beings live on those planets.

Probably we shall never know. "We" does not mean just those who are living today. It means all the men and women who ever will live on the earth. Someday men may venture out beyond the solar system to nearby stars. We can't guess how this will be done, but let's suppose that it can be.

Even so, once the stars a few light-years away have been explored, then what? We can't imagine how man ever could cross our own galaxy.



So reaching the outer galaxies—the worlds of outer space—seems impossible. We must be content, for now, to gaze and wonder, hoping that someday, in a way now impossible to imagine, our descendants will be able to learn if any other living things exist outside our own solar system.

Still, we can believe that somewhere in our vast universe there are intelligent beings. They may even be wiser than we.

The mathematicians have a science known as “probability mathematics.” It is just what the name says—the mathematics of what is probably true. Probability mathematics will tell us that of all the billions upon billions of suns in our own and other galaxies, some must have planets.

Of all the planets, it seems impossible that ours is the only one with intelligent life on it. No one really knows. Experts disagree on the probability of life beyond our own earth.

But here’s one vote for the probability that there is. Right this minute, unknown beings on an unknown planet in outer space may be looking at the endless stars and wondering the same thing: Are we alone in space?

## CHAPTER IV

### *The Solar System*

**B**EFORE wondering about life in the worlds of outer space, let us take a closer look at our own neighborhood. The neighborhood is a huge one, and it contains many things. There is the sun, which is the star the earth depends on for light and heat. There are eight major planets, besides the earth, and many thousand minor planets. There are meteors, comets, moons, and great clouds of dust. All these things put together form the solar system.

Compared with the distances to other stars or galaxies, our solar system is a nice, close family. Still, from an earthman's point of view, the system takes up a lot of space. The distance between the sun and the planet nearest it, Mercury, is thirty-six million miles. The earth is ninety-three million miles from the sun. Farthest from the sun is the lonely planet called Pluto. Pluto is 3,675 million miles from the sun.

Even distances like these, which are pretty small as

star distances go, are hard to imagine. So let's try to put them in earth terms.

If a grapefruit is used to represent the sun, the earth can be represented by a coarse grain of sand. But it will have to be placed forty feet away from the grapefruit and everything measured on that scale, in order to get the entire solar system in a single field. Then, to show the distance to the star nearest our solar system, we would have to place another grapefruit somewhere on the other side of the United States!

Nowadays we accept that our sun is a star and that the earth and the other planets revolve around it. But men have not always known this. Most of our ancestors believed that the earth was the center of everything, although they explained it in different ways.

The Egyptians thought the universe was a bowl, with Egypt in the center. Around Egypt were mountains. The sun was carried across the sky every day in a boat, and at night the stars were hung from ropes.

The Persians thought the earth was like a plate, with a solid dome overhead in which the stars were set like jewels. The plate, they thought, was really an island in an endless sea.

The Greeks thought the earth was a flat disk like a phonograph record, and that the disk was cut into two parts by the Mediterranean Sea. Around the edges of the disk ran Eridanus, the River. The sun and the moon rose out of the ocean, traveled across the sky, and sank

into the river in the west. Each night after sunset, the sun got into a boat and was rowed around the edge of the world back to his starting place.

Most Greeks believed this, but a very few did not. A Greek named Pythagoras studied the stars and dared to say that the center of the universe was not the earth, but the sun. Other Greek scientists came to believe the earth was round. They even figured out its size. But their beliefs were lost, and the people continued to believe in the old legends.

Before the time of Christopher Columbus, men thought the universe consisted of the flat earth, surrounded by water, with a star-studded dome above it. In time, scholars came to know that the earth was a sphere. But even so, they thought it was the center of everything, with the sun, stars, and moon revolving like slaves around it.

And then, in 1473, a Polish boy was born. His name was Nikolaus Kopernicki. We know him simply as Copernicus. He was one of the greatest thinkers of all time.

As a little boy, Copernicus watched the skies. He wanted to know about them, so he studied everything he could find. He entered the University of Cracow, in Poland, one year after the discovery of America. At Cracow, he studied astronomy, but he was not satisfied with what he learned. After graduation he went to Italy and studied for three more years at the University of

Padua. Then, in 1499, he was appointed professor of astronomy at the University of Rome.

Men still believed the earth was the center of all things, and Copernicus taught his students that it was. But this theory just didn't answer some of the riddles of the sky for Copernicus. He began to doubt. After three years of teaching, he was sure it was wrong.

Copernicus found the theories of the Greek scientists among some old manuscripts. They started him on a new line of thought. He retired from teaching and became a priest. He became known for his kindness and his wisdom. He worked out a new money system for his government, and he devised a new calendar for his church. He was really the first man to find out the exact length of the year. His calculations were wrong by less than a minute!

But when he suggested that the earth moved around the sun, he met laughter. No one believed him!

For over thirty years Copernicus studied the skies and thought at great length about what he saw. Near the end of his life, he wrote his findings in a book called *On the Revolutions of the Heavenly Spheres*. The book was published in early 1543, and when it appeared, some friend, trying to save the old astronomer from ridicule, had written in a preface: "This is written to present *not* a scientific fact, but a playful fancy."

The "playful fancy" was this: The sun is the center of our universe. The earth moves around it, and as it

moves, it turns on its own axis, like a spinning top. The spinning explains why there is day and night. The movement around the sun explains the seasons. But the earth is not alone in the sun's family. All other planets also move around the sun. They do not move according to the whim of the gods, or their own whims. They move according to the laws of nature, never moving from their paths, always being in their appointed places at the appointed time.

Copernicus never had a chance to object to the preface in his great work. He died in May, 1543, a few days after his book gave to the world a theory which we today accept as correct.

It is very easy to understand why our ancestors thought the earth was the center of all things. The sun, the moon, and the stars all *seem* to revolve around it while we stand still. What's more, the earth *seems* to be flat.

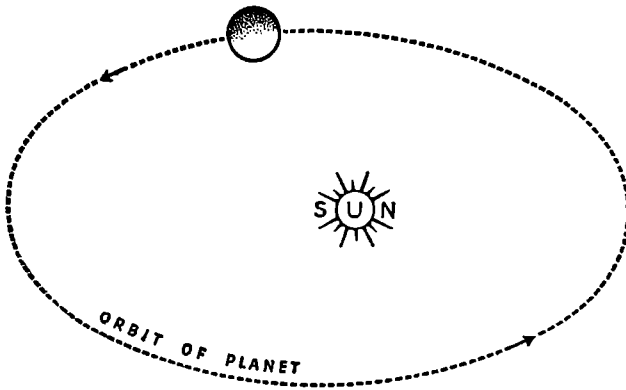
However, we have learned not to pay too much attention to what our senses tell us, because we know that the earth is really a planet, that it revolves around the sun, that the stars really stand still, and that only the moon goes around the earth.

Each planet is different, but most of them behave in about the same way. So let's stop thinking of the earth as our home for a while and just think of it as a planet.

Stars shine with their own light. The planets shine

only because the light of the sun strikes them and is reflected to our eyes.

The planets are not all the same size. Four are larger than the earth and four are smaller. Six of the planets have moons. Two have no moons. One, we're not sure about. The earth is the only planet with a single moon.



*Orbits of planets are ellipses, with the sun nearer one end of the ellipse than the other. This drawing is very exaggerated to show the relationship. The orbits are much closer to being circles.*

All other planets with moons have at least two. One planet has eleven.

The paths of the planets around the sun are called orbits. The word comes from the Latin word for track. The orbits are not perfect circles. They are ellipses.

The planets move in their orbits on schedule. And the schedule is so exact that we can predict where a

certain part of the solar system will be at any moment thousands of years from now!

However, for our own stargazing we are more apt to be interested in this year's schedule. The way to get it is to look up the astronomical figures in the *World Almanac* or the *Information Please Almanac*. Of course there are special books published, but the almanacs give ample information for a new stargazer.

Because sailors and airmen navigate by the sun and stars, the U.S. Government publishes books giving all the information they need about the positions of the sun, moon, planets, and stars.

There also is a type of book called an ephemeris, which gives tables of positions of heavenly bodies for different days of the year. Some of the books give not only sun, moon, and planets, but the positions of the principal moons of some of the planets besides the earth.

We seldom speak of our world as anything but "the earth," but it does have a name. The Romans called it Terra. We see the name now in phrases like *terra firma*, which is Latin for firm earth.



## CHAPTER V

### *As the Earth Turns*

**W**HAT holds the earth to the sun? What keeps it in its orbit?

The answer is gravity, which is the attraction of one object for another. When you fall, you land with a bump because the earth's attraction for you is so great.

So, just as the earth attracts all things on it, the sun attracts the earth. To understand why the earth isn't attracted right into the sun, imagine that you have a ball which is tied to a rubber band. Hold onto the end of the rubber band and whirl the ball around your head.

The rubber band is the sun's gravity: it wants to pull the ball in to you. But the speed of the whirling ball keeps it away from you. The force that keeps the ball away is called centrifugal force.

We may well wonder at the perfect balance in which the planets hang, with the sun's attraction balanced by the speed of the planets in their orbits.

The farther the planet is from the sun, the less the

sun's attraction. And, the less the attraction, the less speed the planet needs to keep from being drawn into the sun.

If, on the other hand, the planet had more speed than it needed to balance the sun's gravitation, it might fly off into space, and the sun would have one less child.

In the table on page 176, notice that the farther from the sun a planet is, the less its speed as it goes around the sun.

So little Mercury, closest to Old Sol, whirls around at 30 miles per second. And frozen Pluto, farthest planet from the sun, wanders through outer space at a mere crawl—only 3 miles per second, or about 10,800 miles an hour.

The earth is the third planet from the sun. It is much larger than Mercury, the first planet. It is only a little greater than Venus, the second planet. It is bigger than Mars, the fourth planet.

Jupiter, Saturn, Uranus, and Neptune, the fifth, sixth, seventh, and eighth planets, are a lot larger than the earth. Jupiter is the biggest planet. Pluto, the planet farthest from the sun, is thought to have a diameter about one half of the earth's.

Certain words are used to describe the positions and movements of the planets and other heavenly bodies, and it is important to understand what they mean.

First of all, we speak of apparent motion. This is just an easy way to say that things *appear* to move, but really

don't. Each night the stars appear to rise above the horizon, travel across the sky, and finally set. The sun appears to rise in the morning, get higher and higher in the sky until noon, then lower and lower until it sets.

These are apparent motions. The sun and stars appear to move because the earth is turning, carrying us past the sun and stars. It's like being on a merry-go-round and thinking that the fair grounds are going around while the merry-go-round stands still.

Actually, the stars do change position during a period of many thousands of years. The change takes place because the earth wobbles a little bit, just as a top does when it is slowing down. It is a very slow wobble.

At the present time, Polaris is our North Star. The north pole of the earth points almost directly at it. But Polaris was not always our North Star. About 3000 B.C., it was the star called Thuban, in the constellation Draco. Thuban is not very far from Polaris. When the Egyptians built monuments to the goddess called Isis, they sometimes cut a hole so Thuban's light could shine on the altar.

In a few thousand years, Polaris will no longer be our North Star.

About three thousand years from now, the celestial north pole will be in the constellation Cepheus. About twelve thousand years from now, it will be in the constellation Lyra, and Vega will be the closest bright star to the pole. That will help stargazers to find the celestial

pole, too, because Vega is the fourth brightest star in the sky. Polaris is about the forty-eighth brightest. Then, about twenty-three thousand years from now, Thuban will be the North Star again, and if the pyramids are still standing, Thuban's light may shine once more on the altars of Isis. In twenty-six thousand years, Polaris will be the North Star again.

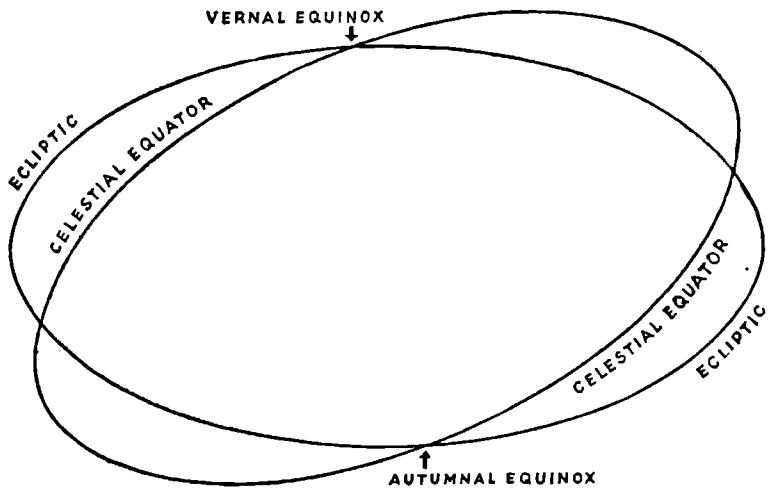
But all this happens so slowly that we need not think about it in talking about star positions. Just remember that the earth's poles always point to the north and south celestial poles, and that the celestial equator is right over the earth's equator.

Since the earth is tipped, and is always tipped in the same direction (toward the North Star), no matter what side of the sun it happens to be on, the sun appears to change position. The celestial equator is a circle. The sun's apparent path is a circle, too. The two circles cross each other in two places, as the picture shows.

The name of the sun's apparent path is the ecliptic.

The two points where the celestial equator and the ecliptic cross are called the "equinoxes." Since the sun arrives at these points at about the same time every year, we can give the dates of the equinoxes within a day or two.

About March 21, at the time of the vernal equinox, the sun rises exactly in the east and sets exactly in the west. Then, day and night are exactly the same length, all over the world.



*The sun's apparent path and the two points where it crosses the celestial equator.*

As spring moves on, the sun appears to move north. It rises a little north of east and sets a little north of west. As we get closer to summer, the sun moves farther and farther north. About June 21, the sun is as far north as it ever gets. This is the longest day in the year for those in the northern hemisphere. It is known as the summer solstice.

From June 22, the sun moves back south again, until it is directly east about September 23, the time of the autumnal equinox. Again night and day are the same length the world over. From September 23, it moves south, until it reaches its point farthest south about December 22, which is the winter solstice. This is the shortest day in the year.

One interesting thing is, the closer the sun gets to the north and south points, the slower it seems to shift. On June 21 and December 22 it seems to stand still for a while. Ancient people, especially American Indians, used to say the sun stopped to rest.

If the sun ever did really stop to rest—that is, if it ever stopped shining, instead of appearing to stop moving, it would be the end of life on the earth. For without the sun the earth would be a dead planet, frozen and without life of any kind on it, endlessly whirling through darkness.

We all know these things, even though we may not have thought about them much. The Indians and other early people knew them, and because of this they

worshiped the sun. In some parts of the world today there are still sun-worshippers among the savages. They know the sun gives us life, even if they have no idea of astronomy.

The first important fact about the sun is that it is a star. Sometimes it is said that the sun really isn't much of a star, and that we shouldn't judge other, more magnificent stars by it. That is unfair to the sun, which is a pretty fine star, as stars go.

It is true that very many stars are much greater. Many are much brighter. Some are thousands of times as big and bright. But it is also true that about as many stars are smaller, darker, or may be without the sun's fine family of planets.

The nearest the earth gets to the sun is 91,342,000 miles. The farthest it gets from the sun is 94,452,000 miles. Its mean—or average—distance is usually given at 93,000,000 miles. The figure is slightly larger than that, but 93 million is easier to remember.

It takes the light of the sun about eight minutes to reach the earth. This means that we never have seen or never will see the sun as it is at the present moment. We always see it as it was eight minutes before. To put it another way, if the sun suddenly turned bright blue, we wouldn't even know it for eight minutes.

The distance of 93 million miles is important for one reason. Astronomers use it as a unit of measurement, and they call it one "astronomical unit." Using this unit

make things easier to explain in the solar system. For instance, instead of saying that Mars is 141,500,000 miles from the sun, we can say simply that Mars is at about one and a half astronomical units.

Planets closer to the sun than the earth are warmer than the earth, and planets farther away are colder. The farther from the sun they are, the colder they are. Beyond Mars, all planets are very cold. Not one of them is warmer than 100 degrees below zero.



## CHAPTER VI

### *Crossing Paths*

THE big question, of course, is, where did the solar system come from, and how does it happen that the planets are all whirling in their neat tracks around one particular star?

The answer must be in the form of theories. A theory is an answer that, based on known principles, seems to fit the facts, but which hasn't itself been proved. There have been a lot of explanations of how our solar system might have come into being. Not so long ago the belief held by most people was that it once was a nebula: a circular, flat mass of gas. The theory was that the slowly whirling nebula broke up into rings, and that the rings gradually melted into balls which eventually got solid and became the planets. The central cluster of gas particles became the sun.

Nowadays many scientists believe that the sun was formed from the gases of outer space at about the same time as the other stars, and that after it was formed, another star, probably larger, came by. The attraction

of the larger star pulled a streamer of the sun's body outward, far into space. There may even have been a glancing collision.

The strange star continued on its way, never to be seen again. But the streamer broke up and formed into masses which eventually became the planets. The attraction of the strange star would have pulled the streamer after it, starting the motion which later continued around the sun. Because of the sun's own attraction, most of the streamer would have stayed close by, gradually moving in an orbit around the sun.

Still another theory says that the sun once was a twin star. The sun's companion suddenly went through some sort of change and became a nova, which is a sort of exploding star described later on. The force of the explosion blew the companion star away from the sun, but left a lot of material behind. This material was held by the sun's attraction and gradually formed into the planets.

Anyway, no matter how it happened, the planets were formed. At first they were just balls of hot gas. But as they cooled, they turned to liquid. After many years, the liquid began to become a solid, and the first step was a crust forming on the outside of the planets.

As the planets were formed, smaller masses of gas near them formed into balls, too. These smaller balls revolved around the planets just as the planets revolved around the sun. Because of this, they are known as the

planets' "satellites," which means "attendants." However, we call them all moons, because that is what we call our own satellite.

Our moon is the only one of its kind in the entire solar system. It is the finest moon of all. First, it is much larger than all other moons, when compared with the size of its planet. Jupiter and Saturn have larger moons, but they are much bigger planets than the earth.

To put it another way, the earth is only a few times greater than its moon, but Jupiter and Saturn are thousands of times greater than their largest moons.

The second thing is that our moon is the brightest one of all. Jupiter and Saturn are so far from the sun that all their moons lumped together wouldn't give as much light as ours. Remember that moonlight is only reflected sunlight. Moons have no light of their own.

The moon goes around the earth once in 27 days, 7 hours, 43.2 minutes. And it so happens that that is also exactly the time required for it to rotate once on its axis. As a result, the same face of the moon always is turned toward us.

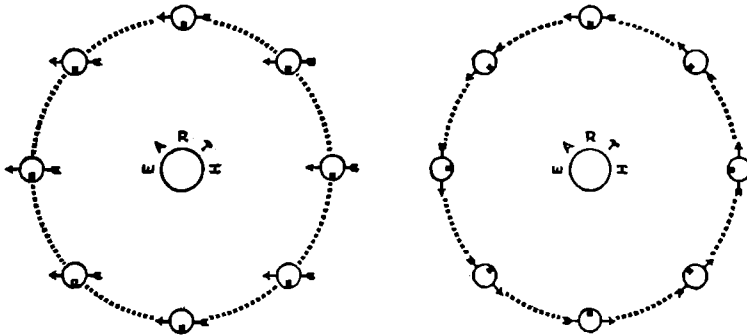
This fact can be pretty confusing. Without some kind of picture, it is a little hard to understand why the fact that we always see the same side of the moon doesn't mean it isn't rotating. The picture shows what actually happens, and what would happen if the moon didn't rotate.

The orbit of the moon, like the orbits of the planets

and the apparent motion of the sun, is within the zodiac as seen from the earth.

When the moon's path crosses the sun's path, as it does in two places, an eclipse sometimes results. That is why the sun's path is called the ecliptic.

To eclipse something means to cut off its light, and



*If the moon did not turn on its axis once each time it goes around the earth, we would be able to see every place on the moon by watching for a month. Since it does turn, we see only one side. The little squares in the picture show why.*

this can happen to both the moon and the sun. It depends on the moon's position.

An eclipse of the moon happens when the moon moves into the earth's shadow. The earth has a shadow that spreads out like a great cone on the side opposite the sun. The entire night side of the earth is the base of the cone.

