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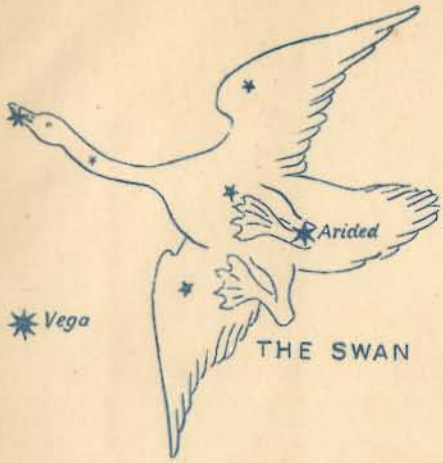
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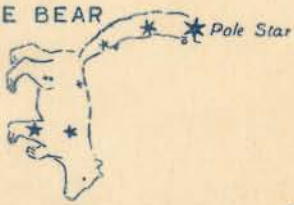
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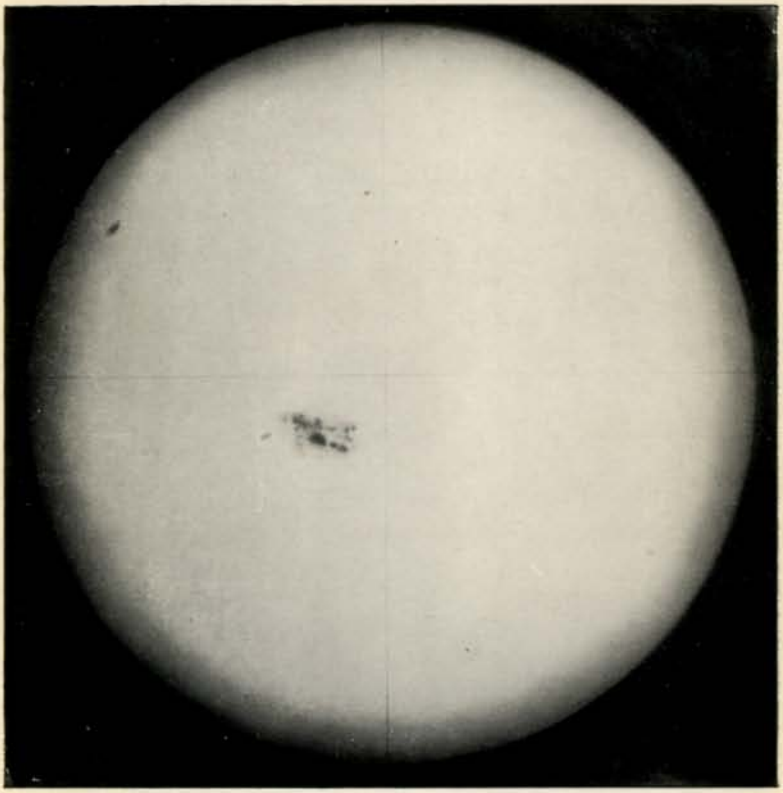


THE SUN, FEBRUARY 3, 1905. *Page 14*

From a photograph taken at the Royal Observatory, Greenwich

THE HEAVENS

CHAPTER I

SUN, MOON, AND STARS

When we look up to the sky from this beautiful world which is our home, we learn at once that the earth, great and wonderful as it is, is not the only wonderful thing that the Creator has made. The Sun, a great globe of fire, comes climbing up over the tree-tops in the east, rises higher and higher in the sky till the middle of the day, and then gradually sinks down in the west as evening comes on. Soon after he has set, one little point of light begins to flash out after another in the darkening sky, until the whole heaven seems to be covered with glittering diamonds; and then the east grows bright again, and the pale Moon comes up, making the stars seem faint and dim, and lighting up the earth with its beautiful cold beams.

What are all these lights, greater and smaller, that shine in our sky by day and by night? It seems quite plain to you that two of them, at all events, are quite different from all the rest. The Sun and the Moon are so much bigger and brighter than any of the other

lights of the sky that we at once imagine that they must be nearer to us than any of the stars. They seem to belong to us, and to be, in a way, the servants of our world. Then we can see that even between the Sun and the Moon there are great differences. The Sun keeps always round and bright, but the Moon is always changing in appearance. You see it first as a thin crescent of light, quite close to where the Sun has set. Night after night it grows broader and rounder, till it is quite full—a great silvery globe rising in the east as the Sun sets in the west ; and after that it gradually loses its roundness again, till you see it in the early morning before the sunrise, a pale crescent, with its horns turned the opposite way from those of the evening crescent. When the Moon is full, it looks exactly the same size as the Sun, and we might imagine that there was no great difference between them, except that the Sun is much brighter, and does not change in appearance as the Moon does. But really it is not so. The reason why the Moon looks as big as the Sun is because it is very much nearer to us. Actually it is a very small body compared with most of the other heavenly lights, while the Sun is very big, as we shall see later. So, at the very beginning of our story we learn that things are not always just as they seem to be, and that a small globe close at hand may look as large as a very big one far away.

Now, if you go out on a clear night and look up to the sky, you will see a great number of stars—so many

that it seems almost impossible to count them ; and if you watch these stars for a little while, you will see that they are all moving across the sky. Stand where you can see a tall tree or a church spire against the sky, and watch a bright star that is close to it on the east side. In a few minutes the star has come to the edge of the spire ; then it passes behind it, and is out of sight for awhile ; and then it comes out again on the west side, and begins to move away. And all the other stars in the sky are doing exactly the same—all moving from east to west—except in one place. If you turn and look up to the sky in the north, you will see one fairly bright star (it is called the Pole Star), which does not seem to move at all ; and the stars that are quite close to it move so slowly that you can scarcely notice their motion.

In fact, all the stars in the sky seem to move in circles round the Pole Star : the ones that are nearest to it in small circles, and those farther away in larger circles, till you come to the ones whose circle is so big that you only see the half of it, as they rise in the east, pass right across the sky, and set in the west. The Sun and the Moon, you remember, move as the stars do : they travel across the sky from east to west in part of a great circle.

If you could get a great hollow ball made so that it turned about on an axle passing right through it, and if you painted on the inside of it the Sun and Moon and all the stars, then, when you stood at the centre of the ball, and had it turned round upon its axle, you

would see exactly what you see when you look at the sky. So you might think that the reason for these movements of the stars is that the whole sky turns round about the world just as your hollow ball turns round about you. And that is what everybody thought for many hundreds of years. They imagined that the world stood still in the centre, and that round it there turned, not one globe, but many transparent globes, sphere after sphere, one carrying the Moon, another the Sun, and beyond these still others, carrying the other worlds and the stars.