Eclipses of the sun happen when the moon reaches a point between the earth and the sun.

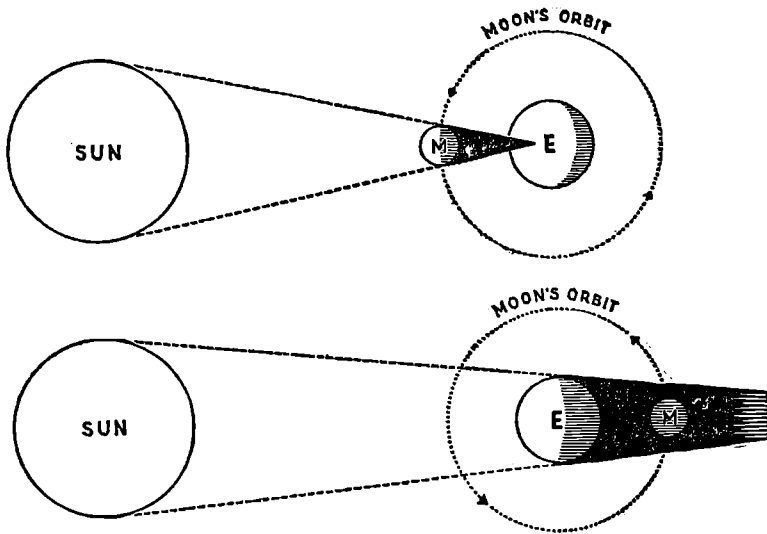
All eclipses are known in advance, because we know exactly the moment at which the moon and sun will be in the right positions. If you read that an eclipse of the moon is coming soon, try to see it. Hope for clear weather so that you can keep track of the moon as it crosses through the earth's shadow.

During an eclipse, as the moon first enters the earth's shadow, the curve of the shadow can be seen on its face. This is a partial proof that the earth is round. Even when the moon is inside the shadow completely, it will still be visible, although very faint. It may change color from copper to orange, or several shades between. If there is a little haze, there may be other colors.

Much more exciting than an eclipse of the moon, mostly because it happens so seldom, is an eclipse of the sun.

The moon is smaller than the earth, and many, many times smaller than the sun, but it is at just the right distance to block out the sun's light. You can see how a small object can block off the sight of a larger one by holding your hand in front of the sun.

When the moon goes exactly in front of the sun, and covers the sun entirely, there is a total eclipse. But sometimes, because the distance from the earth to the moon changes, the moon may appear to be a little smaller than the sun. When this happens the sun is not hidden completely. The edges of it show around



ABOVE: *Eclipse of the sun.*  
BELOW: *Eclipse of the moon.*

the moon, like a ring. This is called an “annular” eclipse, the word coming from *annulus*, which means ring. Sometimes there is a partial eclipse, when the moon seems to take a little chunk out of the sun before it passes by.

Eclipses are important in studying the sun, and scientific expeditions often go halfway around the world just to be in the path of a total eclipse.

Be sure to watch every year for information about eclipses. They are almost always featured in newspapers, and the stories tell in advance where and when they may be seen. The *World and Information Please* almanacs list all the eclipses for the year.

If you ever have a chance to see a total eclipse, don't fail to do so, even if it means taking a little bit of a trip. It is one of the most wonderful sights nature has given man.

To know what happens in an eclipse, you must know the different parts of the sun. There is the interior of the sun, which we never see. Then there is the surface, called the “photosphere,” which is the part we see when we look at the sun.

Right above the photosphere is a layer more than a thousand miles deep. It is made up of a lot of the same elements that we have on earth, but so hot that they are gases. This is called the “chromosphere.” Above it is the “corona.” Corona means crown, but the sun's corona is more like a halo of soft light.

Besides these, there are great tongues of incandescent hydrogen called "prominences." These spurt out from the sun at great speed, many thousands of miles into space.

Right up to the start of a total eclipse, there is nothing out of the ordinary to be seen. Then, as you watch through your dark glass, a tiny, crescent bite is taken out of the sun. The crescent grows rapidly, and it is easy to see why the ancient people believed eclipses were made by some sky monster taking a bite out of the sun. As the sun vanishes little by little, the light begins to fade. It isn't really noticeable until most of the sun is gone. Finally, only a thin crescent of light remains. In a few seconds the eclipse will be total, so be ready! You have only a few heartbeats in which to watch for many things.

At the very last breath, before totality, the edge of the sun shines between the mountains of the moon. A few brilliant spots appear as the last rays of sunlight strike through jagged mountain passes. These spots are called Baily's Beads.

The beads vanish, and the eclipse is total. There is a weird dark-in-day gloom over the world. Perhaps night birds wake up and start to chirp. Night insects fly out of hiding. If it is summer, a chill brings out the goose flesh on us. The chill is because of a sudden sharp drop in temperature.

If we're watching, though, we're more interested in



the soft light of the corona. People with field glasses see the prominences, too. They flash upward from the hidden disk of the sun, spearing thousands of miles into the corona.

Then, very swiftly, the crescent of light appears again as the moon continues on its way. As the first glimpse of sun appears, it seems much larger than it is. The corona is still visible. So the forthcoming bit of sun seems like an enormous, bright jewel, set in a soft, glowing ring. This is the famous “diamond ring” that appears so often in pictures of eclipses. It lasts only a breath, then the crescent of sun appears.

The total part of the eclipse is so swift, and there is so much to see, that it's a good idea to know in advance just what to watch for, and in what order. Besides the sun, watch the stars that appear. If it's summer, you'll see the constellations of winter, and vice versa.

But, even if you do plan, you may not do all that you want to. The first eclipse is spellbinding. It's the kind of sight that makes you stand with mouth open, forgetting science and just watching.

## CHAPTER VII

### *The Moon*

IF you could live on the surface of the moon, there would be a lot to see. First of all, the sky would be different. You would see the same stars we see from the earth, but many more of them, because the moon has no atmosphere. The air we breathe is the earth's atmosphere. It extends for many miles above the earth's surface.

An atmosphere like ours is necessary for life such as we have on earth, but it would be easier to watch the stars without it. The air cuts down the light of the stars. So on earth we cannot see many of the stars that could be seen from the moon. Also, since the air moves constantly, it seems to make the stars twinkle. From the moon, we could see that they shine steadily.

The earth's atmosphere keeps in a lot of the heat from the sunshine during the day, so it doesn't get too cold at night when there is no sun. On the other hand, it protects the earth by blocking out some of the sun's energy, keeping the temperature down so we can live.

The moon, with no air at all and with a very slow rotation, gets the full force of the sun for days at a time. The temperature on the sunlit side soars up to the boiling point of water, and even higher. On the dark side, the temperature is far below zero. It gets as cold as 240 degrees below zero.

Because of the temperatures and the lack of air, you could not live on the moon without an insulated suit and your own air supply, such as some deep sea divers carry. A diver's suit might be handy, because there are seas of a special kind on the moon.

Long ago people thought the flat places on the moon were really water seas, and they gave them wonderful names, like Sea of Nectar, Sea of Humors, Ocean of Storms, Sea of Cold, and Sea of Serenity. The names are given in Latin on the moon maps, but if you remember that *mare* means sea, you'll know which are the seas whenever you look at a moon map. For many years we have known that the seas are really plains. A famous English astronomer, Dr. Hoyle, believes that the plains are filled with dust made up of particles of rock. So if you stepped into a moon sea, you might go over your head in dust.

Around you on the moon would be mighty mountains, jagged and almost unscalable—except that the lesser gravity of the moon would make a superman out of every earthman. Imagine being able to soar in great, leaping bounds. You could do it on the moon.



### KEY TO MOON MAP

1 Schickard	13 Pitiscus	25 Ptolemaeus
2 Schiller	14 Vlaco	26 Hipparchus
3 Scheiner	15 Janssen	27 Albategnius
4 Longomontanus	16 Fabricius	28 Abulfeda
5 Wilhelm I	17 Zagul	29 Catharina
6 Tycho	18 Piccolomini	30 Cyrillus
7 Maginus	19 Furnerius	31 Theophilus
8 Clavius	20 Walter	32 Fracastorius
9 Newton	21 Regiomontanus	33 Santbech
10 Cuvier	22 Purbach	34 Petavius
11 Stöfler	23 Arzachel	35 Phillips
12 Maurolycus	24 Alphonsus	36 W. Humboldt

## KEY TO MOON MAP—*Continued*

37 Vendelinus	56 Copernicus	H Haemus Mts.
38 Langrenus	57 Aristarchus	I Caucasus Mts.
39 Macrobius	58 Herodotus	J Apennines
40 Cleomedes	59 Kepler	K Carpathian Mts.
41 Gauss	60 Encke	L Straight Range
42 Posidonius	61 Herschel	M Promontory Laplace
43 Hercules	62 Hevel	N Sinus Iridum
44 Atlas	63 Riccioli	O Prom. Heraclides
45 Endymion	64 Grimaldi	P Alps
46 Goldschmidt	65 Gassendi	Q Alpine Valley
47 Aristoteles	66 Mersenius	R Riphaen Mts.
48 Eudoxus	67 Pitatus	S Straight Wall
49 Cassini	A Leibnitz Mts.	T Palus Putredinis
50 Plato	B Mare Australe	U Palus Nebularum
51 Aristillus	C Altai Mts.	V Cordilleras
52 Autolychus	D Pyrenees Mts.	W Dörfel Mts.
53 Archimedes	E Mare Smythii	X Lacus Mortis
54 Timocharis	F Palus Somnii	Y D'Alembert Mts.
55 Eratosthenes	G Mare Humboldtianum	

Key to place names reprinted by permission of McGraw-Hill Book Company, Inc. from *New Handbook of the Heavens* by Hubert J. Bernhard, Dorothy A. Bennett, and Hugh S. Rice.

You would find the surface of the moon cracked and scarred, with deep clefts and high cliffs. Probably most of the moon would be made up of rock like granite. It would be interesting, but unless you were a geologist or some other kind of specialist, you probably wouldn't be interested for very long, and the green earth would look mighty good to you when you got back.

You could explore the craters, one of the most interesting things about the moon. We have craters on the earth, too. Volcanoes form them. Once it was thought that the moon craters had been formed by

volcanoes. Later it was believed that meteors striking the moon made craters, just as a rock dropped into mud will form a crater. This belief is still the most widely held.

There is another theory that is interesting. Professor George Gamow, of Washington University, explains what happened in terms of pancakes. When a pancake is cooking, gas bubbles break out and make pock marks in the surface of the cake. In just this way, gases and water vapors may have burst through the not-quite-solid moon surface as the moon cooled, forming the craters.

The seas, the craters, and the mountain ranges are shown on the moon map on page 60.

As you watch the moon, try to identify the most prominent landmarks by checking them against the map. Many of the seas can be spotted easily. The mountain ranges can be found without telescopes and so can a few of the most prominent craters. A good pair of binoculars would be helpful.

Look for the crater Tycho, which is in the southern part of the moon. On a clear night when the moon is full you can see white streaks radiating out of the crater. These streaks are called "rays" and they appear to be coming out of many craters. Most of them can be seen only with telescopes. No one knows for sure what they are.

Sometimes the full moon is hard to look at because it is so bright. This is because your eyes are adjusted to

the dim light of night, and the moon is very bright by comparison. But it isn't bright compared with the sun. If the sun were a roomful of electric light bulbs, the moon would be only a lighted match.

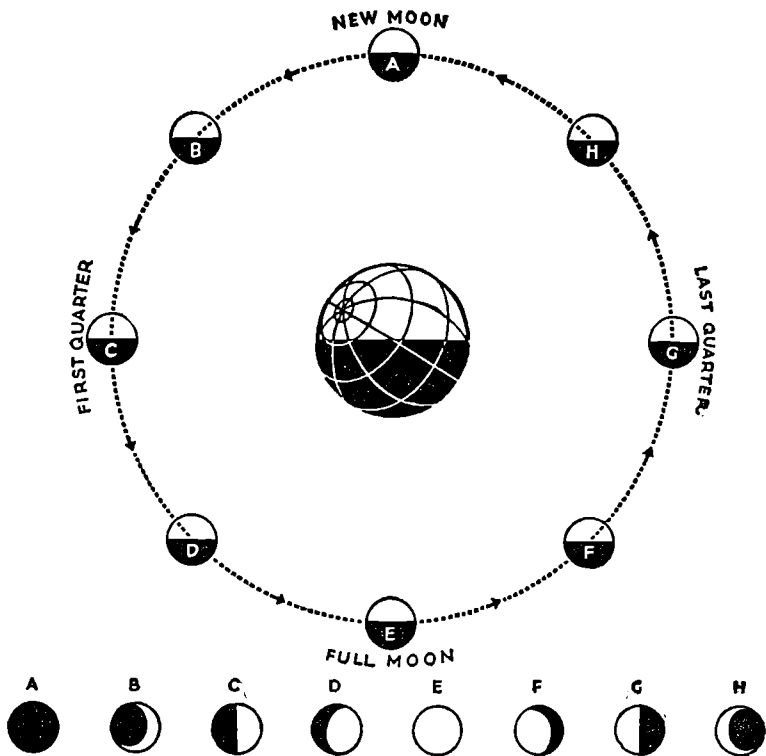
There are times when sunlight strikes the earth, is reflected off to the moon, and reflected back to earth again. This light from the moon is called "earthshine." The best time to see it is when the moon is a crescent. Then you may see the crescent lighted by sunlight and the rest of the moon lighted very dimly by earthshine.

The way the moon looks changes as the weeks go by. These changes are called "phases," and they are caused by the fact that the moon has no light of its own. All of its light is reflected sunlight. So the side of the moon that is toward the sun is light, and the side away from the sun is dark. How much of the moon's light side we see depends on which side of the earth the moon is on. The picture shows why.

Because the moon always turns the same side toward the earth, no man has ever seen the other side of the moon. Actually, we see more than half of the moon, but there is a part we have never seen.

What's on the other side? Probably the same things we see on the side that faces us.

We see the man in the moon, of course. It takes a little imagination, and a fairly full moon, but he is there. His face is made up of the dry seas and the mountain ranges.



*The moon has phases because a different amount of its surface is lit by the sun according to its position.*



Is there any possibility of life on the moon? The question has bothered men for years. In fact, there was a great joke played once by a man who claimed to have seen cities on the moon. But it's an unhappy fact that our beautiful satellite is a dead world, with no atmosphere, unbearable changes in temperature, and no water.

Yet, such a statement can't be made without some additions. There are people who have made a study of the moon their hobby. There is even a society, the Association of Lunar and Planetary Observers, whose members try to keep alive the study of the moon. *Luna* is Latin for moon. Some of these moon-gazers, mostly amateurs, have reported seeing unusual things on the moon. Amateur astronomers have added a great deal to our knowledge of the heavens, and they should be listened to with respect.

Some of the things they have reported include clouds. Wispy clouds which don't live long, to be sure, but clouds just the same. They also have reported seeing changes in certain places which might be some strange form of plant life. However, some astronomers explain this by saying that the changes are due to the angle at which sunlight strikes.

Another series of reports has been made on streaks of light, such as would be made by meteors. If meteors can be seen, there must be a thin atmosphere.

We don't like to think of the moon as entirely dead,

so let's leave the question open. If there is plant life on the moon, it must be of a very odd kind to live through temperatures that range from boiling down to 240 degrees below zero. But let's hope our attendant has a little bit of life left, even though it may be only a few strange plants in an otherwise dead world.

## CHAPTER VIII

### *Wanderers of the Sky: Comets and Meteors*

THERE have been trains, planes, horses, cars, and a thousand other things with the name of "Comet." Comet usually means speed. Meteors mean speed, too. There is a fast train called "The Silver Meteor."

Both meteors and comets are wanderers of space, and they do move fast.

#### *Comets*

Comets have caused a lot of trouble in the world's history, because people didn't know what they were. A comet in the sky has caused people to believe the world was coming to an end, or that the devil himself was riding in the sky in a chariot of fire. People have written fanciful stories about the world being wrecked by a collision with a comet. Battles have stopped when a comet appeared. Yet, comets are nothing but innocent

sky tramps. They belong to the sun, just as the planets do.

When artists draw pictures, they always show comets with long, fiery tails. Some comets have tails. Others have no tails. Some have more than one tail.

There is a lot we don't know about comets. But we do know much more than men did in the days when Halley's comet first frightened people all over the world.

We know that comets aren't as dangerous as they look. Although they have some light of their own when near the sun, most of their brilliance is reflected sunlight. We also know that the heads of comets probably are made up of a lot of little pieces of stone and iron and perhaps even chunks of frozen gases.

If a large comet should strike the earth, it would do a lot of damage. There is no doubt about that. The greater the comet, the greater the damage. But no matter what the comet's size, the old earth would just keep moving on in its course around the sun and the comet wouldn't travel through space any more.

Comets have struck the earth. We'll talk about that a little later.

First of all, we must learn the parts of a comet.

To begin with, there is the head. When first discovered, almost always with a telescope these days, the head is visible as a faint patch of light. Since the light is fuzzy, the head is called the coma. *Coma* means hair.

The Greeks called comets *kometes*, which comes from the same word and means long-haired. You can see where we got our word comets.

As the head of the comet approaches the sun, it gets brighter. Then we may see a nucleus within the head. "Nucleus" means the center of something. The nucleus of the comet is its brightest part. Outside of it are sheaths, or maybe just one sheath. The sheaths aren't quite as bright or quite as solid-looking. Outside of the sheaths may be envelopes, which are very thin, filmy layers.

As the head approaches the sun, a tail may start to form. The tails look very brilliant, but they are formed of very fine particles which cover miles of space. There may be several hundred feet between each little particle.

Sometimes the tails are wonderful to see. One comet had a tail 100 million miles long. One comet developed nine tails.

The tails stream out behind as the comet nears the sun. The tail swings out more and more as the comet goes around the sun until finally, when the comet is moving away from the sun once more, the tail is leading the way!

The earth has gone right through the tails of comets, and nothing happened. One time, observers thought the sky was a little more luminous than usual. Another time, observers saw nothing at all.

Comets are found almost every year. Sometimes three or four are found in one year. Most of them are not seen, except by people who watch for them. Some amateurs spend all their time looking for new comets or watching for old ones to reappear, and a lot of comets have been discovered by amateurs.

Perhaps once every twenty-five years, on an average, a comet appears that is so brilliant that people all over the world see it.

Where do they come from?

Some comets have great orbits that take them far out beyond Pluto. Some have much smaller orbits. There are other comets that appear once and are never seen again. Some of these may not even belong to our solar system, according to one theory. They *may* be interstellar wanderers traveling between the stars.

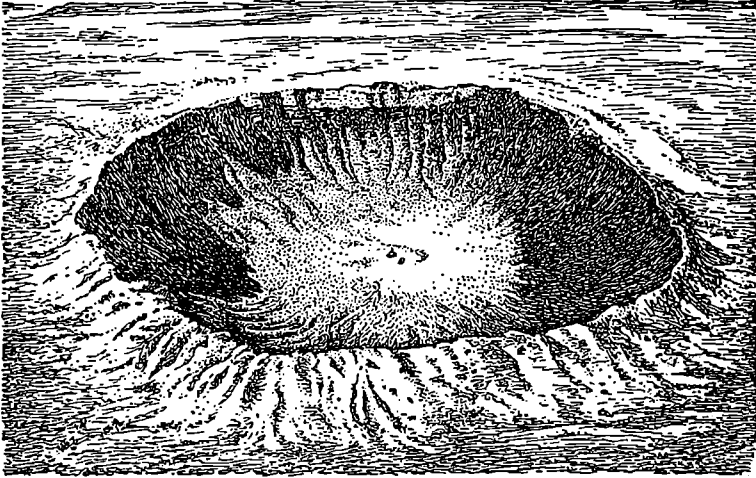
The comet which returns to the sun oftenest is known as Encke's comet, which reappears once every 3.3 years. About twenty comets have orbits that bring them back to the sun in less than twenty years, and a list of them may be found in the *World Almanac* along with the dates when they are next expected.

Perhaps the most famous comet of all is Halley's comet, which was first discovered before the time of Christ. This famous comet has a period of seventy-six years. It is due next in 1986.

In the state of Arizona, we Americans have what may be a monument to a dead comet. It is Meteor

Crater, and it was once said by a famous Swedish scientist to be the most interesting place on earth. Of course he was speaking as a scientist.

When seen from aerial photographs, Meteor Crater looks like a section of the moon. It is a giant hole in the



*Meteor Crater, Arizona.*

ground almost a mile across and from 130 to 160 feet deep. No one knows for sure how old it is.

Craters—106 of them in an area of 125 acres—were made in modern times when a dense swarm of meteors hit Siberia. There are eyewitness accounts of that event. People who saw it told of the brilliant light in the sky, the shudder of the earth when the things hit, and of trees, rocks, and dense clouds of steam thrown high in the air. The date was February 12, 1947.

## *Meteors*

Such collisions as those causing Meteor Crater might be called cannon shots from space. If so, we are struck by rifle bullets many hundreds of times every day. The bullets are of iron, stone, or sometimes nickel. They are meteors.

Space seems to be full of dust, rocks, and other bits of rubbish. Not a day or night goes by when the earth doesn't run into particles of it. What results is usually known as a shooting star.

Most shooting stars are no bigger than an apple seed. Many are even smaller. They enter the atmosphere of the earth perhaps eighty miles over our heads. When they strike the air, even though it is very thin up there, they turn into vapor and become luminous. This is because they are traveling so fast.

When we see meteors streak across the night sky, they may be traveling as fast as forty miles a second. Almost always they turn into vapor completely within the wink of an eye, perhaps leaving a very faint trail behind them.

Sometimes, though, the meteor is large enough so that it doesn't vaporize before it reaches the earth. Then it may be found and added to the collection of some museum, and it is called a meteorite. Remember that a meteor and a meteorite are the same thing in different places. In space, the bit of cosmic dust is a meteor. Once it is on the earth's surface, it is a meteorite.



Although most meteorites are only the size of small rocks, some are on view that weigh several tons. One of the most interesting collections of big meteorites is in New York City at the Hayden Planetarium, which is part of the American Museum of Natural History. Some experts now think that these pieces are really tiny asteroids.

Dr. Clyde Fisher, whose name was often mentioned in connection with the Hayden Planetarium, once estimated that over one hundred thousand million meteors enter the earth's atmosphere every day. Most of these are extremely tiny.

Meteors travel in swarms. Many swarms have orbits around the sun. Some of the swarms travel the same tracks as comets that have failed to show up again. So perhaps some swarms of meteors are the leftover pieces of a comet.

Watching meteors can be fun. Some amateurs make a special hobby of it, carefully charting the points where the meteors first appear and the points where they vanish. They also time the flight of the meteor. From their figures, astronomers can find the direction from which the meteors came and how fast they traveled.

But watching meteors usually means making a night of it, because they are best seen after midnight. Still, a few can be seen with a few hours watching at most any time of night.

If you ever decide to make a hobby of watching meteors, there is a special organization to help you. It is the American Meteor Society, Flower Observatory, Upper Darby, Pennsylvania. But before you decide to go in for meteor watching, get well acquainted with the skies. Information about meteors is given in relation to the stars, so you have to know the stars pretty well first.

Lucky watchers sometimes see a specially bright meteor known as a fireball, or "bolide." Fireballs may be seen during the daytime, and they may explode. If you see one, consider yourself fortunate. They are rather rare.

Throughout the year, at certain times, are swarms of meteors that appear and give a finer display of shooting stars than usual. The swarms, called showers, are named for the constellations from which they seem to come. They have nothing to do with the stars of the constellations. It is just that their paths happen to cross the earth's in such a way that they appear in the sky in certain constellations. The point from which they appear to come is called their *radiant*.

Summer meteor showers that may give good shows are the Aquarids, which come from the constellation Aquarius, and the Perseids, which come from the constellation Perseus. Both of these showers start in late July. The Perseid show continues into August.

Winter meteor showers are the Orionids, which

come from Orion shortly after the middle of October, the Leonids from Leo, the Lion, in the middle of November, and the Geminids from Gemini, the Twins, just before the middle of December.

The important showers which can be seen from the United States are listed on page 178.

We know that really fine meteor showers have occurred in the past through old stories and legends. The American Indians have recorded in their picture language at least one time "when the stars fell down." In 1833 and 1866 there were unusually fine showers. During the Leonid shower in 1833, one observatory counted over a quarter of a million meteors between midnight and dawn.

The wanderers of space are the most numerous of the sun's children, and they are also some of the most interesting. They do come to earth—with a bang, sometimes—and we can examine them. They are the only things of space that we can touch.

## CHAPTER IX

### *The Inner Planets: Mercury and Venus*

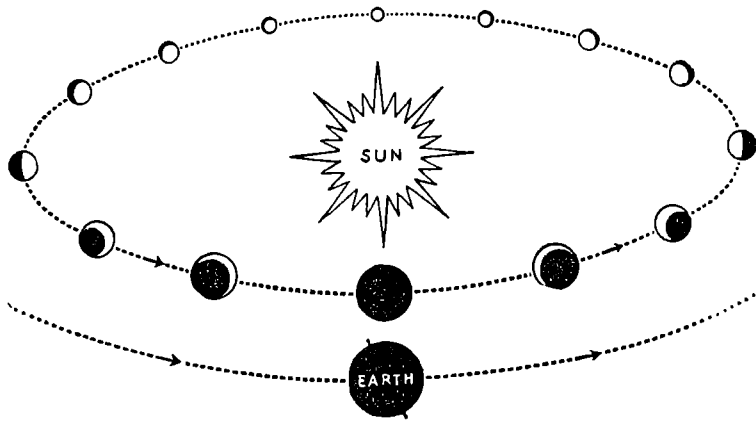
○ OF THE nine planets, two are between the earth and the sun. They are Mercury and Venus.

Because they are between us and the sun, both appear for only a short time right after sunset or before sunrise. Both have phases like the moon: the picture shows why. Both planets are smaller than the earth and neither has a moon.

#### *Mercury*

In Greek mythology, Mercury was thought to be the messenger god. When he took the form of a man, he wore winged shoes so he could travel fast. The planet Mercury does travel fast. It is the speediest of all the planets. It flies through space at about thirty miles per second.

It is closest to the sun, and therefore has the smallest orbit. So, since it has only a short way to go and travels



*Since Venus is between us and the sun, it has phases like the moon and its apparent size changes. Mercury's apparent behavior is the same as that of Venus.*

so fast, Mercury goes around the sun in only eighty-eight days. That is another way of saying that one year on Mercury is only eighty-eight days on the earth.

Like our moon, Mercury revolves only once while traveling around its orbit. It is the smallest planet. It is a lonely little world, so hot on one side that lead would melt, and so cold on the other that part of the air would freeze.

The closest Mercury ever gets to the earth is 50 million miles. When it is farthest away, on the other side of the sun, it is 136 million miles from us.

Unless you are patient, you may have trouble seeing Mercury at all. Copernicus, it is said, never saw the little planet. But he didn't have almanacs to tell him the six or seven times every year when Mercury can best be seen. These are the times when the planet is farthest east or west of the sun.

Mercury will seem like a star, but its brilliance will vary according to whether it is half-full or only partly full. Remember it has phases, like the moon. When it is brightest, it is about as bright as Sirius, the Dog Star, which is the brightest real star in the sky. When it is dimmest, it still will be bright. Then it will be about as bright as Betelgeuse, the red giant star in the constellation Orion.

Sometimes Mercury appears as a morning star and sometimes as an evening star. If you are doubtful about Mercury, check the sky with a star chart. If no star is

shown in the place where you see a bright object, it must be a planet.

We can be almost certain that there is no life on Mercury. The temperature on the sunny side, which is higher than 400 degrees, would not allow life. The temperature on the dark side, close to absolute zero, would freeze anything.

We have said there is no atmosphere, and it is true there is none that astronomers have been able to find. Still, it is possible in theory that Mercury could have a very, very thin atmosphere of oxygen and carbon dioxide. Also, there is a broad belt between the dark and sunny sides where the temperatures are not as extreme. If there is life on Mercury, it must be in this twilight belt, but it is very doubtful.

## *Venus*

Venus, the planet named for the Greek goddess of love, is one of the finest sights in the sky. She is the earth's closest neighbor, not counting the moon. When nearest, the planet is only 26 million miles away. What's more, Venus is almost a twin of the earth, although slightly smaller. The earth's diameter is 7926 miles. Venus has a diameter only about 350 miles less.

Like the earth, Venus has an atmosphere. We do know that, but we really know very little else. She is

the planet of mystery. No one ever has seen her surface, because clouds cover her all the time. We're not even sure how long her day and night are—that is, how long it takes for one rotation on her axis. The best we can say is that Venus probably rotates in a few weeks, or in a few months. No one knows exactly. We do know that Venus goes around the sun once in about 225 earth days.

Transits of Venus, when the planet crosses in front of the sun, are exciting events in astronomy. When the planet crosses the sun, it can be seen that there is a good, thick atmosphere. Also, the time it takes for the planet to cross the sun's disk is very carefully watched and used to check mathematical calculations.

From observations taken during transits of Venus, we know part of the planet's atmosphere is about five miles thick. There is a lot of atmosphere under that layer about which we know nothing.

Astronomers have photographed Venus in a number of ways, trying to see through the clouds that always cover her surface, but so far they have had little success. That is why we do not know just how long it takes for Venus to turn on her axis. The way we find out is to watch some mark on the surface, to see how long it takes for a complete revolution. The only marks on Venus are clouds.

Because of the clouds, we can only make theories about the surface of Venus. For some years many have



believed Venus may now be as the earth was millions of years ago. Venus is surely hotter than the earth, because it is nearer the sun. So if there are swamps, they must be steaming hot.

But there is some doubt that Venus has any water. No water vapor has been found in the atmosphere of Venus, which might show that the planet is really a desert. But where do the clouds come from? They are almost surely not like earth clouds. A famous English astronomer, H. Spencer Jones, believes that great dust storms rage on Venus all the time, and that the clouds are dust clouds.

So the question of life on Venus is not settled, but many scientists doubt that life is possible at all. Their reasons are the absence of water and oxygen for living things to breathe, and too much heat. Other scientists are more hopeful, and prefer to leave the question open until we know more about the planets.

Life or not, Venus is still a wonderful sight in the dawn and evening skies. It is the finest object in the sky, next to the moon and sun. At its brightest, it can cast a shadow. Then Venus is many times brighter than Sirius, our most brilliant star.

Since Venus is between the earth's orbit and the sun, it is only found near the sun. It is the same for Mercury. These two planets never can be seen in the late-night sky. They are morning and evening planets.

The Greeks first thought Venus in the morning and

Venus in the evening were different stars. They named them Phosphoros and Hesperus. They also thought Mercury was two stars—Mercury in the evening and Apollo in the morning.

Venus is very much easier to see than Mercury. At best, it can be seen for about four hours. Look for its rising and setting times in the almanac. If you know exactly where to look, Venus can be seen in the daytime.

Venus is so bright sometimes that it has been mistaken for beacon lights, or lights on top of buildings, or even for flying saucers. And, most wonderful of all, Venus may have been the Star of Bethlehem that led the Wise Men to the stable on the night that Christ was born.

## CHAPTER X

### *The Red Planet—Mars*

**M**ARS, the Red Planet, was named for the ancient Roman God of war. It is the fourth planet from the sun. Also, it is perhaps the most interesting planet, after the earth itself.

For a long time, we knew very little more about Mars than we did about the other planets. We knew that its day is 24 hours 37.5 minutes long, just slightly longer than the earth's. We also knew that it has white caps on its poles, which might or might not be snow caps like the earth's.

Then, in 1877, Mars came close to the earth. Schiaparelli, an Italian astronomer, who had a very good telescope, found streaks crossing the planet.

In reporting what he found, Schiaparelli used a word that resulted in people mistaking what he meant. He created a lot of excitement that still continues today.

Some areas of Mars seem to resemble oceans, and others continents, so the areas had been named for

seas or land. To the Italian astronomer, it seemed that the streaks he saw connected the seas by crossing the land portions.

Schiaparelli charted the streaks. He called them channels. That was what caused people to make the mistake in words, because the Italian for channels is *canali*. If he had called them something else, people wouldn't have been so excited. Schiaparelli really meant channels, which are created by the flow of water. When water seeks an outlet, it may cut a channel, and the channel may be a straight line or it may not.

But *canali* is so close to the English word canals, that people began to speak of the "Martian canals." Canals, to most people at least, mean channels that are man-made. So the belief grew that people lived on Mars and that they had built canals.

Some of the channels the Italian astronomer sketched were easily seen. Others could be seen only after much watching. They were like fine hairs in the telescope. Some were only a few hundred miles long, others extended for thousands of miles.

In 1893, after years of study, Schiaparelli decided that his *canali* really were channels through which water ran. They all ended in oceans. Where two *canali* crossed, there were round places like lakes—known as oases. Every once in a while some canals would split and make two canals.

Schiaparelli himself said the regularity of the canals

had led some people to believe that the canals were the work of “inhabitants of the planet.” The idea, he said, “includes nothing impossible.”

The Italian’s work caused great excitement and a lot of interest in Mars. Meanwhile, in 1877, it was discovered that Mars has two moons. The discoverer was an American, Asaph Hall, and he found the moons with the 40-inch telescope at the Naval Observatory in Washington.

The moons were named Phobos and Deimos, because in Greek mythology these were the names of the god Mars’ attendants. These moons are really only giant rocks. Phobos, the inner one, is thought to be only ten miles in diameter, while Deimos is only about five miles across.

Phobos is only about 3700 miles from the surface of Mars, and it travels at high speed, going around the planet in a little more than 7.5 hours. This means that a Martian would see Phobos rise and set three times each day and night.

Deimos, the smaller moon, is a little over 14,500 miles from the surface of Mars and takes slightly over 30 hours to make one revolution. So while Phobos races across the sky, Deimos hangs there, taking about two days between rising and setting, as seen by a Martian.

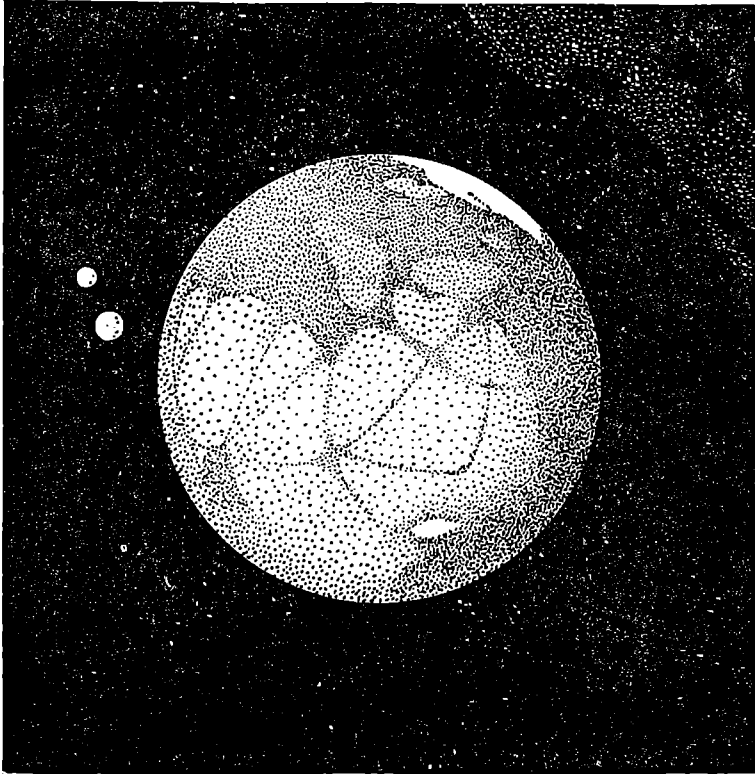
It is interesting to note that these moons were described in *Gulliver’s Travels*, by Jonathan Swift,

150 years *before* the American astronomer discovered them! Back in 1727, Swift stated that the innermost moon revolves in the space of ten hours; the other in twenty and one half. Was this pure invention that just happened to turn out to be true, or had Swift seen something that no astronomer had seen? No one knows.

Shortly after these discoveries, one of America's great astronomers, Percival Lowell, opened an observatory in Arizona and began a study of Mars. He found that the seas could not really be water, because they themselves were crossed with faint channels just like the rest of the planet. Changes took place in these areas, both in color and in form. The changes seemed to be connected with the seasons.

Lowell concluded that there must be intelligent life on Mars. The changes in color and form were vegetation, he thought, while the canals were made by Martians in order to conserve their small water supply. He published a book, called *Mars as the Abode of Life*.

Since then, there has been a lot of discussion. Photographs do show some streaks, but not all astronomers believe they are really canals, or even particularly straight channels. Most experts believe the canals are not clear, mathematically perfect lines, but broad and uneven in outline. This doesn't mean that Schiaparelli and Lowell were trying to fool anyone. Looking through a telescope is apt to result in odd impressions. The two great astronomers thought they saw the complex chan-



*Mars.*

nels across the planet, and they really did see some. Photographs, which usually are better than the eye, do not show all that the astronomers drew on their sketch pads. But perhaps the photographs have not told the whole story. The canals are at the very limit of vision, so that it takes a lot of study and experience to see them.

What would a space traveler find on Mars? There is always disagreement between experts when we have so little evidence, but a few things are believed by most.

The traveler would find that the reddish color of Mars which we notice from the earth is due to vast areas of barren land. It is common on earth for minerals to turn a reddish color when they combine with oxygen. Rust is a good example. Iron objects rust because the iron combines with the oxygen in the air. Perhaps so much of the surface of Mars has oxidized—combined with oxygen—that most of the oxygen that used to be in the Martian air may now be seen in the reddish color.

But not all of Mars is red. There are darker places, scattered here and there in great patches, which look like continents or seas. Most scientists agree there must be plant life of some kind in these places. No one has any exact information on what these plants are like, but scientists have suggested that they may be like moss or lichens, or even shrubs.

There would be mountains on Mars, but lower and



more weathered than the earth's. Instead of being like the Rockies, they would be more like the Appalachian foothills.

The spaceman would not do much exploring except near noonday, unless he was equipped with an electrically heated suit and helmet. Portable oxygen bottles would be essential.

Mars definitely does have an atmosphere. It can be seen in photographs taken with ultraviolet sensitive film. But the atmosphere is very thin, and it must be very low in oxygen, which is the gas needed to support human life. What's more, there is little water vapor in the air, because Mars has a water shortage. There isn't nearly enough to fill the canals Schiaparelli and Lowell saw.

So we can imagine the spaceman standing in the midst of a barren, reddish plain near the Martian equator. It is noon, and we can imagine him perspiring under his oxygen mask, because the temperature is 80 degrees—like a summer day on the earth! Of course the temperature varies, because Mars has seasons. This spaceman arrived during the Martian summer.

The spaceman might see clouds form overhead. We have seen Martian clouds through telescopes. The clouds would be seen against a sky much darker than ours, because the air is thin and doesn't scatter the light so much.

Toward sunset, the spaceman would get back into

his spaceship. With darkness, the temperature goes way down. It may go as low as 100 degrees below zero. The highest and lowest temperatures scientists have found on Mars range from about 80 degrees to 130 below zero.

Would the spaceman find animal life—human life—on Mars?

It is very hard to know. He might find animals which have adapted themselves to the great ranges in temperature, but probably not a great many. He might find all animal life had vanished, leaving the ruins of a dead civilization. On the other hand, he might possibly find a few Martian survivors living in heated, air-tight dwellings of some kind, venturing out only during the hours of sunlight.

Someday, almost surely, we will know.

We do know now that Mars is a dying planet, with most of its atmosphere gone, only a little of its water left. Perhaps sometime in the future our dream of interplanetary travel may come true and some earthman may step on the crumbling soil of Mars.

If it should happen, let us hope there are Martians to greet him. It would be rather comforting to know that in the open reaches of space we at least have one planet with neighbors.

## CHAPTER XI

### *50,000 Little Planets*

|| IN THE year 1800, astronomers knew of seven planets: Mercury, Venus, the earth, Mars, Jupiter, Saturn, and Uranus. They also had noticed that the planets were spaced at fairly regular intervals. There was even a law that gave the spacing, known as Bode's Law, after the astronomer who first found it.

Bode's Law was pretty accurate out to Mars. But after Mars, there was a great gap before Jupiter's orbit. Beyond Jupiter, the law was less accurate, but it was close enough to give the approximate positions of the planets.

Astronomers puzzled for a long time over the great gap between Mars and Jupiter, and some of them thought a planet must be in there somewhere, even though it hadn't been found.