But suppose that your hollow ball was standing quite still, and that you yourself were turning round about inside it from west to east. You can see that the result would be that all the painted stars would seem to move round from east to west, just as they did before. And this is what really happens with regard to our world and the sky. The world is always spinning round from west to east, and so the Sun and Moon and all the stars appear to turn round from east to west, though they do not really do so. They all have motions of their own, it is true; but the motion that takes them right across our sky from east to west in twelve hours, and under our world to the east again in another twelve, is due to the fact that the world spins round like a great top in twenty-four hours.

But now I want you to notice another example of how different things may really be from what they appear. There are a few among the stars which shine

very brightly indeed—two or three in particular that are often brighter than any other stars in the sky—and that shine with a much steadier light than the others. You know how the stars are always twinkling and flashing; but, if you watch these two or three, you will see that they scarcely ever twinkle, but keep steadily shining. Now, if you could watch for several nights one of those stars that do not twinkle, you would find out that it was not keeping its place among the stars. The other stars never appear to change their places. They move across the sky from east to west, but they always keep the same places with regard to one another. But these others move about—very slowly indeed, but still so that you can see that they have moved among the rest of the stars.

These moving stars are really not stars at all. They are worlds, something like our own world. And, though they shine so brightly, they are not nearly so big as even the very dimmest and faintest of the other stars. They look so bright simply because they are very much nearer to us than any of the true stars. The name that has been given to them is the "Planets," or "Wanderers," because they appear to wander among the stars; and they belong to the same family to which our own world belongs—a family which is called the "Solar System." The head of the family is the Sun, and he is the centre round which all the worlds of his system travel. They move continually round him in rings which are not exactly, but very nearly, circles. Some of these worlds are smaller than

our own, and some are very much bigger; but none is anything like so big as the Sun, which keeps them all moving round him, and gives them light and heat.

And then away out beyond the very farthest of these worlds, so very far beyond that it is almost impossible for us to understand the distance, there shine all the other stars that you see twinkling in the sky at night. They are quite different from the planets, which are the brothers and sisters of our own world; indeed, they are not to be compared with the planets at all, but with the Sun himself; for the Sun is a star, and the stars are suns. In fact, if the Sun were moved as far away from us as an ordinary star, he would not look nearly so bright as many of the stars we see at night.

When you begin to watch the stars carefully, you will soon find out many things about them that you never thought of before. You will find, for instance, that they are not only different from one another in brightness, but in colour as well, for there are all kinds of delicate shades of colour to be found among them. You will find, too, that you cannot see nearly so many stars as you used to think you could; though if you ever look through a big telescope you will see, perhaps, a thousand for every one that you can see without it.

Ever since there have been men on the earth they have been interested in the starry heavens, with all the wonders which they show. For thousands of years

astronomers have studied the Sun and Moon, the planets and the stars, trying to find out as much as possible about them. They have invented wonderful instruments to help them in their study, such as the telescope, which, as it were, brings the planets nearer to us by making them seem bigger, so that we can see their surfaces and the changes that happen on them, or the spectroscope, which tells us what the Sun and the stars are made of. And gradually they have come to know a great deal about the worlds of our own family, and are constantly learning more even about the distant stars. And my purpose in the chapters that follow is to try and tell you simply what we know about all the wonders of the host of heaven—Sun, Moon, and Stars.

CHAPTER II

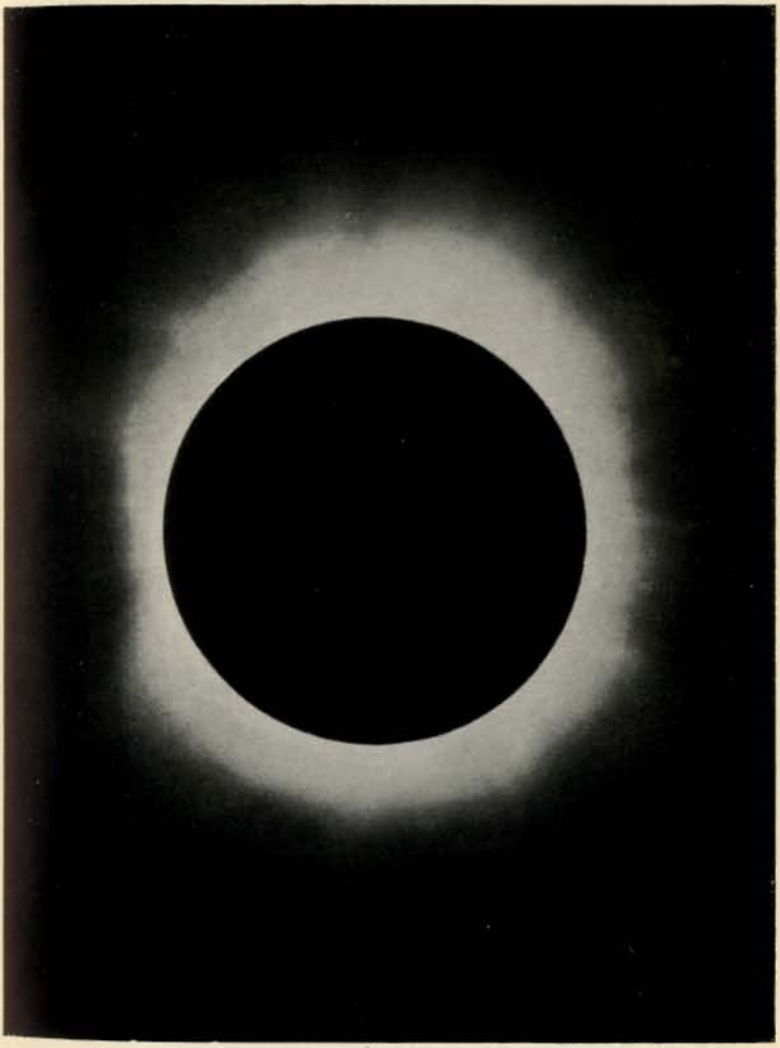
THE SUN : OUR LIGHT AND LIFE

We have seen that our world belongs to a little family of worlds which circle round the Sun, and that these worlds are very different from the other stars which we see at night. As these worlds of the Solar System are so much nearer to us, and so much more closely connected with us than the stars, we shall look at them one after the other before we turn to think of the vast

distances and numbers of the stars. And in dealing with the family to which we belong, it will be best to begin with the head of the household—that great star which we call the Sun.

First of all, let us try to get some idea of his size. The world seems a very great place to us, and when we are told that it measures about 8,000 miles from pole to pole, and about 25,000 miles round about, we think that these are tremendous figures. But the Sun is more than a hundred times the diameter of the earth, for it measures nearly 900,000 miles from pole to pole. In fact, it is so big that it would take more than 1,250,000 worlds like ours rolled into one to make a globe as big as the Sun. But when we speak of such figures, we cannot really understand what they mean, so we must try in another way to get an idea of the Sun's size.