Then on January 1, 1801, the Italian astronomer Piazzi was making a catalogue of the skies, charting every star which could be seen with his telescope. On this particular night he discovered a star where none

ever had been seen before. Observation showed clearly that it moved. Calculations gave its orbit.

No doubt of it, Piazzi had found the missing planet! He named it Ceres.

What a tiny planet it was! Until then, Mercury had been the smallest planet, with a diameter of about 3000 miles. Here was a planet with a diameter of only 480 miles. It had a very strange orbit, too, one much odder than any of the other planets. Of course, it was watched very carefully, but before it could get around the sun, an announcement came from Bremen, Germany.

A doctor of Bremen by the name of Olbers was an amateur astronomer. In scanning the sky near Ceres, he found another little planet! It was named Pallas, and the theory grew up at once that Ceres and Pallas once had been a single planet which broke into two parts. Since Pallas had a diameter of only 305 miles, the two tiny planets lumped together wouldn't have made a respectable moon, much less a real planet member of the solar family.

Dr. Olbers wondered if the original planet might not have split into more parts, and he suggested that other pieces might be found. A third small planet (they are called "asteroids") was discovered and named Juno. Then Olbers himself found the fourth, named Vesta. Since then, "pieces" of the planet have been found almost every year. In recent years, many hundreds have been found. We know of over 1500 with orbits defi-

nitely charted. Around 5000 more have been seen, but not charted as yet. One leading authority (Lenschner) estimates there may be over 50,000 of them. One, known as Riceia, was discovered by Dr. Hugh Rice of the Hayden Planetarium, who offered a number of fine suggestions for this book.

These asteroids are sometimes, but less often, called "planetoids." Astronomers often call them "minor planets."

Ceres still is the largest asteroid. The others are smaller, ranging down to little lumps of rock a few hundred feet in diameter. There is a very good chance that many thousands of asteroids never will be found at all, because they are too small to be seen. Probably many are no bigger than a house. Some may be even smaller.

We can imagine these lonely chunks of solid stuff whirling endlessly through black space, the sunlight reflecting from their sides. None has an atmosphere, or any growing thing on it. They are just great or small pieces of rocky material marching forever around the sun.

Unless one of them gets captured!

This may have happened. There is some reason to believe that Mars may have raided the asteroid belt, using its gravity as a lasso, roping in two pretty fine asteroids and holding them fast in its gravity. Phobos and Deimos may once have been minor planets.

About the only asteroid which *possibly* may be seen with the unaided eye is Vesta, which is the brightest of the asteroids. To see Vesta, you will have to know exactly when and where to look, and have excellent eyesight and perfect weather. Even then, you will have trouble. If, after you have located the major planets and the principal stars, you want to try for Vesta, find a copy of an ephemeris that gives the data for asteroids. A little study will tell you how to use the figures which give the information for locating Vesta. If you have field glasses, you will be able to see Vesta easily once you've located it.

In spite of the fact that all but one of the asteroids are invisible to the naked eye, these tiny worlds are interesting. We don't know what they're made of, or even how many there are. We mentioned one man's belief that there are more than 50,000. Others believe there may be twice that many, or even more.

Perhaps—and this is nothing but pure imagination—some of the asteroids may be valuable elements or compounds. We don't know for sure how they were made, so the sky is the limit both for asteroids and imagination.

*The Giant Worlds: Jupiter and Saturn*

OUTWARD from the sun, beyond the great belt where the asteroids swing, are the orbits of the giants. They are tremendous planets, compared with the earth. If you think of a mouse standing next to an elephant and a horse, that will give you some idea of their size.

Besides being the biggest, these giants are two of the most interesting planets in the solar system. One is Jupiter, who in ancient mythology was the wisest and most powerful of the gods. The other is Saturn, who was the father of Jupiter.

Other names for Jupiter in the old legends are Jove and Zeus. We still see the name Jove in adjectives that describe the planet Jupiter. For instance, the moons of Jupiter are often called Jovian moons.

Another name for Saturn was the Greek name of Cronos, which means time. Since time moves forward in a way which nothing can stop, eventually overcoming everyone and everything, Saturn was pictured with

a dark, rather unpleasant face. This belief lives on in the word saturnine, which is sometimes used in stories to describe men with dark, “devilish” faces.

### *Jupiter*

In our comparison of the two planets, Jupiter is the elephant. Even by comparing the earth with a mouse and Jupiter with an elephant, it is hard for earth-people to understand the planet’s size.

This mighty planet has an atmosphere, too, and it is a very thick one. Many scientists believe that Jupiter isn’t as large as it seems, and that much of its size is because we see its atmosphere and not its surface. The atmosphere is probably several thousand miles thick. Another theory is that the atmosphere is so heavy it has squeezed the gases near the surface into ice. So we can imagine Jupiter as a ball of rock and minerals surrounded by a tremendous coat of ice thousands of miles thick, with an atmosphere over 5000 miles thick on top of that.

Of course, the ice would not allow anything to live, nor would the pressure of the atmosphere. But more than that, the atmosphere of Jupiter is made up largely of two poisonous gases which are found on the earth. One is ammonia, which is used in many houses, and the other is methane, which is often called marsh gas.



Bubbles you see rising in a swamp often are filled with methane.

But even though the atmosphere is poisonous, it is beautiful, and it does things scientists have not yet explained. The famous Red Spot is one odd thing. It was first noticed in 1859. It lasted for years, then finally got fainter and fainter and went away. But it came back again. It is over 30,000 miles long and about a quarter as wide. It changes constantly. Sometimes it is very red, like a brick house, and sometimes it is so pale it can hardly be seen at all. No one knows what it is.

When it was first seen, and for years after, it was thought that volcanoes on Jupiter might cause it. The idea was that Jupiter, being so big, had not yet cooled. But now we have a pretty good idea that Jupiter is coated with ice, but is much colder than ice. It is probably around 200 degrees below zero.

Like Venus, Jupiter never shows its surface. The atmosphere and clouds are too thick. But scientists estimated its day and night long ago by the speed with which markings in its clouds traveled. The markings are much plainer and steadier than those on Venus, so the estimate is pretty accurate.

To the stargazer, Jupiter is a fine sight. It is brighter than any star in the sky, even brilliant Sirius, which is the brightest star. But it is less brilliant than Venus. Where the earth spins once in twenty-four hours, Jupiter spins once in about ten. It moves so slowly through

space that it stays near one spot for a long while, as seen from the earth. Jupiter, being far out in space, has a long way to go in its journey around the sun. One year equals more than eleven earth years. The closest Jupiter ever gets to the earth is about 367 million miles. When it is farthest away, it is about 600 million miles.

As you watch Jupiter, you may notice a strange thing. Sometimes it seems to move ahead quite rapidly, as you keep track of it from night to night. At other times it seems to stand still, then to move backwards. Actually, of course, Jupiter keeps plowing ahead through space at a steady eight miles per second. But the earth first overtakes it, then passes it, because we are moving so much faster. So Jupiter's apparent motion changes. Other planets outside of our orbit behave the same way.

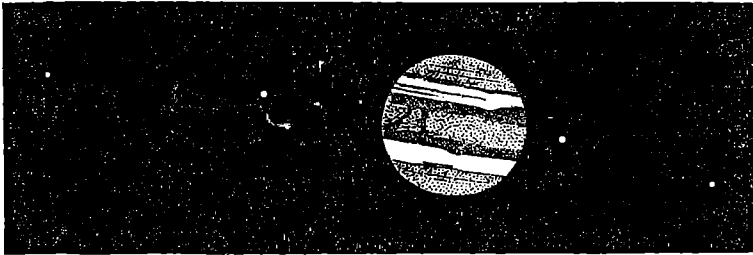
It is worth going to quite a lot of trouble to get a pair of good binoculars or a telescope with which to look at Jupiter.

Galileo did. Jupiter was one of the first things he looked at after he had improved the first astronomical telescope. He reported later that he noticed something he had never been able to see before. Near Jupiter were three tiny stars. He thought they were just fixed stars, but their regularity—their positions, in relation to Jupiter—made him wonder.

The next night, in searching the heavens, he turned again to Jupiter. The little stars had moved! They were

all on the same side of the planet. A few more nights of checking and calculating and Galileo found that instead of the three little stars, there were four, and they circled Jupiter. He had found the first moons other than the earth's own.

That is why we say getting a good glass of some kind, by borrowing or by persuading an amateur astronomer who has one to let you look through it, is really exciting. For you can see for yourself what Galileo saw. Four



*The moons of Jupiter.*

moons! Io, Europa, Ganymede, and Callisto, discovered in 1610 by the immortal Galileo.

If any of the four are at their greatest extension from Jupiter, you will be surprised at how far distant they are from the planet. Because of book and magazine illustrations, we get a definite impression that the moons, including our own, are very near their planets. By looking at Jupiter, you will be able to see that they are not.

One look won't be enough. You may see only one or two moons if the others happen to be behind Jupiter,

or crossing it. Or, you may see all four close to the surface of the planet. So watch for several nights if you possibly can.

Keep track of them, charting their positions from night to night, and you can get to know them by name. Io is the one nearest Jupiter. Look at Io when she is farthest west or east, and you are looking at a distance of 263,000 miles.

The next moon outward from Jupiter is Europa, then Ganymede. Callisto is the fourth moon, and is 1,175,000 miles from the planet. Ganymede and Callisto are bigger than the planet Mercury.

Besides these four, Jupiter has seven moons that you cannot see. It took photography to find some of them because they are so small.

One interesting thing about Jupiter's moons is that the outer three go around the planet backwards. Almost everything in the solar system moves counterclockwise as seen from the Northern Hemisphere.

Counterclockwise means "against the clock." Notice how the hands of a clock move. Counterclockwise is as though the clock were running backwards. If you could stand at the sun's north pole and see all the planets, they would be moving counterclockwise. If you could stand at Jupiter's north pole, all the moons would be moving counterclockwise except the outer three, which would be moving clockwise.

The fact that three of Jupiter's moons, and the outer

three at that, revolve backward, may show that the moons are really stolen asteroids. If so, they were stolen a long time ago.

Remember that asteroids travel in their orbits around the sun because of the sun's attraction. But the asteroids are pretty far out, so the sun's attraction isn't as strong as it is closer in. Asteroids often have very odd orbits, and some cross the tracks of the planets. An asteroid getting near giant Jupiter could be pulled out of its track by Jupiter's own great attraction and held fast by the planet's own gravity.

You can see for yourself that Jupiter has a greater attraction than the sun in the planet's own neighborhood, because it holds its moons fast. If the sun had the greater attraction, it could steal Jupiter's moons. In fact, any moons very far outward from the present eleven probably would be stolen by the sun.

### *Saturn*

A few hundred million miles beyond Jupiter lies the second giant planet, Saturn. In one way, Saturn is the most remarkable planet of all.

Whenever an artist illustrates something with star pictures, we can depend on his including a picture of Saturn. Sometimes the artist gets really excited about it and puts in several Saturns, usually different sizes. The

reason is that the planet has rings. It is the only member of the solar system which has.

Like Jupiter, it has a poisonous atmosphere and temperatures of over 200 degrees below zero. There is no possibility of life on Saturn.

Saturn can readily be seen with the unaided eye. When it is most brilliant, it is about the sixth brightest object in the sky.

Saturn turns on its axis about like Jupiter. Its day is about ten hours and a quarter. But it moves through space slowly, with a speed of only six miles per second, compared with the earth's eighteen and a half miles per second.

Being so far from the sun, it has a long way to travel in its course around the sun. Its year is equal to more than twenty-nine earth years. This means Saturn appears to stay in the same place in the sky for a long while.

If you possibly can, look at Saturn through a telescope, in order to see the wonderful rings. For a long while men wondered what the rings were, and there were arguments about whether they were solid, or made of gas, or something not yet explained. Now we know that the rings must be millions upon millions of separate particles—rocks and boulders, probably. They are actually millions and millions of very tiny moons whirling around the planet.

The rings start about 7000 miles from Saturn and

extend about 41,500 miles from the inner to the outer edge. These wonderful moonlets are in a band only about ten miles thick.

The general belief is that the moonlets which make up the ring were once a full-scale moon that broke up



*Saturn's famous rings are the only ones of their kind in the solar system. Titan, Saturn's biggest moon, is almost as big as Mars.*

into millions of pieces, but continued to circle its planet.

Besides the rings, Saturn has nine moons. Only four of Jupiter's have names. The rest usually are known by numbers. But Saturn's family is all named. The moons are outside of the rings. Starting with the one nearest the planet and going out, they are Mimas, Enceladus,

Tethys, Dione, Rhea, Titan, Hyperion, Iapetus, and Phoebe.

Of these, only one is of any importance to the stargazer who can't use a really good telescope. That one is Titan. It was discovered by the same astronomer who first saw the rings in a position where he could tell what they were. His name was Christiaan Huygens, and he found Titan in 1655 at the same time he saw the rings.

Titan is a wonderful moon. It is much bigger than Mercury. It is almost as big as Mars. It's the only moon in the solar system which is known to have an atmosphere—a poisonous one like that of Saturn itself.



## CHAPTER XIII

### *The Outermost Worlds: Uranus, Neptune, and Pluto*

**B**EYOND Saturn are the three outermost planets of the solar system: Uranus, Neptune, and Pluto.

The discoverer of Uranus was William Herschel, and he made his discovery by accident. He wasn't looking for a planet. He was mapping the stars. While making his survey, he came across a star which wouldn't stand still. It turned out to be another member of the solar system, way out in space, over a billion and a half miles from the sun. It was named after the father of Saturn, Jupiter's grandfather. Uranium, the element from which the first atomic bomb was made, was named after the planet Uranus.

Uranus can be seen without a telescope, but to do so takes very good eyesight and a knowledge of the heavens. Even when brightest, the planet is very faint, and one must know just where to look for it. This information is given in publications such as *Sky and Telescope*.

A billion miles beyond Uranus is a planet which can

be seen only with a telescope. Even with a telescope, finding it isn't easy. The planet is Neptune, named for the god of the sea. Oceanus is another name for the same god.

The most exciting thing about Neptune is the way it was discovered. In 1800, the French astronomer Bouvard started working on new calculations for the orbits of Jupiter, Saturn, and Uranus. Among other things, he figured out the attraction of these planets for each other. Such attraction makes a difference in a planet's orbit.

When he came to charting the orbit of Uranus, he got into trouble. Nothing he could do would make his tables come out right.

Later, within a short time of each other, another Frenchman and an Englishman began to work on the problem. The Englishman, Adams, started first. The Frenchman, Leverrier, started a little later. Both had the idea that an undiscovered planet beyond Uranus might be causing the strange behavior.

Adams finished his calculations first, but the British Astronomer Royal thought he must be mistaken and paid no attention. Then Leverrier finished his figures and published them. The Royal Astronomer sat up and took notice, because the figures Adams had given him were very much like those of the Frenchman.

The search for the planet began at once. Adams's figures were used at Cambridge University. Leverrier's

were used at the Berlin Observatory. It happened that the astronomers at Berlin had just been mapping the part of the sky where the new planet was predicted and that gave them a head start. Two nights later, the Berlin astronomers announced the planet had been found. The date was 1846.

Both Adams and Leverrier are honored for their brilliant work. Although they did not work together, they are considered co-discoverers.

The finding of Neptune didn't satisfy astronomers for long. When its orbit was figured out, it still couldn't account for all Uranus's peculiar movements. Many astronomers worked on the problem, including the Americans Percival Lowell and W. H. Pickering. These Americans, working separately, calculated the probable position of Pluto and the search began.

There were many false alarms. Moving objects were found, and identified as asteroids. Then, in 1916, Lowell died. But the search kept on. Photography did the looking. Photographs by the hundreds were taken, several of the same sky area. By comparing them, an object moving among the stars could be found.

It was not until 1930 that success came. In January of that year, something was found. But the finders were careful, and said nothing. The object was watched carefully until, in March 1930, Clyde W. Tombaugh announced he had discovered Pluto, the planet which traveled in outer darkness. Pluto, who was god of the

dark underworld in old myths, had joined the brighter gods in the solar system.

We still know very little about Pluto. We know its mass pretty accurately, but we have only a probable estimate of its size. We do know its orbit, which is so irregular that it cuts inside of Neptune's in places.

Uranus has five moons and Neptune has two. We don't know whether Pluto has a moon.

Neptune and Pluto cannot be seen with the unaided eye. Uranus can be seen, but only with very good vision and under unusually good weather conditions, as we have said. Neptune can be seen with field glasses, but only a very large telescope can find Pluto.

Is there another planet, out beyond Pluto? There are little things about the orbits of Uranus and Neptune that the discovery of Pluto hasn't explained, and some astronomers believe another planet isn't impossible.

It's exciting to think that somewhere in the blackness of space beyond frozen Pluto may be one of the sun's lost children. If so, there is a good chance that it will be discovered in our time. Astronomers now, with the mighty Schmidt and the giant Hale telescopes on Mount Palomar, California, are working on the most complete study of the skies ever made. They will locate space objects far beyond any ever discovered before. And while they search for distant sky treasures, let's hope they find one nearer home—a new member of our solar family.

## CHAPTER XIV

### *The Sun*

IF you could stand on Pluto, our sun would look like the other bright stars around you. It would be the brightest thing in the sky, but it wouldn't look like our sun.

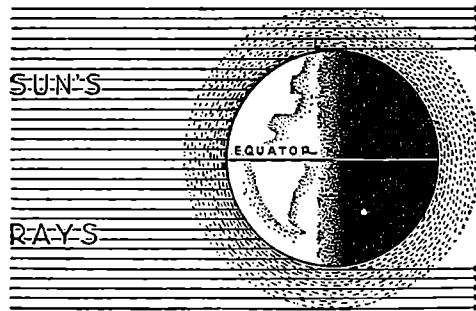
To earthmen, the sun is something special. It is hard to think of it as "just another star," but that is what it is. There are many thousands of stars exactly like it, medium-size yellow stars scattered throughout our galaxy and all the other galaxies.

Not all stars are alike, of course. They are divided into classes by size, color, and other more technical things. A star's spectrum has a lot to do with the class it is in. If we were to put all the stars in a line, according to brightness, the sun would be pretty close to the middle.

The sun is so bright that we find it hard to look at, except perhaps in the early morning and late afternoon. At those times it shines through much more of the air, because of the angle at which it rises or sets.

The air, or atmosphere, cuts down much of the light.

For those without special equipment, the best way to see the sun is through a piece of smoked glass, dark plastic, or a dark photographic film negative. To smoke a piece of glass, hold it over a candle, moving it back and forth so the soot from the candle forms on it in a smooth, even film. A few common household things are made of very dark shades of transparent plastic, and these would be good to look through, too. Most amateur



*The earth's atmosphere protects us from the sun's rays.*

photographers make mistakes in taking pictures, so many of us have film negatives that are very dark. If one of these is not dark enough to make looking at the sun comfortable, two held together may be.

Looking at the sun, you can see that it is a shining globe. Sometimes you can see spots on it.

When you look at the sun, you are looking at atomic explosions. Scientists say that the enormous energy of the sun comes from subatomic reactions something like

the one that has been talked about for the making of hydrogen bombs. In this kind of reaction, atoms of hydrogen, which is the lightest element, fuse together to form another element called helium. Helium is a gas, like hydrogen, and its name comes from the Greek word for sun.

As the atomic fusing goes on, the sun gives off the energy released by the action. This energy is tremendous. We on earth get only the very tiniest part of it as it flashes across the void between earth and sun. Yet the little bit we get is enough to run the world. It is stored up in growing plants, which are eaten by animals, including man. Sometimes the plants are not eaten, but decay and provide necessary things for new plants to grow. Long ago, decaying plants were pressed into the earth and after many thousands of years formed coal.

In recent years men have tried many ways of harnessing the sun's power directly. We have learned how to make the sun heat certain kinds of houses, or how to heat water. But no one has yet made a really good sun machine to run engines with.

One way that has been tried is using lenses, such as cameras and telescopes have. To see how energy can be gathered in this way, we need only to have a reading glass, or the lens out of some kinds of flashlights. With the glass, after experimenting a little, the sun's rays can be brought to a fine point on a piece of paper. But be careful if you try this, because a beam of sunlight con-

centrated through a lens can char the paper and cause it to catch fire.

Of course giving off this energy has some effect on the sun itself. Every second, scientists say, the sun loses about four million tons of itself. This sounds like a lot, and it is, by earth standards. But the sun is so big that it can continue to give off this amount of matter and energy for billions of years. At the end, when the sun is very old, it may grow cold. This was what most people used to think until just a short while ago. Now some scientists believe stars may get help from outer space, perhaps in the form of new hydrogen atoms. So the sun may live longer than we used to think.

If the sun is so huge that it can spend its energy so recklessly, how big is it?

The easiest way to imagine it is to think in terms of the earth. If we could place a row of earths across the face of the sun, it would take 109 to reach from edge to edge. If we wanted to pile up enough earths to equal the volume of the sun, it would take a lot more than a million.

The diameter of the sun is 865,000 miles. Its mass is 333,000 times that of the earth. And scientists figure that if an earthman could stand on the sun, he would weigh about twenty-eight times what he would on the earth.

Of course a man could never stand on the sun. The temperature on the sun's surface is about 10,000 de-



grees Fahrenheit. Authorities have estimated that the temperature inside the sun may be 25 *million* degrees.

The coolest places on the sun are in the spots which you may see through your smoked glass. These are sunspots, and they are like great storms. They look dark, or black, but they are really white-hot. They only look black because the rest of the sun is so much brighter.

You might not see sunspots for a long time, even if you looked every day. But sooner or later, they would appear. Actually, they are almost always there, but they might not be large enough to be seen without a telescope. By the way, never look at the sun through a telescope or field glasses of any kind unless there is something to protect your eye, like smoked glass. Even a few seconds could burn your eye.

The sunspots are mysterious things. Some years there are many, other years few. They go in eleven-year cycles, gradually decreasing, then increasing. They are thought to be huge magnetic storms—like pure electricity suddenly gone crazy—whirling across the sun like cyclones.

When there is a lot of sunspot activity, we know it on earth without even looking. Radios don't work as well, and the short-wave commercial radio stations may have hours when no radio signal gets through. The Aurora Borealis, the wonderful northern lights, which are electrical in nature, seem to gain strength with the increase in sunspots.

Experts do not agree on just how sunspots affect the earth, but they do agree that there is some effect. In years to come we probably will know a great deal more than we do now.

Just as an extra piece of information, most of the sunspots could swallow the entire earth quite easily. The biggest ones could swallow hundreds of earths.

We can't be sure that other stars have sunspots, but on the other hand, we have no reason for thinking that our sun is the only one which has them. For all we know, sunspots may be a part of every star.

So far, in talking about individual stars, we have used what are known as their familiar names. For instance, Betelgeuse, Deneb, Vega, Regulus, Polaris, Antares, and Sirius might be called the nicknames of these stars. In addition to these nicknames, every star has a family name and a first name.

The family name is that of the constellation in which the star is located. Betelgeuse is in the constellation Orion, so Orion is its family name. Star first names are Greek letters, or numbers. Most of the stars we can see have Greek letters for first names. Betelgeuse's first name is Alpha, the first letter in the Greek alphabet.

In using the name of the constellation, the possessive form is used. For example, if the constellation was called "Brown," the form would be "Brown's." So the

correct name for Betelgeuse is Alpha Orionis. This is the same as saying "Orion's A." It is also correct to say Alpha in Orion.

Professional and amateur astronomers use the preferred form, which is Alpha Orionis. Actually, many of them use abbreviations, especially for the longer constellation names. For instance, Beta Persei is preferred, but some astronomers may shorten it to Beta Pers. Or they may shorten Delta Hercules to Delta Herc.

In the following pages, both the constellation names and the familiar names of the stars are given. If you decide that astronomy is a hobby you want to follow, you will need to know the constellation names as they are given. But the familiar names are interesting, and surely a name like Algol is more pleasing than Beta Persei.

The familiar names of stars go far back in history. Many of them, including Betelgeuse (Alpha Orionis), were named by the Arabs. Betelgeuse is in Orion's armpit, and the original name in Arabic meant "The armpit of the one in the center."

Some stars were named for people, both real ones and people who lived only in myths. Castor (Alpha Geminorum) and Pollux (Beta Geminorum), for instance, were the twin sons of Jupiter in Greek mythology. They were half-brothers of Helen of Troy. One star was named for a real king. It is Cor Caroli (Alpha Canum Venaticorum), which means "The heart of

Charles.” The king was Charles II, one of the Stuart Kings of England.

Learning the stars is fun, and as you learn their names and what they mean, you are also learning something about history and mythology. It is one of the most interesting ways of learning about the ancient legends.

*The Demons of Space*

IN THE days when the naming of stars began, there was no real science, and people believed in ghosts, demons, ghouls, and a thousand other unpleasant things. If something happened which couldn't be explained, it was easy to blame it on a demon. When a comet passed by, or a shooting star flashed across the heavens, that, of course, was the work of sky devils. An eclipse of the sun was a sky demon trying to eat up the sun.

Men did accept, though, that the stars stayed in their places night after night—except for the planets. The fixed stars were dependable.

Then someone noticed one star that didn't behave. It wasn't one of the planets. This star stayed in the same place, but it winked. The wink wasn't very fast. It took about three days. During this time the star would grow faint, then brighten again. Nowadays we say that its brightness drops from second magnitude to third magnitude, then rises to second magnitude again.

The only explanation people in ancient times could think of was that a demon was winking, high in the sky. So the star was named "The Demon." The Arab word for demon, *Al Ghul*, gradually became Algol. And that is what the star is called today. Its other name is Beta Persei. It is the second brightest star in the constellation Perseus, and Beta is the second letter in the Greek alphabet.

Sometime later, another winking star was found. This one, though, didn't act like Algol. In the first place, it wasn't as bright. But more interesting, its light faded out altogether, so that the star vanished. Then, much later, it would come back again, very faint at first, then gradually become brighter until it was its old self. All this took about eleven months.

Anything that happens so slowly isn't very frightening, so instead of blaming the star's actions on a demon, the star was named Mira, which means "The Wonderful." Mira is Omicron Ceti.

Today we know Mira's light doesn't go out. It varies from a point between third and fourth magnitude down to the ninth magnitude, when it can be seen in a telescope but not with the unaided eye.

You can watch Algol and Mira today, just as the ancient people did. Later chapters will tell you how to find them.

Some time after the discovery of Algol and Mira, another star was found that faded and brightened in the

same way. It has no familiar name. It is Delta Cephei, the fourth brightest star in the constellation of Cepheus.

We know today what makes some stars change in brightness, although we still have a lot to learn.

Changing stars—and there are a great many of them—are called variables. Algol, Mira, and Delta Cephei represent the three main types.

To explain Algol, we must talk for a while about double stars. Many stars you see aren't single stars at all. Sirius, remember, has a dwarf white star for a companion. Other stars you will want to find in the skies and which have companions are Polaris (Alpha Ursae Minoris), Aldebaran (Alpha Tauri), Antares (Alpha Scorpii), Regulus (Alpha Leonis), and Cor Caroli (Alpha Canum Venaticorum). There are many others.

Alpha Centauri, our nearest star neighbor, is really a star system. Alpha has a companion, and the two whirl around each other. But that isn't all. There is a third star which travels in an orbit around Alpha and its companion. This star takes many thousands of years to make the trip around the inner two. At the moment, it is in the part of its orbit nearer to the earth. So it is really closer to us than Alpha Centauri itself. It is the star nearest the earth. Proxima Centauri is its name, because *proxima* means nearest. Proxima cannot be seen without a very powerful telescope. We can't see Alpha itself, except from the very southernmost part of the

United States. It is one of the brightest stars in the Southern Hemisphere.

Such three-star systems are quite common. Systems with more than three stars can also be found pretty regularly.

The easiest double star to see is Mizar (Zeta Ursae Majoris) in the handle of the Big Dipper. If you have pretty good eyes and the night is clear, you can see Mizar's naked-eye companion, named Alcor. Mizar has another companion, too, but it cannot be seen with the unaided eye.

Castor and Pollux are the twins in the constellation Gemini. Pollux is the brighter, but Castor is the more interesting. Castor is really six stars!

One astronomer has estimated that one out of every four stars is a double. So you can see they are really very common. Many can be seen in small telescopes, and some are very beautiful. Beta Cygni, which has the familiar name of Albireo, is a glorious blue and golden double. It is easily found in the summer skies and doesn't take a very powerful glass to resolve into two stars. Antares, the red star in the constellation of the scorpion, has a lovely green companion. Some of the double stars are red, orange, blue, garnet, violet, gold, or different shades of green. If you find that astronomy is really the hobby you want to follow, you will probably make a telescope or perhaps buy one. Then you will be able to see the double stars for yourself.



But to get back to Algol.

Algol is a double star. Imagine two balls on opposite ends of a stick, with the stick held in the middle and twirled, and you will understand how Algol and its companion travel around each other.

The companion star is darker than Algol.

The plane in which the two stars revolve is edgewise, as seen from the earth.

Can you see what happens?

Once during each two days, twenty hours, and forty-nine minutes, the dark companion passes in front of Algol.

“Dark” perhaps isn’t the word, because Algol’s companion is really pretty bright, although not so bright as Algol.

When the two stars are side by side, we see their combined light. Then Algol has a magnitude of 2.1. But when the dark companion crosses in front of Algol, the light of the brighter star is cut down and the magnitude drops to 3.2.

Stars that revolve around each other are called “binaries.” The word comes from the Latin and means two by two. Algol is an “eclipsing binary” because it is eclipsed by its companion.

Eclipsing binaries are one kind of variable star.

Mira, the Wonderful, is a different kind. Mira is a red giant star, like Betelgeuse, Antares and Aldebaran. You already know the distances in the solar sys-

tem, so imagine our sun growing until it reached to the orbit of Mars. That's how big Mira is.

Mira, while much greater than our sun, is much less dense. White dwarf stars, much smaller than our sun, are very much more dense. Dense just means how tightly packed together they are.

Something happens inside of Mira. Astronomers don't know exactly what it is, but they know Mira grows smaller, then expands again. As it swells and shrinks, it grows brighter and dimmer.

Mira is what is known as a "long-period variable." It takes 330 days to fade from 3.5 magnitude to 9 and brighten up again. And whereas Algol is very regular, Mira is undependable. From full brightness to greatest dimness and back again is known as the star's "period." Mira's period may vary as much as a month.

Almost all the long-period variables are red giant stars. Betelgeuse is a red giant, and it varies. But it does not change by very much—only eight tenths of a magnitude. What's more, it is very irregular and no one knows when it is apt to change.

Betelgeuse, Mira, and other red giant stars are actually "thinner" (more tenuous) than air. One scientist says they are just red-hot vacuums.

Delta Cephei is the third type of variable star. This one star has given its name to all other stars of its kind. They are known as "cepheid variables." They are like Mira in one way. That is, their changing brightness is

because of something that happens inside the star. They have periods ranging from a day to about fifty days.

Cepheid variables are yellow stars, and they are supergiants, greater even than the red giants. They are also among the brightest things in space.

Of the three kinds, cepheids are the most important, because they can tell us the distance from the earth to the star systems to which they belong.

The way to use cepheids as measuring sticks was discovered by an American woman astronomer, Miss Henrietta Leavitt. She worked out a system showing that the period of a cepheid has a connection with its absolute magnitude.

It is now possible for astronomers to observe a cepheid's apparent magnitude and use a mathematical formula to figure out how bright it really is and its distance from us.

Of course the arithmetic is far from easy, and there is no need in bothering about it. The main thing is that cepheid variables are the best yardsticks in outer space. When you read that a galaxy is 300 million light-years away, you can be sure its distance was found by using cepheid variables.

Delta Cephei is a star you can see. How to find it is told in later chapters. Other cepheid variables which you can see are listed on page 179.

Besides the variables, there was one other important

kind of star the ancient people noticed. When they saw one, they said a new star had been born. These stars are “novae.” The word *nova*, which means one such star, comes from the Latin for new. These new stars, also called temporary stars, suddenly blaze into being, shine brightly for a while, then grow dim again.

Nowadays we know they are not really new stars. They are faraway, dim stars that explode. Astronomers think that the whole star does not explode, but that its outer layers burst forth with a tremendous blast. The inner core of the star remains about the same. After the explosion is over, which takes a long while, the star is still there, but is its old dim self once more.

Some astronomers think that all stars during their lives become novae. It’s sort of a cosmic growing-up process which could happen to our own sun. No one can tell in advance when a nova will appear. When one does, it is named for the constellation in which it is found, like Nova Persei, Nova Aquilae, or Nova Orionis.

As you can see, the constellations really are the regions from which everything is named, so if you want to actually locate the stars in the sky, learning the constellations is the proper starting point.

## CHAPTER XVI

### *Star-Hunting*

THERE are eighty-eight constellations in the whole sky. Within them, a total of perhaps 9000 stars can be seen with the unaided eye from all over the earth. But within the reach of astronomers' telescopes are billions of stars.

Some of the constellations can't be seen at all from the United States. Some can be seen, but not very well, because they are right on the borderline of visibility.

Finding the constellations is exciting—and it also may be pretty difficult. So, to start with, don't try to learn too many at once. Stick to the important ones. They are on the star maps in the following chapters. Later, you can learn the fainter ones. Meantime, here are a few of the constellations besides the Great Bear and Little Bear that you will be able to find easily:

<i>Auriga</i>	The Charioteer
<i>Canis Major</i>	The Big Dog (The Greater Dog)
<i>Cassiopeia</i>	Cassiopeia (Queen of Ethiopia)

<i>Leo</i>	The Lion
<i>Lyra</i>	The Lyre (musical instrument)
<i>Orion</i>	The Hunter
<i>Taurus</i>	The Bull
<i>Pegasus</i>	The Winged Horse

A good place to start star-hunting at any time of the year is in the northern sky. You can do this at the same time that you start watching constellations rise above the eastern horizon.

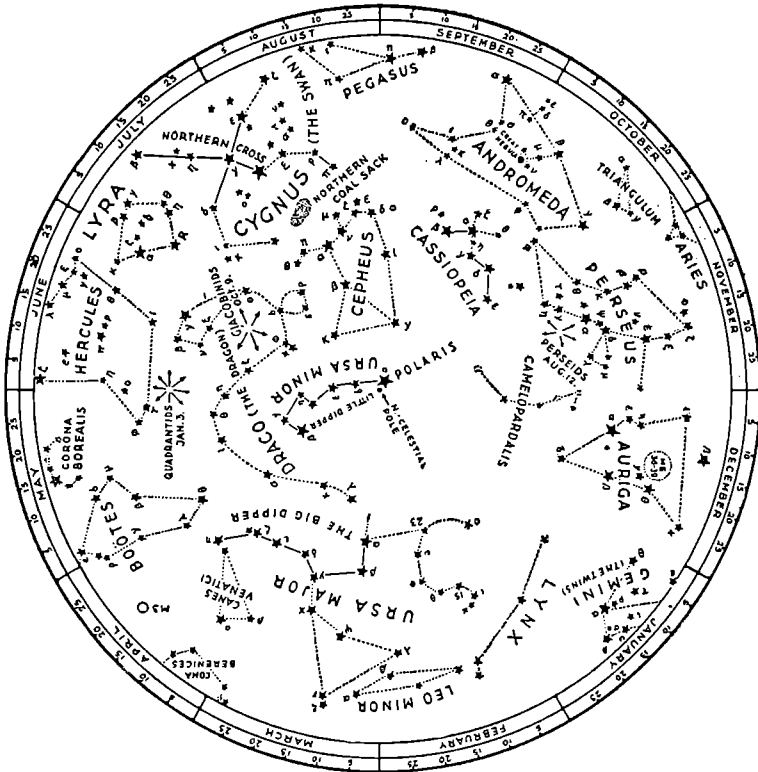
You will find that the “eastern horizon” really covers the north and a part of the south, and it extends upward about as high as you can look without leaning backward.

No matter where you are in the United States, there are some stars which may be seen night after night. They are the stars nearest Polaris, the North Star.

To find those stars, you must first find Polaris. As a reminder, refer to the picture on page 16 to find out how to do this. When you have located Polaris, notice how far it is above your horizon. Any stars no farther from Polaris than the distance from Polaris to the horizon are known as “circumpolar” stars. For you, they never set. They go around Polaris in a counterclockwise circle.

Stars that are not circumpolar seem to rise in the east and set in the west.

The constellations that are circumpolar for the mid-



*Map of the North Circumpolar Constellations.*

dle of the United States and its northern half are Ursa Major, Ursa Minor, Draco, Cassiopeia, Lynx, Cepheus, Camelopardalis, and part of Perseus.

Within the Great Bear (Ursa Major) and the Little Bear (Ursa Minor) are the Big Dipper and the Little Dipper. These are among the oldest known constellations. The Greeks steered their ships by them. The American Indians told stories about them.

The Little Bear hasn't much of interest in it except for the North Star, Polaris, at the tip of its tail. But the Big Bear, or Great Bear, has more to see.

First of all, there is Mizar, the star at the bend of the handle. If your eyes are good, and it's a clear, dark night, you probably will be able to see Alcor, Mizar's naked-eye companion.

Second, close to the Dipper is Cor Caroli, the brightest star in the constellation Canes Venatici, the Hunting Dogs.

To get back to the Big Dipper: remember it is only a part of the Great Bear. To find the Bear's head, look at the circlet of stars beyond the pointers. But don't confuse them with either the Sickle or the Northern Crown. In January, the Sickle, part of Leo the Lion, rises above the horizon. Look for the Northern Crown on the chart for the northern skies.

Between the Big and Little Dippers stretches the tail of Draco, the Dragon. Almost on a line between Kochab (Beta Ursae Minoris), in the Little Dipper, and Mizar,



in the Big Dipper, is Thuban (Alpha Draconis), which was the North Star in the days of ancient Egypt. Thuban is in the Dragon's tail. The Dragon winds out toward Hercules, who is standing on the Dragon's head.

High in the north, during fall and winter, one of the easiest constellations to find is Cassiopeia, Queen of Ethiopia. At this time of year, the constellation looks like a big *W* to those looking from the south. Caph (Beta Cassiopeiae) and Ruchbah (Delta Cassiopeiae) are two of the brightest stars in the *W*, but Schedir (Alpha Cassiopeiae) and Gamma Cassiopeiae are the most interesting. They are variables.

Between Draco, the Dragon, and Cassiopeia is Cepheus, King of Ethiopia. Delta, if you remember, is the best known cepheid variable. It is the bright star in Cepheus nearest Beta Cassiopeiae.

On the other side of Cassiopeia, between the queen and the head of the Great Bear, is the faint constellation Camelopardalis, the Giraffe. The name comes from the old name camelopard, dating back to the days when the name was given the giraffe because it was thought to resemble both a camel and a leopard. This constellation is a good test of your eyes, because it is made up of faint stars.

One more constellation should be mentioned in describing stars of the north. Draw a line between Alkaid (Eta Ursae Majoris), the tip of the Great Bear's Tail,

and Cor Caroli. Extend this line onward and you reach one side of the faint constellation Coma Berenices. It is made up of faint stars, and nearby is one other important thing: Messier 3.

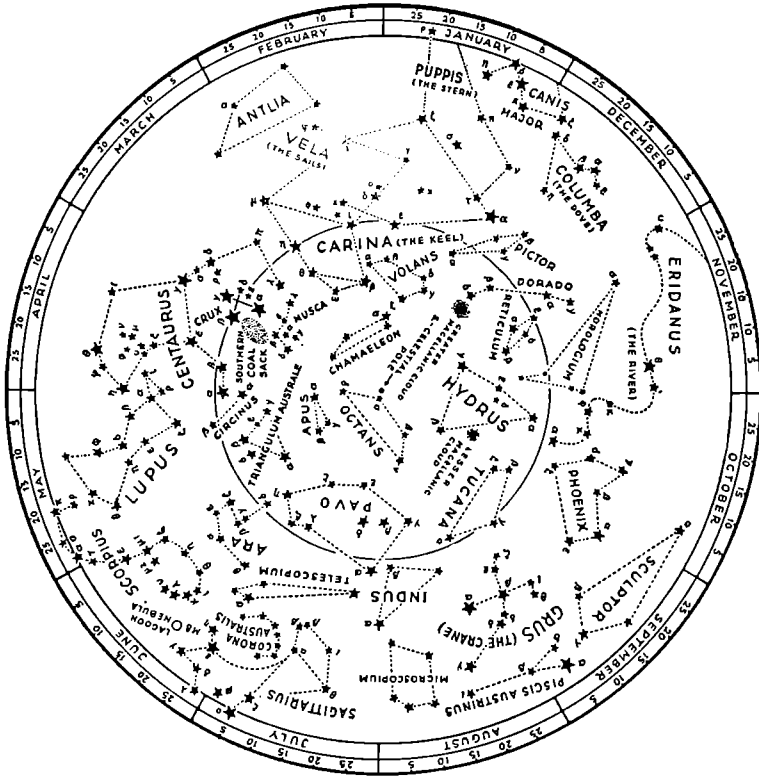
We have not mentioned Messier objects until now. There are over 100 of them, and none of them are stars. Only a very few can be seen without a telescope. Messier, the astronomer who listed them, gave them the numbers by which they are known.