Suppose that he were hollow, like a great soap-bubble, and that our Earth were put at the centre of the bubble. Then the Moon could still go on travelling round about us, just as she does now, and outside of her there would be room for another Moon to circle round us, almost as far away from us again as our present one, still inside the shell of that huge bubble (Fig. 1). And yet the Sun does not seem so very big when you look at it. If you hold out a sixpence at arm's length, you will find that it more than covers the bright globe. So if the Sun is really so big, and yet looks so small, the reason must be that he is very far away from us; and so he is.

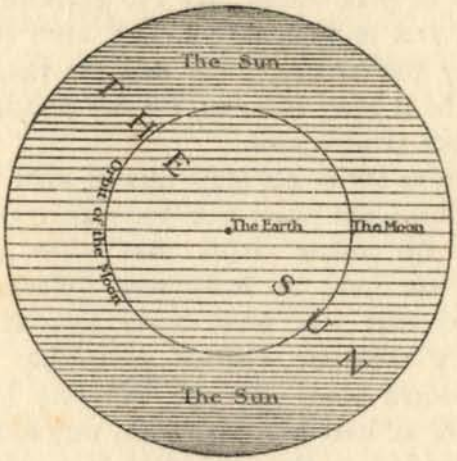


SOLAR CORONA. *Page 22*

From a photograph by Professor Campbell, Lick Observatory, U.S.A.

The Sun's Distance

We think that a journey round the world is a very long one, but a journey to the Sun would be nearly 4,000 times as long as that. In fact, if you could travel at sixty miles an hour all the way, it would take you almost 180 years to get to the end of your journey,



Comparative Sizes of the Sun and Planets.

and your ticket, at a penny a mile, would cost you nearly £400,000! If you happen to burn your finger, you know that what takes place is something like this: the nerves at the tip of your finger send up a message to your brain, and your brain decides that touching fire is painful, and orders your muscles to pull the finger

away. Of course, all that happens so quickly that you do not really know that it is happening. But if you had an arm long enough to reach to the Sun, and put your finger on his globe to-day, you could never live long enough to know that you were burned, for the sense of pain would take 150 years to travel up that long arm to your brain! But, after all, we cannot really understand either how big the Sun is or how far he is away from us, for our minds refuse to take in such great figures.

Now let us try to get some idea of what the Sun is like. Perhaps you think you know that already; he is just a flat, white circle. But when we turn a telescope on him, he looks very different. Only, remember that you must never look at the Sun through a telescope without protecting your eyes with coloured glass, else you will very likely blind yourself, or at least hurt your sight very badly. Here, then (Plate II.), is the Sun's face as a telescope will show it to you—a broad, round, white disc, shaded a little at the edge, so that you can see it is not really flat, but a globe. And here are two or three little black splashes upon the whiteness, looking as if somebody had spilt some ink on the paper. Now, these black splashes are the famous sunspots that I dare say you have often heard about. They do not look very wonderful, do they? But let us try to think what they really are like. They measure often many thousands of miles from side to side, and some of them are so big that you could lay ten worlds

upon them in a row, and still the spot would not be altogether covered.

What they are no one can actually say. Some astronomers think that they are great hollows in the Sun's surface, where the stuff which he has thrown out above him, and which has got cooled, is gradually settling down again ; but this is not at all certain. All we can say is that the spots are caused by great storms and eruptions within the Sun, and that they tell us that this great globe is not solid and steady, like the Earth, but is constantly tossing and heaving up and down, almost like water boiling in a kettle.

If you were to watch a sunspot for several days, you would see that it is always changing. In a day or two it might look quite different from when you saw it first ; sometimes the changes come so quickly that parts of the spot as big as our world alter their shape in a few hours. So you see that the Sun can scarcely be a place that you would like to live in. Even if you could stand the heat, which would melt in a moment the hardest things we know of, you would find that there was nothing solid to put your feet on. Great fiery waves would always be rising and falling around you ; every now and then jets of flame would shoot up thousands of miles high ; and sometimes huge gulfs, in which worlds might be swallowed up, would yawn beneath your feet.

But if you watch a spot carefully, you will see another kind of change taking place. It is near one edge of the sun at first. Next day, it will be a little

nearer the middle, and, in about twelve and a half days from the time it first appeared, it will be going out of sight at the edge opposite to that where you first saw it; while, if you wait another twelve and a half or thirteen days, you may see it coming back again just where it first appeared. Do you understand what that means? If you were standing on the Moon, and watching our Earth, you might see Britain coming into sight at one side of the globe. It would cross the centre and go out of sight at the other side in twelve hours; and if you waited another twelve hours, you would see it appearing again where you first saw it. And you would say: "The world takes twenty-four hours to turn round." Well, when a sunspot takes twelve and a half days to go from one side to the other, and another twelve and a half to come back into sight again, that means, you see, that the Sun turns round in twenty-five days, just as our world does in twenty-four hours. Only—and this is the strange thing—the Sun does not turn all at the same speed. Our world spins round all in a piece, and, if it did not, I suppose it would fly all to bits; but some parts of the Sun take twenty-five days to turn round, some take twenty-seven, and some take longer still.

When you begin to see clearly, you will notice that, besides the sunspots, there are other marks on the face of the Sun. Near the edge, and generally close to a spot, you will see white markings of all shapes and sizes, looking as if they were the crests of the fiery

waves thrown up by the solar storms. Astronomers call them "faculæ," or "little torches." And all over the surface there is a beautiful delicate mottling of grey and white, which sometimes makes the face of the Sun look rather like a plate of rice-soup.

Altogether, then, you see that the Sun is very different from what you would imagine when you see him shining day by day. Indeed, I believe that if you were to say that he is more like a great bubble than anything else, you would not be very far wrong. Of course, he is such a bubble as you never dreamed of in all your life—a bubble far bigger and heavier than all the worlds that go round about him put together; a bubble which, instead of being made of soapsuds, is made of iron, lead, lime, and all sorts of other things, heated so hot that they have become glowing gases. But still he is more like a bubble than he is like our own world, or the Moon, or any of the other planets.

You know, of course, how important the Sun is to us all. It is his tremendous weight that keeps us travelling in a circle round about him, so that we may always be brightened by his light and warmed by his heat. But did it ever strike you how enormous his heat must be? We sometimes feel the sunshine uncomfortably hot on a summer day, but we may be thankful that the Sun is so far away from us, for if he were to come even as near to us as the Moon does we should scarcely have time to feel uncomfortable. We should simply shrivel up and vanish, and our solid

world would melt, like a drop of wax in the flame of a candle.

Now, for thousands upon thousands of years the Sun has been pouring out this tremendous flood of light and heat on every side. How does he keep it up? What can stoke the furnaces that produce such a continual glow? Mere burning can never account for his heat. If he were one lump of solid coal from centre to circumference, he would burn right out in 6,000 years, and we should already be beginning to know that he had become colder than he was, say, at the time of the Norman Conquest. But you know that heat can be made not only by burning, but also by friction, or rubbing. When a train comes into the station, and the brakes are put on, the sparks that fly from the wheels tell you that heat is being produced. The motion of the train and the force that stops it is being converted into heat. Now, if the Sun contracts, as we know it does, its outer layers are constantly pressing upon the inner ones, just as the brakes press upon the wheels of the train, and that pressure is always making heat. Indeed, if the sun contracts only 250 feet in a year, that will supply him with all the heat that he sends out.