Messier 3 is a globular cluster of stars. It belongs to Canes Venatici, but it is close to Coma Berenices. An even better way to find Messier 3 is to guess at three fifths of the distance from Cor Caroli to Arcturus (Alpha Boötis). You may have to try for several nights before locating it. When you do, it will be very dim. But try. There are stars aplenty, but only a few visible Messier objects. They are worth the trouble.

Just as there are stars near the north celestial pole that never set, there are also stars around the south celestial pole that never set for people in those latitudes.

But people below the equator do not have one thing that the northern sky offers—a bright pole star like Polaris. Polaris is not actually at the celestial north pole, but it is less than a degree away—close enough so that it doesn't make much difference except for navigation or other special purposes.

The celestial south pole is in a rather empty part of



*Map of the South Circumpolar Constellations.*

the sky. No bright star marks it. There is a faint star of 5.5 magnitude named Sigma Octantis that may be found by using the famous constellation of the Southern Cross as a guide.

In the very southernmost part of the United States, people can see the Southern Cross at the right time of year—from midnight early in April to early evening in June. There, people also can see all of the constellation Centaurus, including Alpha Centauri, our nearest star neighbor, which is low on the horizon as far north as the tip of Florida.

The crossarm of the Southern Cross is a pointer which shows the way to Alpha Centauri. The long arm of the Cross points toward the general position of the south celestial pole. The pole is in the constellation Octans, the Octant. You have to know where to look to find Sigma Octantis, the south pole star.

Alpha Centauri, you remember, is in the constellation of the Centaur. The constellation is named for the famous half-man, half-horse, Chiron, who was the wisest of the centaurs of mythology. Besides Alpha, there is another famous object in this constellation. It is known as the finest of the globular star clusters. It can be seen with the unaided eye and is called Omega Centauri.

But perhaps the most interesting things in the southern sky are the Magellanic Clouds. These were named after the great sea captain and explorer, Ferdinand

Magellan, who was the first European to see them. They can be mistaken for real clouds, although they are distant clouds of stars. Each is a universe—an island universe. Some astronomers believe they may be connected with our own, like patches in the outer ends of one of the spirals. They do look like pieces of the Milky Way which have broken off. The large cloud, which is a dozen times the size of the full moon, is about 75,000 light-years away. The smaller, which is about half the size of the larger one, is about 84,000 light-years away.

There is also something which sometimes is known as the Black Magellanic Cloud. It is a dark nebula—a tremendous patch of gas and dust that shuts off the light of the stars beyond. It is most often called the Coalsack Nebula, and when first discovered, it was thought to be a hole through the stars into outer space. It is just east of the brightest star in the Southern Cross.

The southern skies are rich in stars. And between the tip of Scorpius's tail and Sagittarius lies the center of our galaxy—the heart of the Milky Way. If you ever have a chance to travel far south of the equator, take note of the many sky objects to be found. But you can be sure that our own familiar skies will look mighty fine when you return home.

*Stars from January to June*

**T**O GUIDE you in your stargazing, this chapter and the next one follow the stars as they appear in the sky month by month. Naturally, we start with January, as any calendar does. But you can start stargazing very profitably in any month of the year.

When you begin, first get acquainted with the stars around the north celestial pole. Learn them well, and the rest will not be hard. But remember always that too big a bite is hard to chew. Take them a constellation at a time. Get to know one constellation and its principal stars before you go on to the next one.

The stars and constellations are described in the following pages as seen in the early evening.

*January*

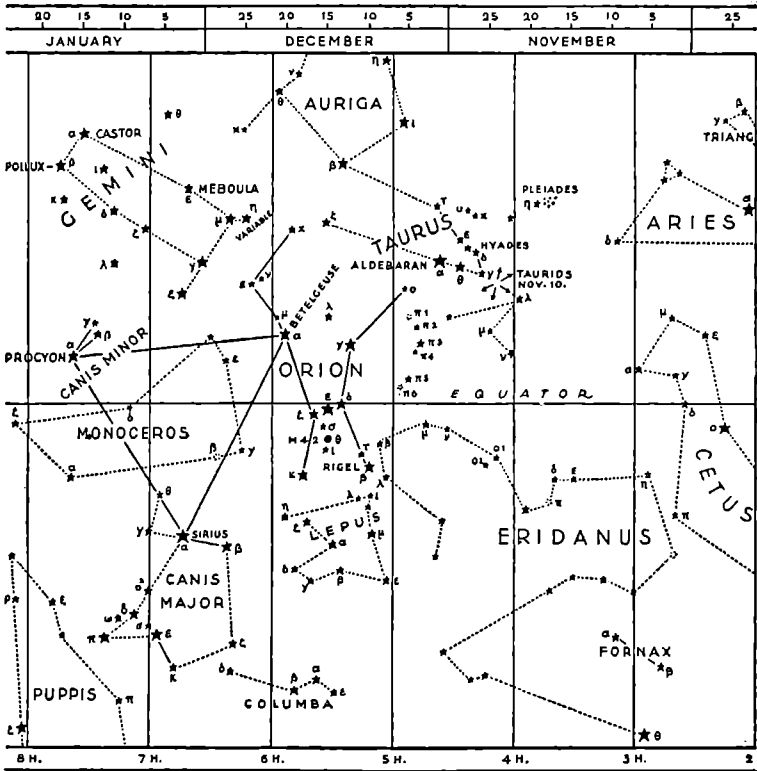
This is a fine month to start stargazing, because we can see the constellation Orion and the other constellations around it.

In Greek mythology, Orion was a mighty hunter, and the son of Neptune. He was a favorite of Diana, the Huntress, but he had the misfortune to make Diana's brother, Apollo, his enemy. Apollo arranged his death, and the sorrowful Diana put Orion in the sky where he is still a giant among constellations. He has a sword belt, a sword, and a club. He holds a lion's skin. Sirius, his dog, follows him, while the Pleiades, who were nymphs in Diana's court, flee before him.

It is best to look for Orion on a night when the stars are not too bright. Then the faint stars can't be seen, but the brightest stars can. This makes the picture clearer. It won't be hard to find Orion's belt. It is made by three stars evenly spaced in an almost perfect line. The center star, Alnilam (Epsilon Orionis), is the brightest one in the belt. Alnitak and Mintaka (Zeta and Delta Orionis) are the other two. Alnitak is the easternmost of the three belt stars.

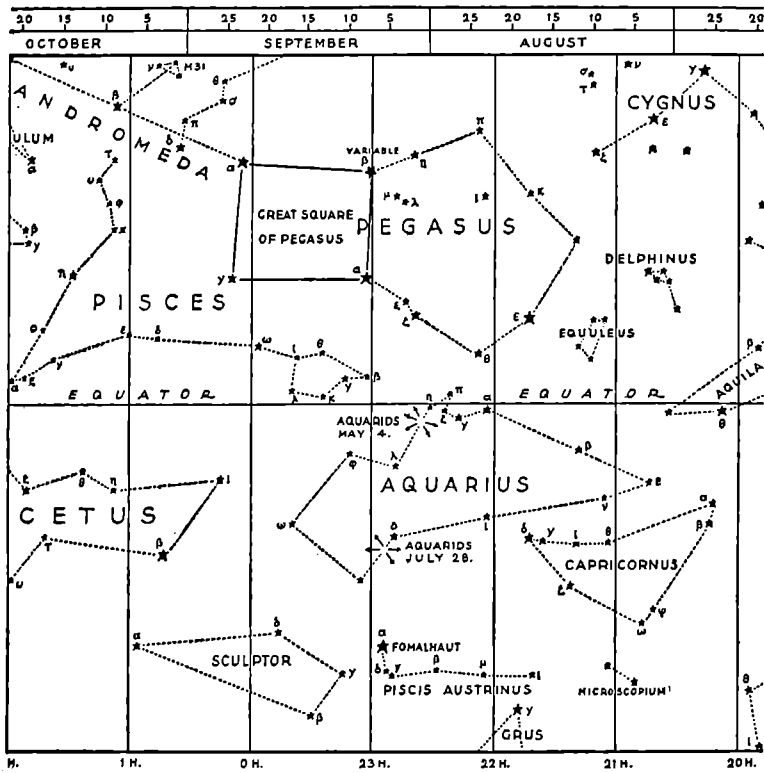
Four bright stars make a pretty good rectangle with the stars of the belt in its center, but tilted at an angle. Check the positions of the stars with the chart. Betelgeuse (Alpha Orionis) is in Orion's right shoulder, Bellatrix (Gamma Orionis) is in his left. Saiph (Kappa Orionis) is his right knee. The brilliant star Rigel (Beta Orionis) is in his left foot.

Once you have found the belt, draw a line across it at right angles—an imaginary line, of course. The red



*Sky Charts.*





Sky Charts.

star toward the east is Betelgeuse. On the other side of the belt is Rigel. The rest are easy to find.

The lion's skin Orion holds is pretty faint and it takes a good night and sharp eyes to see it.

Dangling from Orion's belt is his sword. In the sword is the Great Nebula in Orion—a vast cloud of luminous gas spreading across millions of miles of space. It looks like a small patch of mist. The Great Nebula is Messier 42.

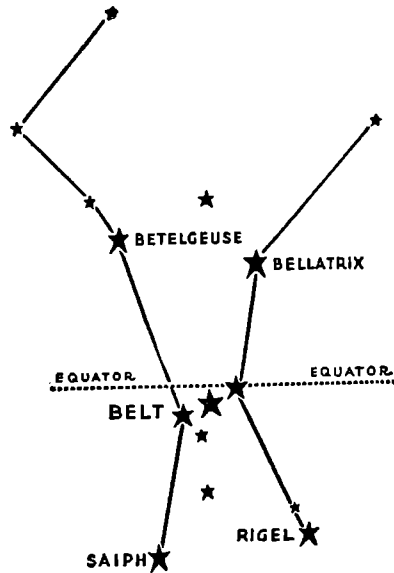
Once you have located Orion, the January sky has a lot to offer. Draw a line downward (eastward) through Orion's belt and you will easily find Sirius (Alpha Canis Majoris), brightest star in the heavens. Sirius, the Dog Star, is in the constellation of Canis Major, the Big Dog.

Starting with Sirius and going around to your left in a tremendous circle, there is an ear in the sky. Orion forms the ear lobe.

Learn the brilliant stars that form this imaginary "ear," and you can easily learn their constellations. Here's the list, starting with Sirius and going upward to the left around the ear.

"Upward" and "left" do not mean very much in the skies, usually. But this description is for early evening at the start of the year when Orion is above the eastern horizon, and Sirius has just risen. At any other time, change left to north, upward to west, and right to south.

From Sirius go to Procyon (Alpha Canis Minoris),



*Orion is one of the brightest constellations in the sky.  
The celestial equator runs right through his belt.*

in the constellation of the Little Dog, Canis Minor. Between Sirius and Procyon is the faint constellation Monoceros, the Unicorn. This constellation is important for one thing: Messier 50, a star cluster.

Continuing upward and to the left, you reach Pollux (Beta Geminorum), then Castor (Alpha Geminorum). These are the Twins of the zodiac. The constellation name is Gemini. These twins were brothers of Helen of Troy, and mighty warriors. They were the gods of the Roman horse soldiers, and the Roman warriors swore by them. When they made an oath they said "By Gemini!" which meant "By the Twins!" And even today we hear the phrase, "By Jiminy!" It means exactly the same thing. Say it and you are swearing by the Twins.

Upward once more to the brightest star you see, a fine, brilliant yellow one. It is Capella (Alpha Aurigae), the Little Goat. Capella is held in the arms of Auriga, the Charioteer.

Off to the right you will find the Seven Sisters of the Pleiades. Don't try to find all seven if the night isn't very clear. There are only six fairly bright ones. The seventh bright one had to leave the sky, legend says, because she couldn't bear to watch the burning of Troy. Her name was Electra. The other sisters watched and grew pale with horror as their city burned. They've been pale ever since. Alcyone (Eta Tauri) is the brightest one.

The Pleiades are a cluster of stars which travel as a group through space. Although only six fairly bright and six more faint ones can be seen clearly on most good nights, a telescope shows a great many more.

The Pleiades are the top of our sky "ear." They are in the shoulder of Taurus, the Bull. Draw a line from them back to Sirius and you pass through Orion. But before you reach Orion, you pass a red star. It is Aldebaran (Alpha Tauri), which is the right eye of the Bull, another of the zodiac signs. Notice that Aldebaran is at the start of one leg of a V. The other stars of the V, fainter than the red giant Aldebaran, are the Hyades, an open star cluster which travels together through space like the Pleiades.

Go back to Orion. Start with Rigel and see if you can trace the dim, wandering line of Eridanus, the River, which ran around the ancient world and through which the sun rowed in a boat from west to east every night.

Eridanus ends in the far south with the star Achernar (Alpha Eridani), which can't be seen from most of the United States. The River's winding course is hard to follow.

Within a bend of the River, but visible only if you're pretty far south, is Fornax, the Furnace.

Below Orion's feet, being chased by Sirius, is another faint constellation, Lepus, the Rabbit or Hare. Brightest star in Lepus is Arneb (Alpha Leporis).

In the north January sky, the Big Bear's head can be found easily. It is like a circlet of stars. Between it and Gemini, the Twins, look for the constellation Lynx.

Once you have learned the part of the January sky on the eastern half of the heavens, you have made a fine start. There is just one more thing. Through Orion's belt runs the celestial equator. If you have a chance to follow Orion across the sky, use it to trace the celestial equator.

### *February*

Following Gemini and Canis Minor above the horizon as the days pass is Cancer, the Crab. Find Pollux and Procyon and use them as two corners of a triangle. Cancer, one of the zodiac signs, is at the third point of the triangle. It is a faint constellation, and not very interesting except for Praesepe, the Beehive, a star cluster which is Messier 44. The Beehive, composed of many hundreds of stars, is a faint patch in the Crab's back.

Between Cancer and the celestial equator is the head of Hydra, the Water Snake or Water Serpent. Early in February, Alphard (Alpha Hydrae), Hydra's brightest star, will rise above the horizon. But Hydra's tail won't be visible until the middle of April. Alphard will rise south of the celestial equator, but you may be able to see it.

Right behind Alphard, about the middle of the month, will come the faint constellation Sextans, the ship's sextant, which is right on the equator.

But at the same time, and more interesting, is the arrival of one of the bright stars, Regulus (Alpha Leonis). Regulus is in the handle of the Sickle, which you can see quite clearly on a fairly clear night. The Sickle is part of Leo, the Lion. North of Leo, look for the Lion Cub, Leo Minor, a broad triangle of three stars. The Cub is a faint constellation.

There are no less than four Messier objects in Leo, the Lion; numbers 65, 66, 95, and 96. They are all spiral galaxies, but none is visible to the unaided eye.

### *March*

As March winds clear the sky, Leo the Lion continues to rise. Denebola (Beta Leonis), the bright star at the tip of the Lion's tail, comes into view. South of Denebola, across the celestial equator, look for Crater, the Cup. It is a dim constellation.

Right after Denebola rises Beta Virginis, in the western end of the constellation Virgo, the Vestal Virgin. And nearby, on the celestial equator, is something you won't be able to see—the autumnal equinox. When the sun crosses that spot in September, fall begins in the Northern Hemisphere, and spring in the Southern

Hemisphere. Virgo lies across the equator. No less than eleven Messier objects, all galaxies, are in Virgo, but none can be seen without a telescope.

March is a good time to get reacquainted with Cor Caroli in Canes Venatici, and to hunt for Messier 3, a globular cluster.

### *April*

Early in April watch just south of the celestial equator for the brilliant star Spica (Alpha Virginis) to rise above the horizon. Then, after the middle of the month, watch north of the equator for bright Arcturus (Alpha Boötis). Denebola, tip of the Lion's tail, forms a huge triangle with Arcturus and Spica. On the line between Denebola and Arcturus, about halfway, you will find the southern edge of Coma Berenices, named for the hair of a queen of Egypt.

Arcturus is in the constellation Boötes. Spica is part of the constellation Virgo, which is still rising.

Watch for Corvus, the constellation of the Crow, which follows the cup constellation, Crater. Corvus is south of the equator.

Far to the south in the middle of April rises Centaurus, the half-man, half-horse centaur. You may be able to see the bright star Theta Centauri. You won't be able to see all of the constellation unless you are



very far south. Then, watch for our nearest neighbor, Alpha Centauri.

By the end of April, all of the constellation Boötes will be visible by nine o'clock. The arrival of the star Alpha in Libra, the Scales, south of the equator, will announce the coming of May.

### *May*

Look in the northern sky for Corona Borealis, the Northern Crown. Its brightest star is Alphecca (Alpha Coronae Borealis). Look for Thuban, too, in the tail of Draco, the Dragon.

Once you have found the Northern Crown, go directly south from it and find the head of Serpens, the Snake.

South of the equator will be Libra, the Scales, another of the zodiac signs. Libra is a beam balance, the kind you see in the hands of the blind goddess of justice. But the constellation doesn't look at all like scales and is rather dim. At one time, Libra was the claws of Scorpio, the scorpion which follows right after it and is another zodiac sign. About the middle of the month, watch for Dschubba (Delta Scorpii) and Beta Scorpii, brightest stars in the head of the scorpion.

South of the star Dschubba, you may be able to find Lupus, the Wolf, a faint constellation.

Keep following the line of the Scorpion and you will see the twin stars, Mu Scorpii. Mu I is a variable.

Also above the horizon before the end of the month, but far to the north, will be the constellation Hercules. Look for the Great Cluster in Hercules, a star cluster which is Messier 13.

## *June*

The month of June brings Sabik (Eta Ophiuchi) above the horizon in the early evening. Sabik is the bright star in the right leg of the constellation Ophiuchus, who holds the Serpent, Serpens, in his hands. His head and shoulders are north of the equator, his waist and legs south. His left arm and left leg rose late in May.

Right before Sabik, but north of the equator, watch for Rasalague (Alpha Ophiuchi) in the head of Ophiuchus. Rasalague follows Ras Algethi (Alpha Hercules), a nearby star which is a variable in the constellation Hercules.

Late in June, pretty far north, comes a brilliant star, Vega (Alpha Lyrae). Vega is in the constellation of Lyra, the Lyre, which is a musical instrument a little like a harp. Keep an eye on Vega. It will help locate other stars later.

Also late in June, the end of the serpent's tail, last

star in the constellation Serpens, Theta Serpentis, appears above the horizon.

South of the equator, the faint constellation Scutum, the Shield, is a few degrees above the horizon. The shield belonged to Jan Sobieski, a hero of long ago.

Farther south, Sagittarius, the Archer, one of the zodiac signs, is rising. Near the celestial equator is the milk dipper, a part of Sagittarius.

By the end of June, the constellation Lyra has fully risen. But it is not yet high enough in the sky to see its wonders—if we stick to early evening for our stargazing.

Actually, the year starts well, but by midyear it is doing rather poorly. Not until next month will real sky beauty be there to see.

But be of good cheer. It's June, and you already know more than half of the stars that can be seen from the United States!

## CHAPTER XVIII

### *Stars from July to December*

WE HAVE not mentioned the Milky Way. The reason is, if you live in a city you might not be able to see it very well, because of the glow of light that lies over every city at night. If the city glow isn't too strong, you should see it faintly. If you live away from the city, where the nights are really dark, you will recognize the Milky Way the moment you see it.

You remember we said earlier that the solar system is at one side of the Milky Way galaxy. So of course one part of the sky will have a thicker mass of stars than the others. In the same way, the part of the sky nearest to the edge of the galaxy will be thinner.

The thin edge comes in the winter. You will find it running through Cassiopeia, and between the bottom edges of our winter "ear" in the sky. Over toward Coma Berenices it is thinnest of all. That's one reason why there are so many galaxies visible near by for astronomers' telescopes. There is no Milky Way, and no vast clouds of gas to cut off their light.

In summer, when Sagittarius and Scorpius are high in the sky, you can look right toward the center of our Milky Way galaxy. It is toward the south, between the scorpion's tail and Sagittarius.

### *July*

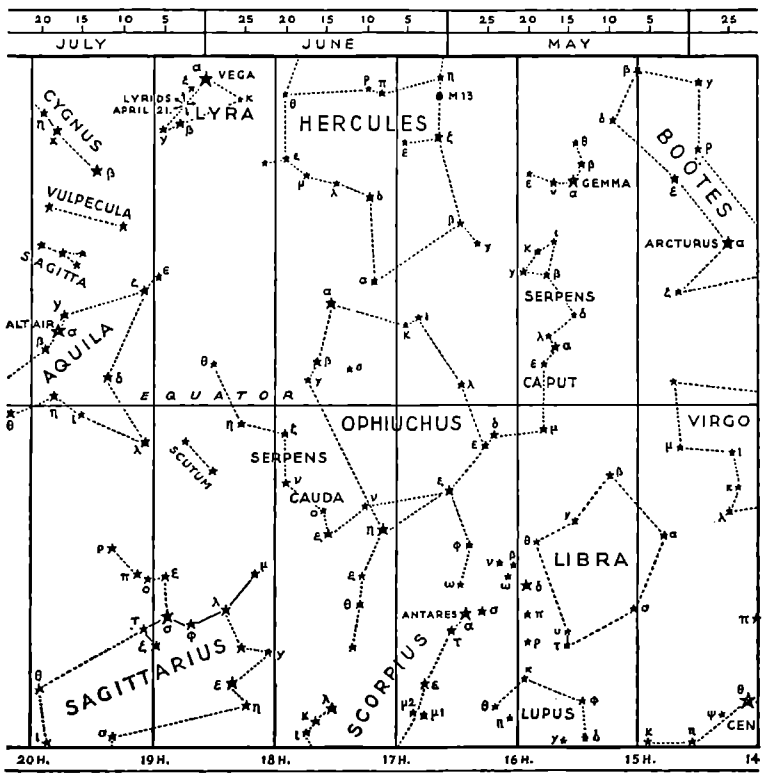
Early in July, the constellation Lyra hangs well up above the horizon. Lyra is the lyre that belonged to Orpheus, a Greek youth who charmed everyone with his music. In Lyra is Vega, fourth brightest star in the sky. It is blue white, and only about twenty-three light-years away. In a few thousand years Vega will be our North Star.

Epsilon, a star northeast of Vega, is a famous test of vision. It can be seen as a double star but is really a double-double.

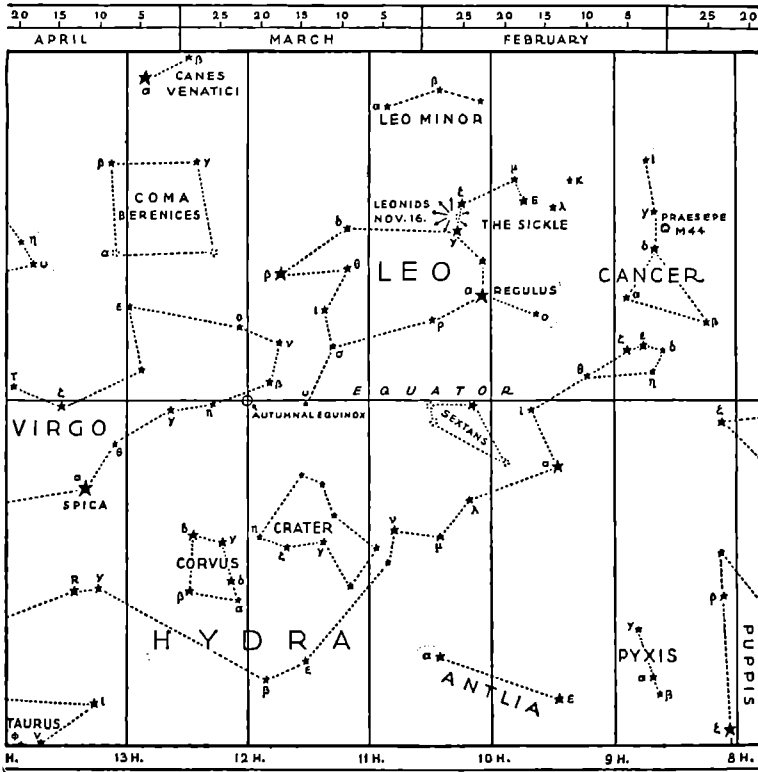
Another star, Beta Lyrae, is a variable. It has a period of about thirteen days, and it varies from 3.5 magnitude to about 4.

In the south, Scorpius may be seen, about as clearly as those in the north ever see it. Dschubba (Delta Scorpii) marks the scorpion's head. Antares (Alpha Scorpii), a red giant star, marks the upper part of his back. Antares is right under the upraised foot of Ophiuchus, who is about to step on the scorpion.

Ophiuchus is a name you probably do not know. The name most often used for him in history is Aescu-



Sky Charts.



*Sky Charts.*

lapius. Once, not so very long ago, the sign of a doctor was a staff—a straight round stick—with a single snake wound around it. Nowadays, the symbol for doctors is a staff with two snakes and with wings at its top. But this symbol isn't the right one, because it is the sign of Mercury, the messenger god. The name for it is the caduceus. The right symbol for a doctor is the staff with the single snake and no wings. It is the staff of Aesculapius, and it came from the man who is remembered by the constellation Ophiuchus.

Follow the curve of the scorpion's tail. The bright star at the very top is Shaula (Lambda Scorpii), a favorite of some navigators.

By the end of July you can see one of the great sky triangles. It starts with Vega (Alpha Lyrae). At the second angle of the triangle is Altair (Alpha Aquilae), in the constellation Aquila, the Eagle. The third angle is marked by Deneb (Alpha Cygni), in the tail of Cygnus, the Swan. The Eagle and the Swan will not be fully risen until next month.

Two little constellations also peer over the horizon as July ends. They are Vulpecula, the Little Fox, and Sagitta, the Arrow.

### *August*

By the end of the first week in August, Cygnus, the Swan, and Aquila, the Eagle, are hanging above the



horizon far enough so that the great star triangle of Vega, Altair, and Deneb can be seen easily. They are the most brilliant stars in that part of the sky. By the middle of August, Vega will be at your meridian, which arches right over your head from Polaris to the celestial equator.

Aquila, the Eagle, is said in the old legends to be Jupiter, who took the form of an eagle to fly to earth from heaven in order to steal Ganymede. He wanted Ganymede to be a servant for the gods. Today, Ganymede is remembered as one of the satellites of the planet Jupiter.

Cygnus was a friend of Phaeton, the youth who drove the sun chariot across the sky and lost control of the sun horses. As a result, great parts of the earth were scorched. Phaeton was finally knocked out of the chariot and fell into Eridanus, the River. His friend, Cygnus, dove into the river looking for him, and kept trying until the gods took pity and changed him into a swan. And there he is, hanging high in the August sky.

There are quite a few stars in Cygnus, but the main ones form a cross, called the Northern Cross. Deneb is at the top of this cross, which isn't a very straight one. South from Deneb, look for the "Rift," a black gulf in the Milky Way which is a dark nebula. At the foot of the cross is Beta Cygni, the fine double which can be resolved into two stars with

a telescope or binoculars of from ten to twenty magnification.

Between Deneb and the North Star, Polaris, you will find Cepheus, King of Ethiopia. This is a good month to check up on Delta, the variable in Cepheus, and a good time to see the Northern Coalsack, a dark nebula between Cepheus and Cygnus.

By the middle of August, Capricorn, the Sea Goat, another of the zodiac signs, has risen fully. Capricorn is south of the celestial equator, and between it and the equator, Aquarius, the Water Bearer, is rising. It won't be fully risen for early evening star-hunters until September.

At the end of the first week in August, the first stars in Pegasus, the Flying Horse, have risen. Between the constellations of Cygnus, Aquila, and Pegasus, look for two little constellations, Delphinus, the Dolphin, and Equuleus, the Foal, or Little Horse.

### *September*

Watch for the four stars that form what is called the Great Square of Pegasus, which will be fully risen shortly after the middle of the month. The star Alpheratz (Alpha Andromedae), although it is one corner of the Great Square, doesn't belong to the constellation Pegasus at all. It belongs to Andromeda.

Once the Great Square has risen fully, look south of it and find the steeple of stars which marks the end of Pisces, the Fishes, another of the zodiac signs. This steeple is known as "the circlet of Pisces." Near the circlet, on the celestial equator, is the vernal equinox. When the sun reaches this spot, spring will start once more in the Northern Hemisphere.

By early September, the constellation Aquarius is above the horizon in the early evening. Aquarius, an old man with a jar of water, is pouring a stream into the mouth of Piscis Austrinus, the Southern Fish. The Fish will be fully above the horizon about the middle of the month. You will know it when you see the star Fomalhaut (Alpha Piscis Austrini). It is the only bright star in that part of the sky, south of the celestial equator.

### *October*

Andromeda started to rise in September, and by the time October is a few days old, the Great Nebula, Messier 31, is rising. This is a spiral galaxy like our own Milky Way. As you locate it, think of this fact. You are looking at a whole star system, made up of billions of stars.

After the Great Nebula is well up in the sky, look south of the celestial equator for the bright star Deneb

Kaitos (Beta Ceti). It is in Cetus, the Whale. Trace out Cetus as it continues to rise, until finally Mira, the Wonderful, is above the horizon later in the month. Mira (Omicron Ceti), remember, is a long-period variable.

By the time you see Mira, the Fishes, Pisces, are high in the sky. You can trace its outline as it wanders over a good part of the sky. Near Pisces, newly risen, find Hamal (Alpha Arietes). This star is in Aries, the Ram, another of the zodiac signs.

As October ends, you will be able to find Triangulum, the faint triangle in the northern sky.

High above the north pole find Perseus. Perseus was another son of Jupiter. He was the hero who killed the dreadful Medusa, the monster with snakes for hair. In Perseus you can easily find Algol (Beta Persei), the Demon Star, which, you may remember, is an eclipsing binary.

## *November*

In November, Aries, the Ram, and Cetus, the Whale, are well up in the sky for early evening watchers. In the North, Cassiopeia is right side up and looks like a *W* once more, to those who look from the south.

But we have almost come full circle, because toward

the end of the month you easily can find the Pleiades, which are in the shoulder of Taurus, the Bull.

### *December*

Now the top of our "ear" is rising once more, and old friends reappear. You will easily remember Aldebaran, and the Hyades which form the face of Taurus, the Bull. You can find El Nath (Beta Tauri) and Zeta Tauri, which mark the tips of the Bull's horns.

Capella, the Goat Star in Auriga, the Charioteer, will be an old friend. Perhaps you can even trace the great curves in Eridanus, the River.

Gemini and Orion will be familiar, too. You will know not only the Twins, Castor and Pollux, but Zeta Geminorum in the hem of Pollux's robe, which is a variable with a period of a little more than ten days. You will know Eta Geminorum, too, in Castor's left foot. This variable has a period of 231 days! Bright Alhena (Gamma Geminorum), in Castor's right foot, will be remembered easily. So will Wasat (Delta Geminorum) in Pollux's belt.

By the time the year begins once more, you will know the major constellations and a great many stars. You will know them so well it will be easy to tell the planets when you see them, because the planets will not be a part of the constellations.

Each new stargazer will need to study the maps. But don't depend on them entirely. As you know, they can mislead you, because star maps are small and printed on flat paper, while the sky is vast and shaped like a bowl.

Patience and real interest are what you need. Once you've learned even a few stars, you will be very glad you took the trouble.

## CHAPTER XIX

### *Deeper into the Stars*

SOME people are contented with knowing only the names of the stars and a few important things about them. But others find a lifelong hobby in stargazing. Those who do become advanced amateurs and many of them do very important work that helps us in our effort to understand more about the universe.

If you follow the steps given in this book and learn the constellations and the principal stars, you have made a good beginning toward the hobby of astronomy. But it is only a beginning, and there is a great deal left to do.

One simple thing, which you can do as you watch the night skies, is to take star pictures.

An expensive camera is not needed. A simple box camera will do, so long as it has some device for leaving the shutter open. Some inexpensive cameras have such a device and others do not. Those that do usually have a *T* somewhere near the shutter control. The *T* stands for "time."

To take a star picture, fix the camera firmly on a steady support. A wooden box might do. A camera tripod would be ideal, but isn't really necessary. Take the box and camera out into a field, away from the lights of houses. Of course you must pick a good, clear night.

Set the camera on the box pointing at Polaris. You can keep the camera in place by propping it up with blocks of wood. If the stars can't be seen in the view finder, which is often the case, sight along the top and side of the camera until it is pointed correctly. Try to have Polaris right in the center of the picture.

If the camera has a lens opening that can be changed to various settings, open it as wide as possible. Put the shutter mechanism on *T*, and then push the lever or button that opens the shutter. Don't disturb the camera once the shutter is open. Leave it for a half hour the first time. Next time, leave it for a full hour. When time is up, close the shutter. Your camera instruction book will tell you how to do this, and also whether your camera has a time device.

When the film is printed, you will find white streaks on a black background. The streaks are the paths of the stars during the time the camera was open. They will form a circular pattern, with Polaris near the center.

That picture will prove to you that Polaris really is near the north celestial pole, but not exactly on it. You



can see that because Polaris itself makes a tiny streak.

Another star picture you can take is of the celestial equator. Look at the star map for the right month, find a star that is on, or near, the celestial equator, and use that for your aiming point.

A way to find the celestial equator is this: Get a carpenter's try square. Many families have one, and if yours doesn't, perhaps you can borrow one. A try square is usually made of metal, and is shaped like the letter *L*. Place the sharp point of the *L* on your camera rest, and sight along one leg of the *L* at Polaris. When Polaris is exactly along the line of sight, try to fix the tool in place. Then sight along the other leg. The point in the sky along the line of sight will be pretty close to the celestial equator. This is because the equator is 90 degrees from the pole, and one leg of the try square is 90 degrees from the other.

Take a picture just as you did of the northern skies. When the picture is developed, see how the stars travel in straight lines instead of circles.

The moon is a good camera subject, too. Pick a night when the moon sets early. Prop up your camera as before, but with the moon at the very top of your view finder and the horizon at the bottom. Of course you will have to take the picture starting with the time when the moon is in the right position. Leave the shutter open until the moon has set. If the lens aperture is adjustable, close it a little for moon pictures. When the film

is developed, you will see the moon's track get dimmer as it slides down toward the horizon. The reason is that the closer to the horizon, the more atmosphere between you and the moon, the less light gets through.

You can make the same picture in reverse by starting just when the moon starts to rise and stopping when it is out of camera range.

If your sky pictures don't come out on the first try, use the trial-and-error way until you find the right way for your camera. No exact rules can be given, because each kind of camera is different.

Of course the more sensitive the film, the fainter the stars you can record. So get the "fastest" film you can use in your particular camera. Your photo store will tell you which film it is.

Such pictures are fun, but they will only prove what you already know from reading. So to increase your knowledge, you must look elsewhere.

There is a special kind of star museum, called a planetarium. The Hayden Planetarium in New York may be the most widely known, but there are fine ones in other cities. The Adler, in Chicago; the Buhl, in Pittsburgh; the Fels, in Philadelphia; the Griffith, in Los Angeles; and the Morehead at the University of North Carolina all have wonderful Zeiss projectors similar to the one in the Hayden Planetarium. Baltimore, Boston, Buffalo, Kansas City, Portland (Oregon), Springfield (Massachusetts), and Stamford

(Connecticut) also have fine planetaria. What's more, some schools are now owners of planetarium projectors.

The inside of a planetarium is like an inverted bowl—the bowl of the sky. Underneath the bowl is the complicated Zeiss projector which is shaped like a dumbbell. The projector is cleverly made to put an exact duplicate of the stars on the planetarium ceiling. The stars are correct according to brightness and constellations, and they are so much like real ones that you soon forget you are indoors.

The projector is mounted in a very intricate way so that motors can turn it to imitate all the complex motions of the stars.

If you want to see within a few minutes how the “wobbling” of the earth makes the north celestial pole shift over thousands of years from Polaris to Thuban to Vega, the projector can show you. If you want to see how the stars would look if you were on the moon, the projector can show you that, too. Or it can make the stars travel their exact apparent paths across the sky from dusk to dawn in a few seconds. It can show you how the stars look from any place on earth.

Of course not all these things happen in any one evening or afternoon at a planetarium. Instead, there are shows, or lectures, that change often. Each lecture is on some part of astronomy.

Lecture is a poor word, because sometimes lectures are dull, and planetarium shows never are. If you are

at all interested in the stars, they are very exciting. The men who give the lectures are fine speakers, and they can make you laugh and they can make your mouth open in wonder.

Each planetarium also has exhibits of one kind or another. There are meteorites to be seen, and navigation instruments, and pictures showing some of the mythology you can find in the skies.

So if you live near a planetarium, try to see every program, if you can. Take a notebook and pencil with you and make notes on the lecture to help you remember.

You may find it possible to take a course in navigation or telescope-making if you live near a planetarium. Or you may be able to join a star club. There is a Junior Astronomy Club at the Brooklyn Public Library. Even if you don't live near New York, you can get a very useful and clever kind of star chart showing the stars as they appear from our part of the world. It is called the "Star Explorer," and it costs only 50 cents. Write to "Star Explorer," in care of Dr. H. S. Rice, Hayden Planetarium, New York 24, N. Y.

A number of excellent booklets also may be purchased from the Planetarium, or from the Book Shop at the Museum of Natural History, of which the Planetarium is a part. Write and ask for a list of publications, then select the ones you want. Most of them are very inexpensive.

Two interesting books may be bought at your corner newsstand for only 50 cents, too. They are pocket editions. One is *The New Handbook of the Heavens*, by Bernhard, Bennett, and Rice. The other is *Life on Other Worlds*, by H. Spencer Jones. Both are Mentor Books published by the New American Library, 501 Madison Avenue, New York 22, N. Y.

An excellent history of the constellations, along with some unusual star maps, is contained in "Star Maps for Beginners," by Levitt and Marshall. Your nearest planetarium may have copies of this useful booklet, or you can write directly to the Franklin Institute, Philadelphia, Pa. The usual price is 50 cents.

One thing you will want to know more about is how to locate the stars accurately. Understanding navigation is the best way to learn, because navigation is most directly concerned with star locations.

To put it briefly, each star has a definite track in the sky. The tracks run parallel to the earth's equator. The location of the track is measured by its distance from the celestial equator. The positions of the tracks are given in degrees. North of the equator they are *plus* degrees; south of the equator they are *minus* degrees. The equator is 0 degrees and the poles are 90 degrees. Degrees are given in minutes and seconds, but don't let this fool you: they are not minutes of time, but minutes of *arc*. Each degree has 60 minutes in it and each minute has 60 seconds—of arc.

The great circle running from the north celestial pole to the south celestial pole directly over your head is *your meridian*. You know that the earth is divided into twenty-four time zones (meridians), and that our day is figured from the Meridian of Greenwich (it runs through Greenwich, England). Navigators and astronomers also use another kind of time which is based on celestial hour circles. Starting with the hour circle west of the eastern side of the Great Square of Pegasus, the hour circles run north and south. They progress eastward around the sky.

The “right ascension” of a star is determined by its hour circle. The declination of a star is determined by its distance in degrees between the celestial equator and the celestial poles. Knowing about right ascensions and declinations is a part of learning navigation. A couple of books on this subject that might interest you are *Primer of Navigation*, by George W. Mixter, published by Van Nostrand, and *Boatman's Manual*, by C. D. Lane, published by W. W. Norton.

There are clubs and societies too numerous to mention to which the serious amateur may belong. Most of these have just one purpose, such as meteor work or moon and planet observation. Some schools have astronomy clubs, and in some cities amateur astronomers have formed their own city clubs.