Of course, we cannot suppose that he can go on contracting for ever. But he is so enormous, and the amount that he contracts every year is so small, that it would take nearly ten thousand years before we could tell, even with our finest instruments, that he had grown any smaller. And if we try to think of a

time when he will no longer be able to supply us with as much light and heat as we get from him now, we find that we must measure that time by millions of years. So we need not be afraid that there is any risk of the Sun's furnaces going out in the meantime. He will last our time, and a good deal more.

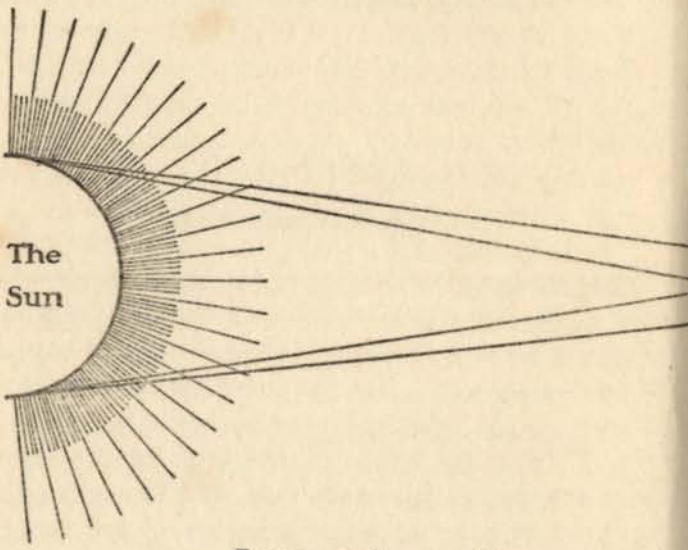
CHAPTER III

THE INVISIBLE SUN

WHAT we have been seeing so far on the Sun's surface, the spots, the white faculæ, and the rice-grain mottling, can be seen almost any clear day if you have even a small telescope. But the Sun that we can see with the eye or the telescope is not by any means the whole Sun. There are wonderful things about the Sun that very few people have ever seen, and that can only be seen all at once in short glimpses of two or three minutes, and only from a narrow strip of the Earth's surface on each occasion. The reason why we cannot see them at ordinary times is because the sunlight itself is so brilliant that they are hidden from us in the glare ; and it is only when the Sun is blotted out for awhile that they become visible. It is this that makes an eclipse of the Sun so important, and that

draws astronomers from all parts of the Earth to the best places along the narrow strip of country from which the eclipse appears to be total.

You know that our Earth is constantly travelling in a ring round the Sun, and that, as we go, the Moon is constantly travelling in a ring round our Earth. Therefore it must come, once in every month, between us



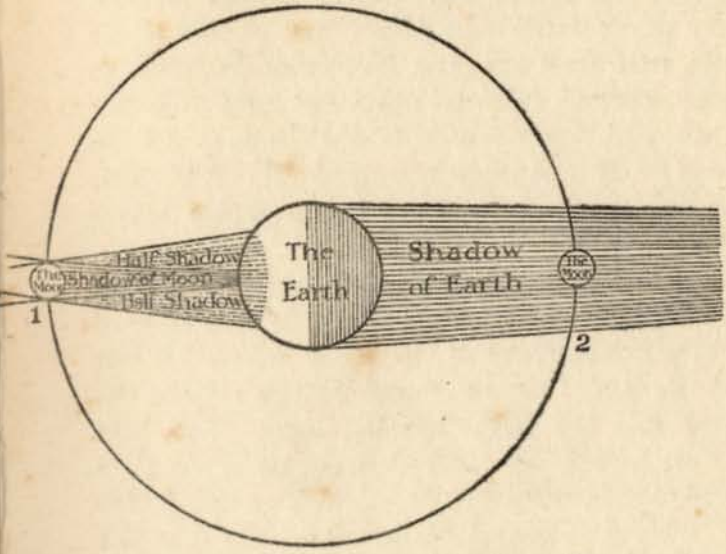
Eclipses of Sun and Moon.

and the Sun. It is not always exactly in a straight line between the two bigger globes. Sometimes it is a little above or below the line, and then nothing happens. Sometimes it comes very nearly, but not quite, into line; and then it seems to cut off a bit, larger or smaller, of the Sun's light, and we see what

RED FLAME OF THE SUN, WITH EARTH (WHITE DISC) FOR COMPARISON. *Page 24*

is called a partial eclipse of the Sun. Even then we cannot see any of the wonderful things that I spoke of. But sometimes the Moon comes exactly into line between the Sun and the Earth, and then we have a total eclipse of the Sun (Fig. 2 [1]).

You know that the Sun and the Moon look almost exactly the same size, though they are really so



1. Total eclipse of sun where shadow of moon falls. Partial eclipse of sun where half shadows fall.
2. Shadow of earth causing total eclipse of moon.

different. So, when the Moon passes across the Sun's face, it just covers it, and the whole bright globe is blotted out for a little while; but the time during which the Sun is quite hidden is very short indeed—

never quite eight minutes, and generally a good deal less. In that little time, however, a great deal can be seen.

As the Moon steals in between us and the bright globe of the Sun, a little bit of the Sun begins to be hidden, just as though something were taking a bite out of the circle of light. Then gradually the dark bite grows bigger, and the daylight begins to fade. The sky grows darker and darker, one or two of the brighter stars peep out, and sometimes the birds go to roost, thinking that the night has come. At last the Moon gets right between us and the Sun, and the last little streak of sunlight is blotted out. And then, in a moment, a most wonderful sight flashes before our eyes.

Where the Sun was shining a little while ago you see a big, round, dark globe, looking as if it were made of black velvet—the globe of the Moon which has just hidden the Sun. But all around it there streams out on every side the most beautiful light. You have seen in pictures of our Lord or of the saints the glory round the heads of the figures—a circle of pale golden light. Well, it is something like that, only it is of a pearly white colour, and instead of being perfectly round, it shoots out here and there in great streams of light, some of them stretching for hundreds of thousands of miles across the sky. These beams grow fainter the farther they get from the Sun, but close in to the edge they are all mingled together in a ring of dazzling brightness (Plate III.).

But that is not all. At the very edge the colour of the glory changes, and there is a perfect circle of brilliant crimson light, very narrow, but very bright, running round the margin of the dark Moon; and here and there a great jet of crimson fire shoots out from the circle, and soars up for thousands, or even for hundreds of thousands, of miles, showing beautifully against the pearly background. These things can only be seen for a very few minutes, for the Moon is always moving onwards. Soon the crimson flames on the one side begin to fade in the growing light, and those on the other side begin to get covered up by the advancing Moon. Then, all of a sudden, there is a blinding flood of light as the edge of the Sun appears again from behind the Moon, and the eclipse is over.

Now, here are three strange things which we have found to be round about the Sun. What are they, and what do they tell us? Astronomers have given names to them. The pearly glory that was mentioned first is called the "Corona," and that, as you know, means the "Crown"; the crimson ring of fire is called the "Chromosphere," which means the "Colour-sphere"; and the jets of red flame are called the "Prominences." Now, all these things belong to the Sun. Though we can only see them all in a total eclipse, they are always there. An instrument has even been invented which lets us see the Chromosphere and its red flames, though not the Corona, when there is no eclipse.

And you can understand at once what a difference all this makes to our idea of what the Sun is like. We see his bright globe every clear day, and we might think that it is all there really is of him. Actually it is only the inner part of him, the core of the Sun—like the rubber core in the centre of a golf-ball. Round about that globe, where the gutta-percha covering would come in a golf-ball, there lies a great ocean of red fire, perhaps 2,000 miles deep or more—an ocean as deep as the Atlantic is broad, and so hot that the fiercest furnace on earth would seem cold compared to it.

I have called it an "ocean"; but perhaps it is scarcely like that, either. It is more like a great sheet of flames, all rising straight up like the blades of grass upon a lawn or stalks of corn in a field, and all constantly swaying, and tossing, and flickering. Underneath it, and within the bright globe which our eyes see, the storms which make the sunspots are continually raging, and every now and then there is a great outburst; huge torrents of flame rush up from below, and the crimson fire is thrown up, perhaps for 100,000 or 200,000 miles, sometimes even to a far greater height.

When we talk about an eruption, we think of Vesuvius overwhelming Pompeii and Herculaneum, or Mont Pelée destroying the towns in the West Indies. But if a flame from one of these eruptions on the Sun were to touch our world, there would be no more eruptions of Vesuvius. The great flame would lick

round the world, burying it in its fiery heart for a little while ; and when it fell back there would be no world left : it would be all dissolved. Our mountains, and continents, and seas, our busy towns and peaceful country villages, and every living being in them would pass away in a cloud of glowing vapour, and no one would be able to tell where they had been. No words can really give you any idea of the greatness and fierceness of these red flames round the Sun, but perhaps the picture, which shows you a great flame with the Earth beside it on the same scale, may help you to understand how gigantic and terrible they are (Plate IV.).

Still beyond this fierce red ocean, with its great flames, there lies the brilliant crown of glory, the Corona. What it is no one can tell you certainly. It stretches away out there on all sides of the Sun, sometimes sending streamers out for millions of miles ; it is always there, and yet it is always changing its shape ; it never seems quite the same in any eclipse as it did in the one before. It appears to be made of material thrown out in some way from the Sun ; but almost the only thing that is really certain about it is that it must be just about the thinnest and least substantial thing known in all the creation (Plate V.).

Later on, when we come to talk about comets, we shall see how thin their tails are—so thin that even the faintest stars shine through thousands of miles of them as though there were nothing there. But the Corona must be thinner still. For some of these

comets, in their swift flight round the Sun, have passed right through this strange crown of light, and it has not checked their speed or changed their shape in the very least. Thirty years ago a great comet came sweeping up to the Sun, and passed round him so close that it must have torn its way clean through the Corona. Astronomers watched with the keenest interest to see whether it would be checked, but there was not the slightest slackening of its wild rush; the comet was going just as fast after it had passed through the Sun's crown of glory as before it plunged into it. Shakespeare speaks of "such stuff as dreams are made on," and the words seem to fit the Corona better than anything else we know of.

CHAPTER IV

"STAR OF THE EVENING"

Now that we have seen a little of the greatness and wonder of the giant star which is the centre of the family of worlds to which our Earth belongs, we can go on to take a glance at each of these worlds in turn. But before we begin with the two which are nearest to the Sun, let us try to get an idea of the sizes of the different worlds which make up our system, and the

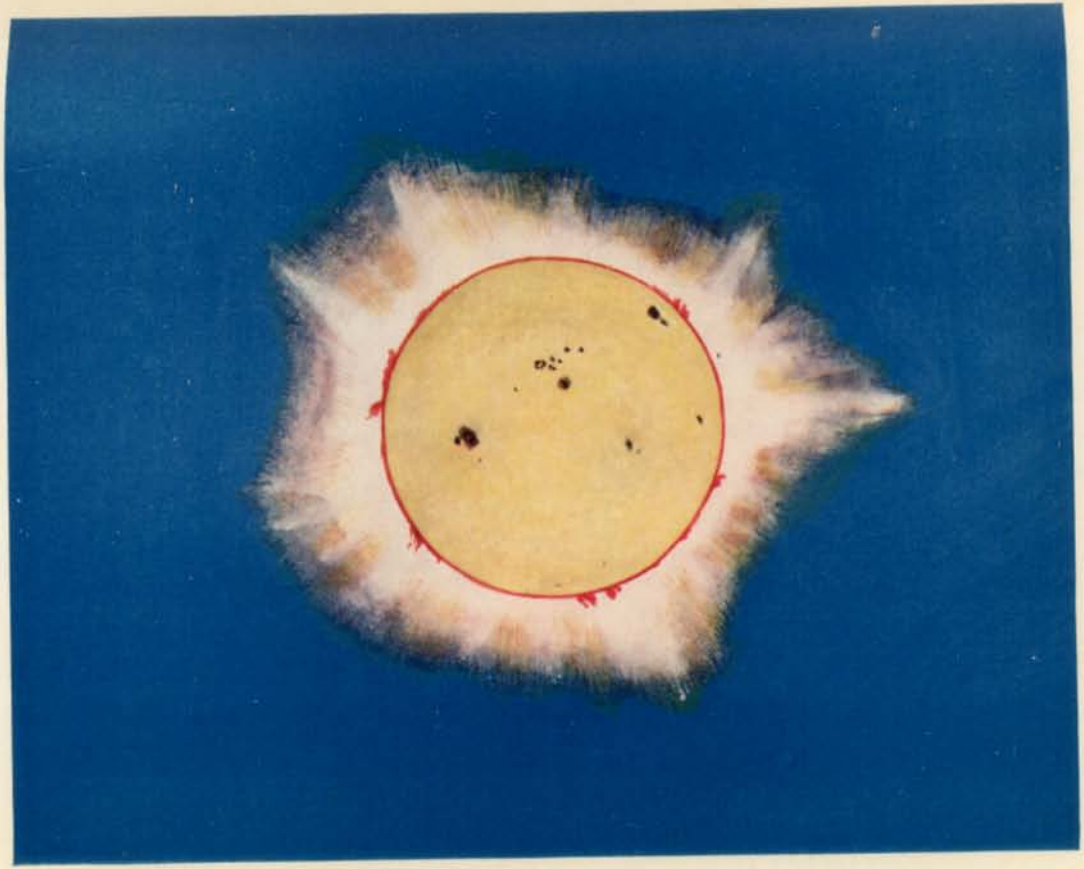
distances at which they circle round the Sun. Fig. 1 will let you see how the planets compare with one another. Two of them, Jupiter and Saturn, are very much bigger than any of the others; two others, Uranus and Neptune, while much smaller than Jupiter and Saturn, are much bigger than our world; two, again, Mercury and Mars, are a good deal smaller than our Earth; and one, Venus, is almost the same size as the Earth.