Amateur astronomers who are really serious about their hobby, and who live close to each other, usually

get acquainted. If you *really* intend to make a serious hobby of astronomy, other amateurs will help you.

There are special publications on astronomy to which you can subscribe. *Popular Astronomy* is one of the best known. It is published by Goodsell Observatory, Carleton College, Northfield, Minnesota.

Another, perhaps equally well known, is *Sky and Telescope*, published by Sky Publishing Corp., Harvard College Observatory, Cambridge 38, Massachusetts.

Once you get into the study of astronomy, you will want a good telescope. Most amateurs make their own, and there are some excellent books on the subject which you should be able to find at your local library. If not, your bookstore will help you.

There is a monthly column in the *Scientific American* magazine which often has very helpful information. This magazine also is certain to carry important news of astronomy, either as a news item or as a full article.

Now and then articles on astronomy, simply and entertainingly written, may be found in *Natural History*, published by the American Museum of Natural History in New York. A yearly subscription, for ten issues, costs \$5.00. Those interested in astronomy usually are interested in all of the natural sciences, so a subscription is very much worth while. What's more, new books on astronomy are reviewed, and there is a Natural

History Book Club to which you may wish to belong.

A warning, though. Astronomy is an absorbing hobby, and it means late nights. Also, it can be expensive if you decide to go in for a telescope and elaborate equipment.

But few hobbies are so rewarding. In the years just ahead, much will be discovered, not only by the giant Hale 200-inch telescope and its companion, the remarkable Schmidt wide-view telescope, but by amateurs and observatories with less wonderful equipment.

Right now, as just one example, the Naval Research Laboratory near Washington is studying the mysterious "radio stars" that send out short-wave radio impulses.

Amateurs are forever turning up new comets—and they will continue to do so. Amateurs are spending clear nights collecting valuable information on meteors. Others are observing asteroids.

Amateurs largely have taken over moon observation. A very important group of amateurs studies variable stars and does sunspot observation. Their organization is The Amateur Association of Variable Star Observers.

There is a lot to be done. If you decide that astronomy is to be your hobby, who knows—you may be one of those who will contribute something to the total knowledge we have gained from hundreds of men through hundreds of years.



## APPENDIX

## Pronouncing Dictionary

The accent is indicated by a ' following the syllable to be accented as *va cá tion*.

ā=as in *say* ee=as in *meet* ī=as in *write* ō=as in *go*  
oo=as in *you*

The ending ae (Latin plural) is pronounced ee

The ending i (Latin plural) is pronounced ī

Achernar (āy' kur nar)	Betelgeuse (bet' ul jyoos)
Aesculapius (es kyoo lay' pi us)	binary (bī' na ry)
Alcyone (al sī' o nee)	Bolide (bō' lide)
Aldebaran (al deb' a ran)	Boötes (bō ō' teez)
Algol (al' gol)	caduceus (ka dyoo' see us)
Alhena (al heen' a)	Callisto (cal lis' tō)
Alnilam (al ni lam')	Camelopardalis
Alnitak (al ni tak')	(ka mel' o pard' a lis)
Alphard (al fard')	Canes Venatici
Alphecca (al fek' a)	(kay' neez ve nat' i sī)
Alpheratz (al fee' ratz)	Canopus (ca nō' pus)
Altair (al tair')	Capella (ca pel' la)
Andromeda (an drom' e da)	Capricorn (kap' ri corn)
Antares (an tā' reez)	Cassiopeia (kas i o pee' ya)
Aquarius (ah kweh' ri us)	Castor (kas' tor)
Aquila (ak' wī luh)	Centaur (sen' tor)
Arcturus (arc tyoor' us)	Centaurus (sen tau' rus)
Aries (a' reez)	Cepheus (see' fyoos)
Auriga (au rī' ga)	Cepheid (sef' ee id)
Aurigae (au rī' jee)	Ceres (see' reez)
Aurora Borealis	Cetus (see' tus)
(au rō' ra bō' rē āl' is)	chromosphere (krō' mō sfeer)
Aurora Australis	Coma Berenices
(au rō' ra aus trā' lis)	(kō' ma ber' e nee' seez)

Copernicus (ko per' ni cus)	Ophiuchus (of' i yoo' kus)
Corona (ko ro' na)	Orion (ō rī' on)
Corona Borealis (ko rō' na bō' ree ā' lis)	Orionid (ō rī' on id)
Cygnus (sig' nus)	Orionus (o ri ōn' is)
Deimos (di' mos)	Pegasus (peg' a sus)
Delphinus (del fī' nus)	Perseids (per' se ids)
Deneb (den' eb)	Phaeton (fāy' e ton)
Deneb Kaitos (den' eb kī' tos)	Phoebe (fee' bi)
Denebola (de neb' o la)	Pisces (pis' eez)
Dione (dī ō' ni)	Piscis Austrinus (pis' is os trī' nus)
Ecliptic (ee clip' tic)	Pleiades (plee' ya deez)
Enceladus (en sel' a dus)	Polaris (pō la' ris)
ephemeris (e fem' er is)	Praesepe (pre see' pee)
Epsilon (ep' si lon)	Pythagoras (pi thag' o rus)
Equuleus (i kwoo' le us)	Rasalague (ras al ag' yoo)
Eridanus (e rid' i nus)	Ras Algethi (ras al gee' thi)
Europa (yoo rō' pa)	Rhea (ree' uh)
Fomalhaut (fō' mal hawt)	Rigel (rī' jel)
Fornax (for' nax)	Sagitta (suh jit' uh)
Galileo (ga le lā' o)	Sagittarius (saj' it tā' ri us)
Gemini (jem' in ī)	Saiph (sāy if')
Hyades (hī' a deez)	Sirius (sir' i us)
Hyperion (hī pee' ri on)	Spica (spi' ka)
Iapetus (ī ap' e tus)	Tauri (tau' rī)
Io (ī' ō)	Tethys (tee' this)
Lepus (lee' pus)	Titan (tī' tan)
Libra (lī' bra)	Triangulum (trī ang' yoo lum)
Magellanic (clouds) (ma jel an' ik)	Tycho (tī' kō)
<i>mare</i> (mah' ree)	Ursae Minoris (ur' see min ōr' is)
Meteorite (mee' tee o rī')	Vega (vee' gah)
Mintaka (min' ta kāy)	Vela (vee' la)
Mira (mī' ra)	Vulpecula (vul pek' yu luh)
Mizar (mī' zar)	Zeta (zay' ta)
nebula (neb' yoo la)	Zodiac (zō' di ac)
nucleus (nyoo'-cli us)	

TABLE I

*The Greek Alphabet*

<i>Letter</i>	<i>Name</i>	<i>Letter</i>	<i>Name</i>
A, α	Alpha	N, ν	Nu
B, β	Beta	Ξ, ξ	Xi
Γ, γ	Gamma	Ο, ο	Omicron
Δ, δ	Delta	Π, π	Pi
E, ε	Epsilon	Ρ, ρ	Rho
Z, ζ	Zeta	Σ, σ	Sigma
H, η	Eta	Τ, τ	Tau
Θ, θ	Theta	Υ, υ	Upsilon
I, ι	Iota	Φ, φ	Phi
K, κ	Kappa	Χ, χ	Chi
Λ, λ	Lambda	Ψ, ψ	Psi
M, μ	Mu	Ω, ω	Omega

TABLE 2

*The Constellations*

Andromeda (the name of a Princess of Ethiopia)	<i>Andromeda</i>	Chamaeleon	<i>The Chameleon</i>
Antlia	<i>The Air Pump</i>	Circinus	<i>The Compasses</i>
Apus	<i>The Bird of Paradise</i>	Columba	<i>The Dove</i>
Aquarius	<i>The Water-carrier</i>	Coma Berenices	<i>Berenice's Hair</i>
Aquila	<i>The Eagle</i>	Corona Australis	<i>The Southern Crown</i>
Ara	<i>The Altar</i>	Corona Borealis	<i>The Northern Crown</i>
Aries	<i>The Ram</i>	Corvus	<i>The Crow</i>
Auriga	<i>The Charioteer</i>	Crater	<i>The Cup</i>
Boötes	<i>The Bear-driver</i>	Crux	<i>The Cross</i>
Caelum	<i>The Chisel</i>	Cygnus	<i>The Swan</i>
Camelopardalis	<i>The Giraffe</i>	Delphinus	<i>The Dolphin</i>
Cancer	<i>The Crab</i>	Dorado	<i>The Swordfish</i>
Canes Venatici	<i>The Hunting Dogs</i>	Draco	<i>The Dragon</i>
Canis Major	<i>The Big Dog</i>	Equuleus (the little horse)	<i>The Foal</i>
Canis Minor	<i>The Little Dog</i>	Eridanus	<i>The River Eridanus</i>
Capricornis	<i>The Sea-goat</i>	Fornax	<i>The Furnace</i>
Carina	<i>The Keel</i>	Gemini	<i>The Twins</i>
Cassiopeia (the name of a Queen of Ethiopia)	<i>Cassiopeia</i>	Grus	<i>The Crane</i>
Centaurus	<i>The Centaur</i>	Hercules	<i>Hercules</i>
Cepheus (the name of a King of Ethiopia)	<i>Cepheus</i>	Horologium	<i>The Clock</i>
Cetus	<i>The Whale</i>	Hydra	<i>The Water-monster</i>
		Hydrus	<i>The Water-snake</i>
		Indus	<i>The Indian</i>

Lacerta	<i>The Lizard</i>	Piscis Austrinus	
Leo	<i>The Lion</i>		<i>The Southern Fish</i>
Leo Minor	<i>The Lion Cub</i>	Puppis	<i>The Stern</i>
Lepus	<i>The Hare</i>	Pyxis	<i>The Compass Box</i>
Libra	<i>The Scales</i>	Reticulum	<i>The Net</i>
Lupus	<i>The Wolf</i>	Sagitta	<i>The Arrow</i>
Lynx	<i>The Lynx</i>	Sagittarius	<i>The Archer</i>
Lyra	<i>The Lyre</i>	Scorpius	<i>The Scorpion</i>
Mensa	<i>The Table Mountain</i>	Sculptor	<i>The Sculptor</i>
Microscopium		Scutum	<i>The Shield</i>
	<i>The Microscope</i>	Serpens	<i>The Serpent</i>
Monoceros	<i>The Unicorn</i>	Sextans	<i>The Sextant</i>
Musca	<i>The Fly</i>	Taurus	<i>The Bull</i>
Norma		Telescopium	<i>The Telescope</i>
	<i>The Carpenter's Square</i>	Triangulum	<i>The Triangle</i>
Octans	<i>The Octant</i>	Triangulum Australe	
Ophiuchus			<i>The Southern Triangle</i>
	<i>The Serpent-bearer</i>	Tucana	<i>The Toucan</i>
Orion	<i>The Hunter</i>	Ursa Major	<i>The Big Bear</i>
Pavo	<i>The Peacock</i>	Ursa Minor	<i>The Little Bear</i>
Pegasus	<i>The Winged Horse</i>	Vela	<i>The Sails</i>
Perseus	<i>The hero, Perseus</i>	Virgo	<i>The Virgin</i>
Phoenix	<i>The Phoenix</i>	Volans	<i>The Flying Fish</i>
Pictor	<i>The Easel</i>	Vulpecula	<i>The Little Fox</i>
Pisces	<i>The Fishes</i>		

TABLE 3 THE PLANETS

	<i>Mercury</i>	<i>Venus</i>	<i>Earth</i>	<i>Mars</i>	<i>Jupiter</i>	<i>Saturn</i>	<i>Uranus</i>	<i>Neptune</i>	<i>Pluto</i>
Mean distance from sun in millions of miles	36	67.2	93.0	141.5	483.3	886	1783	2793	3675
Period: revolution time around sun in earth days, years	88d	225d	365d	687d	11.86y	29.46y	84.0y	164.8y	248.4y
Speed in orbit, miles per second	29.7	21.7	18.5	15.0	8.1	6.0	4.2	3.4	3.0
Diameter in miles	3,000	7,600	7,920	4,220	89,000	75,000	31,000	28,000	6,300
Surface gravity compared with earth's which is 1	0.27	0.85	1.00	0.38	2.64	1.17	0.92	1.12	?
Rotation on axis in earth days or hours	88d	few wks.	1d	24.6h	9.9h	10.2h	10.7h	15.8h	?
Highest surface temperature	770°	140°	140°	86°	-216°	-243°	-300°?	-330°?	-348°?
Number of moons	0	0	1	2	11	9	5	2	?
Approximate magnitude	-1	-4.4	—	-2.8	-2.5	-0.4	5.7	7.8	14
Atmosphere*	No	Yes(P)	Yes	Yes(P)	Yes(N)	Yes(N)	Yes(N)	Yes(N)	No

\*Where answer is yes, (P) indicates life is possible; (N) indicates life is not possible.

THE SUN has a diameter of 865,000 miles; a surface gravity 28 times that of the earth; a period of rotation of 25 days. THE MOON has a diameter of 2,160 miles; a surface gravity of 0.16; and a period of rotation of 27.3 days.

TABLE 4  
 GALAXIES, STAR CLUSTERS, AND  
 NEBULAE VISIBLE TO THE NAKED  
 EYE FROM THE UNITED STATES

<i>Object</i>	<i>Description</i>	<i>Constellation</i>	<i>Distance*</i>
Milky Way	Spiral galaxy	Center in Sagittarius	30,000 to center
M 31, Andromeda Nebula	Spiral galaxy	Andromeda	800,000
M 13, Great Cluster	Globular cluster	Hercules	34,000
M 3	Globular cluster	Canes Venatici	40,000
Omega Centauri	Globular cluster	Centaurus	22,000
Hyades	Open cluster	Taurus	120
M 45, Pleiades	Open cluster	Taurus	500
M 44, Praesepe (The Beehive)	Open cluster	Cancer	500
h & chi Persei	Open cluster, double	Perseus	4,300
M 36, M 37, M 38	Open clusters	Auriga	3,000
M 7	Open cluster	Scorpius	—
M 41	Open cluster	Canis Major	1,300
M 42, Orion Nebula	Bright, diffuse nebula	Orion	1,800
M 8, Lagoon Nebula	Bright, diffuse nebula	Sagittarius	3,600
The Rift	Dark nebula	Cygnus, south from Deneb	—
Northern Coalsack	Dark nebula	Cygnus, Cepheus	—

\*Approximate distance, given in light-years.



TABLE 5  
 PRINCIPAL METEOR SHOWERS SEEN  
 FROM THE UNITED STATES

METEOR SHOWER	RADIANT IN CONSTELLATION	APPROXIMATE DATE
Quadrantids	Northern Boötes	January 3
Lyrids	Hercules, near Lyra	April 21
Eta Aquarids	Aquarius	May 4
Delta Aquarids	Aquarius	July 28
Perseids	Cassiopeia-Perseus boundary	August 12
Giacobinids	Draco	October 9
Orionids	Orion	October 22
Taurids	Taurus	November 10
Leonids	Leo	November 16
Bielids	Andromeda	November 27
Geminids	Gemini	December 12

TABLE 6  
 BRIGHT VARIABLE STARS SEEN FROM  
 THE UNITED STATES  
 (*Selected List*)

STAR	MAGNITUDE		PERIOD	COMMENT
	Brightest	Dimmest		
Alpha Cassiopeae	2.2	3.1	Irregular	
Delta Cephei	3.6	4.3	5.37 days	The star which gave cepheid variables their name.
Omicron Ceti	1.7	*9.6	331 days	Mira, the Wonderful
Alpha Orionis	0.2	1.1	Irregular	Betelgeuse
Rho Persei	3.3	4.1	Irregular	
Beta Persei	2.3	3.5	2.87 days	Algol, the Demon
Lambda Tauri	3.3	4.2	3.9 days	Eclipsing, like Algol
Eta Geminorum	3.2	4.2	231 days	Long period, like Mira
Zeta Geminorum	3.7	4.3	10.2 days	Cepheid
R Hydrae	3.5	*10.1	406 days	Long period
Alpha Herculis	3.1	3.9	Irregular	
Eta Aquila	3.7	4.5	7.2 days	Cepheid
Mu Cephei	4.0	5.5	Irregular	
Chi Cygni	4.2	*13.7	409 days	Long period
Beta Lyrae	3.4	4.1	12.9 days	Eclipsing
R Lyrae	4.0	4.7	Irregular	Period about 46 days.

\*Fades out of sight completely for the unaided eye, which usually can see stars no fainter than 6th magnitude. Algol (Beta Persei) is the brightest short-period variable and is probably the best one for the beginning stargazer to observe.

TABLE 7

THE SIGNS OF THE ZODIAC

<i>Aries</i>	The Ram
<i>Taurus</i>	The Bull
<i>Gemini</i>	The Twins
<i>Cancer</i>	The Crab
<i>Leo</i>	The Lion
<i>Virgo</i>	The Virgin
<i>Libra</i>	The Balance
<i>Scorpius</i>	The Scorpion
<i>Sagittarius</i>	The Archer
<i>Capricornus</i>	The Goat
<i>Aquarius</i>	The Water-Bearer
<i>Pisces</i>	The Fishes

## *More Books about Stars*

**THE CONQUEST OF SPACE**, by Chesley Bonestell and Willy Ley (The Viking Press)

All the thrills of a rocket trip to the moon—with a discussion of the difficulties that lie before us. An accurate description of the moon and planets with fifty pictures by a famous artist.

**A DIPPER FULL OF STARS**, by Lou Williams (Wilcox & Follett Co.)

A guide to the important constellations.

**EINSTEIN, HIS LIFE AND TIMES**, by Philipp Frank (Alfred A. Knopf, Inc.)

This biography of one of the greatest scientists of all time brings home to us the genius that lies behind each piece of new knowledge.

**FIELD BOOK OF THE STARS**, by William T. Olcott (G. P. Putnam's Sons)

A guide to the stars that can be seen with the naked eye or with an ordinary pair of binoculars.

**GLASS GIANT OF PALOMAR**, by David O. Woodbury (Dodd, Mead & Company)

The story of Dr. George Ellery Hale who set about improving the fabulous telescope Jules Verne imagined in his story, *Journey to the Moon*. Dr. Hale built his first telescope when he was thirteen years old—the last one is the 200-inch giant on Mount Palomar in California. A dramatic story of glassmaking and astronomy.

GUIDE TO THE CONSTELLATIONS, by Samuel G. Barton and William H. Barton (McGraw-Hill Book Company, Inc.)

Constellation charts for each month, size 8" x 8", for the northern skies and a chart of the southern sky.

INTRODUCING THE CONSTELLATIONS, by Robert H. Baker (The Viking Press)

The legends of mythology and the religions of all people as they appear in the stories about the constellations—and in the names of the constellations. Beautiful pictures, printed in blue, will help the stargazer follow this imagery.

LIFE ON OTHER WORLDS, by H. Spencer Jones (The Macmillan Company)

(Mentioned on page 165 of this book.)

NEW HANDBOOK OF THE HEAVENS, by Hubert Bernhard, Dorothy Bennett, and Hugh S. Rice (McGraw-Hill Book Company, Inc.)

(Mentioned on page 165 of this book.) Previously we mentioned the pocket paper-bound edition. There is also a cloth-bound edition, which sells at a higher price and is available at libraries and bookstores.

PRIMER FOR STAR GAZERS, by Henry M. Neely (Harper & Brothers)

An unusually easy-to-follow guide to locating the stars at any time, at any season.

SKYSHOOTING by R. Newton Mayall and Margaret L. Mayall (The Ronald Press Company)

How to photograph the moon and stars. Pictures, charts, and diagrams help make this clear and extremely helpful.

STARCRAFT by William H. Barton and Joseph M. Joseph (McGraw-Hill Book Company, Inc.)

A handbook of instructions, charts, tables, including material on telescope-making, and many interesting experiments and activities.

THE STARS IN OUR HEAVENS, by Peter Lum (Pantheon Books, Inc.)

A handsome book that gives all of the star legends—from Japan, China, and Korea as well as from Greece and Babylon.

THE STORY OF OUR CALENDAR, by Ruth Brindze (The Vanguard Press)

A readable story of how we came to have a calendar and the various changes it has gone through.

WHEN THE STARS COME OUT, by Robert H. Baker (The Viking Press)

The story of our solar system is told with enthusiasm, by the author of *Introducing the Constellations*. This book, like the other one, is illustrated with handsome pictures printed in blue.

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