In order to get an idea of how they compare with one another for distance, suppose you could get a broad, flat piece of ground nearly two and a half miles across. In the middle of this plain you would set a globe, 2 feet in diameter, to represent the Sun. Then, walking 27 yards out from the Sun, you would draw a circle round him at that distance, and on it you would lay a small pin's head to stand for Mercury. Fifty yards from the Sun a pea would represent Venus, and 20 yards farther on still another pea would stand for the Earth. A hundred and seven yards from the Sun you would place a large pin's head for Mars; and you would have to go about 260 yards farther before you laid down a large orange for Jupiter, and another 300 yards to place a smaller orange to represent Saturn. Two small plums, one about three-quarters of a mile and the other about one mile and a fifth from the central globe, would stand for Uranus and Neptune. And then you would have to imagine all these different objects travelling, each in its own circle, round about the globe in the centre.

"Star of the Evening"

Now that we have seen a rough plan of how our system is built, and how the worlds in it compare with one another for size, let us begin with the one nearest to the Sun—the planet Mercury. Probably you have never seen Mercury, for he keeps so close to the Sun, and sets so soon after him, or rises such a short time before him, that he is nearly always lost in the bright rays. He is the smallest of all the regular planets, measuring only about 3,000 miles from pole to pole. Being so near to the Sun, he gets a tremendous amount of sunlight and heat, for the Sun looks nine times as big from Mercury as it does from our Earth; but, in spite of that, he does not shine very brightly, so that it looks as though he must be made of much darker stuff than some of the other worlds.

Mercury takes eighty-eight days to travel round the Sun, or, in other words, his year is eighty-eight days long; but the strange thing about him is that, so far as we can find out, instead of spinning round upon his axis in twenty-four hours, like our world, he actually takes eighty-eight days to do that also. So that his day is as long as his year. Now, that will make him a very curious world indeed, for it means that he must always turn the same side to the Sun. And so half of this strange little world has no night and the other half of it has no day. The daylight side is for ever scorched by a Sun which looks nine times as big and bright as we see it; so you can fancy what the heat must be like on that side. But on the other side there will be perpetual darkness, and it will be always cold—



THE SUN, WITH SPOTS, CHROMOSPHERE PROMINENCES, AND CORONA. *Page 25*

so cold that our Arctic winters would seem warm by comparison. It is very strange to think of this little world with one of its sides for ever bound in ice and darkness and the other for ever at the boiling-point; but there seems to be little doubt that this is its actual state. Beyond that we know very little about Mercury.

Sometimes in the evening, not long after the Sun has set, you may see, pretty low down near the horizon, a very bright star, shining with a lovely silvery light. This is the " star of the evening " that the song speaks about, and it is not really a star at all. It is the planet Venus, the world which comes next in order beyond Mercury, and travels round the Sun in a ring just inside that of our own world. There is no star in all the sky that shines so brightly as Venus does when she is at her brightest. I have sometimes seen her shining so brightly that her light cast a distinct shadow, and no star but Venus ever does that.

Now, so far as size goes, you might call Venus the twin sister of the Earth. She is only a little smaller than our world, and she comes nearer to us than any of the other worlds of our family. As she goes round the Sun in a circle inside our Earth's orbit, she appears first on one side of the Sun and then on the other, and so is seen as an evening or as a morning star turn about. And because she is between us and the Sun she shows what astronomers call " phases "—that is to say, she changes like the Moon, and is sometimes round and full, sometimes like a half-Moon, and sometimes just

a thin slip of light, like the New Moon. The planets that are beyond our world cannot do this. We always see them like full Moons, or nearly so ; but both Venus and Mercury change as I have said.

Of course, she is too far away from us for us to see her shape with the naked eye, but if you turn even a small telescope upon her you will see her gradually changing her appearance from week to week. And there are few things in the heavens so beautiful as Venus when she appears like a crescent Moon, for she shines just as if she were made of polished silver (Plate VI.).

How is it that she is so bright ? Well, strange to say, it is probably because she is always wrapped in thick clouds. You know the old proverb, "Every cloud has a silver lining" ; but did you ever think what it means ? It means that those days when our sky is all covered with dark clouds, and we have to sit moping in the house because of the rain, are the days when our world is shining far more brightly to the other worlds than on our bright, cloudless days. For all the planets, and our own world like the rest, shine by the sunlight which they throw back from their surfaces. And when we have dull, cloudy days, the light that doesn't get through the clouds is nearly all thrown back from the outer side of them, so that they shine to the other worlds almost as white as newly fallen snow. If the whole world were wrapped up in a great dark cloud, it would look from the outside just like a huge ball of snow.

Now, what we see when we look at Venus is just the "silver lining" of her clouds. All the time she looks so bright to us the people living on her—if there are any—are having dull, grey weather; and, as she never looks anything else but bright, they must have rather a wearisome time of it. Sometimes astronomers have seen faint grey markings on the brilliant white surface which she turns to us, and perhaps these were breaks in the clouds, or at least places where the clouds were thinner; but nearly always she is white all over. So that one fancies that Venus, just because she shines so bright to us, must really be a very dull world to live upon.

She takes 225 days to travel round the Sun, so that her year is not quite two-thirds as long as ours; but it is not at all certain how long her day is. Some astronomers think that she spins round in about twenty-four hours, like our own world; but others believe that her day is as long as her year—225 of our days. If that is so, then, like Mercury, she must always turn the same face to the Sun, and that face will always have daylight, and be very hot, unless the clouds help to keep it cool; while the other face is always dark and very cold. And that will cause another strange result. You know that the winds which blow on our Earth are mainly caused by the air at the tropics, which is heated by the Sun, rising as it grows warm, and the cold air at the poles rushing in to take its place. But if Venus always turns one face to the Sun, there must be a perpetual gale blowing from the

cold side to the hot side, and such a gale as we cannot imagine. But, after all, this is only guessing, for we do not really know how long her day is.

As Venus travels round the Sun, she sometimes comes right between his bright disc and our world. If her circle or orbit were exactly on the same level as ours, she would do this every time she comes round; but it is tilted up a little from ours, and so she only does it at long intervals. The occasions when she comes right between us and the Sun are called "transits." When one of these happens, Venus appears like a round black dot on the face of the Sun, and travels across it from side to side. It was by watching these transits that astronomers first learned to measure the distance of the Earth from the Sun, and so they used to be very important, though they are not quite so important now, because other ways of measuring that distance have been found out.

The last transit of Venus was in 1882, and I am afraid that none of us will ever see another, for the next one will not happen till June 8, 2004. But, although it is so far away, we already know the very hour and minute when the little black dot will begin to cross the bright edge of the Sun, and how long it will take to travel across and disappear at the other side.

CHAPTER V

THE HOME OF THE MAN IN THE MOON

If we were standing upon the planet Venus, and if her veil of cloud were drawn aside to give us a clear sky, we should see one very pretty sight. Shining brightly against the dark background of the sky would be what seems a double world, made up of one big bright star and a smaller star quite close to it. If we had telescopes, we should be able to make out a great many features of the bigger star. We should see that it had glittering white ice-caps at the poles, and that its whole surface was flecked over with patches of brown, and green, and blue; while here and there brilliant white patches would come and go, blurring the outlines of the other parts. We should see this prettily coloured world turning steadily round and showing us different aspects of its surface; and all the time the smaller world near it, which we would not be able to see quite so well, would be circling round the bigger one. The bigger world is the Earth we live upon, and the smaller one is the Moon; and the two together would make one of the prettiest pictures you can imagine in the sky of Venus.

Of course, we can never see ourselves as others see us in that fashion, but, fortunately, we can get a better view of the Moon than of any other body in the heavens, and we can see many most interesting and wonderful things upon her surface. Indeed, even a

small telescope will show you quite a number of the strange things I am going to tell you about, and it would be well worth your while to try and see them for yourself. You know that when the Moon is full she shows a globe spotted all over with bright patches and grey patches, and when you see these with the naked eye they seem to make up the picture of a man's face wearing a rather sad expression—our old friend the Man in the Moon. When you use a telescope, the man's face vanishes, and you see a great round silvery globe, very bright in some parts, and very grey in others, and altogether looking not unlike a badly peeled orange.

But it is not at full that the Moon is most interesting, but, rather, when she is just about half bright and half dark—say about a week to ten days after New Moon. Suppose, then, that we turn a telescope on her when she is like that. When you put your eye to the eye-piece, you find that the Moon has grown so big that it can't shine through the telescope all at once, and you have to take it in bit by bit. Look, now, at this piece near the middle of the flat edge. You see it is all full of great black holes, or, rather, it is all covered over with bright rings, which are full inside with black shadow, and look almost like the little cells in a piece of honeycomb. These are some of the mountains of the Moon, and very strange and wonderful mountains they are.

You know what a volcano is. We have some volcanoes on our own world—burning mountains that

throw up fire and smoke, and sometimes ashes and lava. Well, these ring-mountains on the Moon seem to have been once volcanoes like Vesuvius or Etna. They are all burnt out now, and no more smoke or fire ever comes from them ; but once, I suppose, they were all burning, and when they were the Moon must have been a most wonderful place, but very uncomfortable to live upon ; for its volcanoes are far bigger than any that we have on our world, and there are thousands upon thousands of them even on the half of the Moon which we see.

But besides these craters there are other wonderful things on the Moon. Here and there are long ranges of mountains, stretching sometimes for hundreds of miles across the surface. If you look at the photograph (Plate VII.), you will see a long, curved streak stretching down from below the middle of the Moon to the flat edge. That is one of the Moon's mountain ranges, called the Lunar Apennines. You can see it quite well on the Full Moon with the naked eye, and it makes the nose of the Man. But when you look at it with a telescope, you see the great peaks, some of them higher than Mont Blanc, shining almost as white as if they were covered with snow, and the long black shadows which they cast stretching for many miles across the plain, like the spires of some gigantic cathedral.

Here and there, too, there are tremendous clefts in the ground, some of them hundreds of miles long, and so deep that no one can tell how deep they are. You

have seen the ground cracking in hot summer weather, and opening up into long clefts. Well, these cracks on the Moon look very like that, and I fancy they were caused by the surface splitting as it cooled down from the tremendously hot state in which it once was. Altogether, then, you see the Moon must be a very strange place, with its thousands of dead volcanoes, and its long mountain ranges, and these great gulfs seaming its surface. Some of the mountainous parts of the world are wild enough, but we have nothing here that is anything like so wild and rugged as some parts of the Moon.

But if we could get to the Moon, and live there for awhile, we should find many other things that are even stranger than its mountains. Suppose that we could land on the central peak of that crater which you see in the photograph (Plate VII.) as a round bright spot, with streaks all round it, near the centre of the Moon. It is called "Copernicus," after one of the greatest of astronomers, and we alight on its peak just at dawn, when the sunlight is beginning to strike upon it. Look around you and see what a wonderful picture is spread before your eyes! Down at your feet is nothing but a great gulf of darkness, far blacker than any darkness that you ever saw on the world; for all our earthly shadows are softened and made lighter by the presence of our air, but on the Moon there is no air at all, or, at least, next to none.

Far away, all around you, about twenty-five miles from you on every side, there rises a great mountain

VENUS. *Page 30*

Drawn by H. MacEwen with 5-inch Refractor

wall, thousands of feet high, shining almost as bright as snow where the sunlight strikes its peaks. We are perched up about 2,500 feet above the blackness at our feet, but these mountains tower four times as high as that, and it is their great shadows that are making everything below us seem so black. Wait a little while, and, as the Sun begins to rise higher, these shadows grow shorter and shorter, and now you can see the plain so far below you that it makes you giddy to look down—a great flat plain, fifty miles from side to side, with these huge mountains all round it, and the peak we are on standing in the middle.

This is what a volcano on the Moon is like now. Think what a size it is! Why, if you could draw a circle round London that would take in Windsor on the one side and Rochester on the other, the whole of the country in that circle would go inside this crater where we are standing; and if you wanted to climb out over its mountain wall, you would have to pile Skiddaw on the top of Helvellyn, and Helvellyn on the top of Ben Nevis before you got a staircase big enough. And this is only a middling-sized lunar crater; there are many far bigger than Copernicus.

But, although the sights around you are wonderful, the sights you see when you look up to the sky are more wonderful still. You would scarcely recognize the starry sky that you used to see from the world, for, since the Moon has almost no air, the stars will shine far more brightly than they do to us, and for every one that you used to see from the Earth you may

see a hundred from the Moon. The Milky Way seems like a great broad pathway of golden dust, stretching right across the heavens, and all the star-groups that we used to know seem to be multiplied a hundred times over.

Then our own world hangs like a great moon in the heavens, only far bigger and brighter than the Moon ever seems to us. It is strange to think of our world, with its dark rocks and soil, shining like the Moon; but it does, and, as it is much bigger, it gives far more light to the Moon than the Moon ever gives to us. You can see the earth-light from our own world quite easily if you know when to look. Two or three days after New Moon you know that you can not only see the thin crescent of bright light, but all the globe, lying in the bright crescent as if in a cup, and shining with a dull rusty light. People call that "the old Moon in the young Moon's arms"; but it is really the light that our world throws upon the part of the Moon that has not come into the sunlight yet.

Standing on the Moon, you would see the great Earth slowly turning round once in every twenty-four hours, and changing, as the days go on, from full to crescent, and back to full again, all our continents, and seas, and islands passing before our eyes as the big globe spins upon its axis. But most wonderful of all would be the appearance of the Sun. For all those strange things that we heard of in the chapters about him—the spots, the red flames, and the white Corona—would be quite easily seen with the naked eye.

All the same, in spite of all the fine things to be seen from it, I do not think you would find the home of the Man in the Moon a pleasant place to live in for very long, for you would never be able to hear anyone speak, and all your talking would have to be done in dumb show. You know that sound requires air to carry it ; and on a world where there is next to no air you might fire any number of big guns, and yet you would never hear anything. And then you would find walking very strange, and would have to be very careful. The Moon is much smaller and lighter than the world, and so, since the weight of anything depends on the weight of the world where it is weighed, you would weigh up there only a sixth part of what you do now ; so your steps would be giant strides of 15 or 18 feet, and if you tried a jump, you would go flying 40 or 50 feet before you came to the ground again. Besides, the Moon's day is a fortnight long, and during all that time you would have no clouds to shelter you from the glare of the Sun, which would be far brighter than we ever know it here ; and the long night would be colder than we have any idea of ; so that altogether I imagine that we would be very glad to get away from the Moon, wonderful though she is, and back to our own quiet world again.

One of the most interesting sights that we can see in the sky is an eclipse of the Moon. We saw already how the Moon, as she travels round the Earth, sometimes comes between us and the Sun, and makes an eclipse of the Sun. But when she circles round to the

other side of the Earth, and gets our world between herself and the Sun, then she is eclipsed. She passes into the great shadow that the world throws away behind it into space, and it is a beautiful thing to see the dark shadow slowly stealing across the bright globe (Fig. 2 [2]).

Even when she is right in the middle of the shadow the Moon is not quite blotted out. For all round the world our air extends many miles upwards, and this air catches the rays of the Sun that come near the edge of the Earth, and acts upon them just like the lens of a telescope. It bends them in so that they fall upon the Moon; and so, though she is actually in the shadow of the Earth, she is still dimly lit up by these rays which have been bent by our air, and you can see the whole globe shining with a dull coppery-red colour (Plate I.). A total eclipse of the Moon is not a very uncommon thing. Any almanac will tell you when the next one will be, and you can watch it and see the curious sight of the great copper-coloured globe hanging in the darkened sky, and then gradually growing bright again as it passes out of the Earth's shadow.

Before we leave the Moon, it might be worth while to notice that there are other faces to be seen in it besides the Man. There is a smaller face quite well marked and easily seen if you have good eyes. It lies about the middle of the Full Moon, and you may try to pick it out for yourself. Some people find a donkey, and others a girl reading; but these are not

quite so easily seen. The Chinese say that the markings represent a monkey pounding rice ; while in India the natives see a rabbit ; and the Persians say that the Moon is like a great mirror, in which we see the reflection of the seas and continents of our own world. But perhaps the most interesting of all the faces is that called the " Moon Maiden," which is shown in Plate VIII. It can only be seen with a telescope, and only when the Sun happens to shine upon it in exactly the right way. I have only seen it a few times myself in many years; but perhaps some fine night you may get a chance to see this face of the Moon Maiden, with her long hair floating behind her, looking out from the cape of the Bay of Rainbows across the Sea of Showers.

CHAPTER VI

A RUDDY WORLD

Among the bright stars in our sky there are several which are distinctly reddish in colour. There is one, for instance, called " Aldebaran," in the constellation Taurus, or the Bull, which is quite orange-red ; and another, called " Antares," which you can only see low down in the south on summer evenings, which is even redder. But sometimes you will see a star which

is brighter and redder than any of these, and which, once in every two years or so, shines so brightly that you can scarcely help noticing it. This is the red planet Mars, which sweeps round the Sun beyond our world in a circle that takes him 687 of our days to travel. Mars is really only a little world, for he is not much more than 4,000 miles in diameter, just about half the size of our own Earth, and not quite twice as big as the Moon. But though he is so small compared with some of the other worlds of our family, he is one of the most interesting of them all, and more attention has been paid to him for a good many years than to any of the others.

There are several reasons for this, but the chief one is that, so far as we can see, Mars is the only planet in our system that is in the least like our own world, or is at all likely to have living creatures dwelling upon it. When you see him in the telescope, the bright red star that you saw with the naked eye expands into a broad red globe of a fiery orange colour. At the poles this globe is capped with patches of brilliant white, which stand out very brightly on the reddish ground that surrounds them ; and the red surface is marked all over with patches and streaks of a darker colour, which are generally of a sort of greenish-blue (Plate IX.).

Now, you can imagine that if our own world were seen from a great distance it might look not unlike that, though perhaps a little brighter in its colouring. And so people got into the way of talking about the

continents and seas of Mars, and maps were made in which these were named after some of the famous astronomers of our world. But the more Mars was studied, the more it grew plain that, whatever the red parts might be, the greenish patches could not be seas. They looked more like what you might see if you looked down from a balloon on a very uneven country covered over with trees; so that many astronomers came to believe that, if there was water about them at all, it was not like our oceans, but rather in the shape of marshy land clothed with vegetation.

Then, about thirty-five years ago, a great Italian observer astonished everybody by telling that he had discovered that the whole of the Red Planet was streaked over with a network of long, thin, dark lines. Some people could not see these lines at all, but many could, after they had once been found; and ever since then more and more have been discovered, until the map of Mars is quite covered with them.

These straight lines are the Canals of Mars, of which, I dare say, you have often heard. "Canals" is not a very good name for them, because, when we talk of a canal, we mean a great ditch, dug by human beings between two seas or two rivers, and filled with water so as to make a waterway; and no one really knows if the Canals of Mars are like that, or, indeed, what they are at all. If they are canals, then there must be some very wonderful engineers on Mars, for these streaks are hundreds of miles long, and several miles broad,

and there are dozens of them. The Suez or the Panama Canal would be an insignificant little scratch in the ground compared to them.

One famous American astronomer who has watched Mars carefully for many years has told us his opinions about the red world, and, if we can believe them to be true, Mars must be a very strange little world indeed. He thinks that there is very little water left on the planet, and that the great stretches of red which we see are mainly desert land. So the people who live on Mars have to be very careful and very skilful in their use of the little water they have. Most of it comes from the melting of the snows at the two poles during the long Martian summers, and in order to use this snow-water and spread it properly over the planet, the Martian people have dug all the great canals.

What we really see in the telescope is not the canal itself, which would be too narrow to be seen at such a distance, but the broad belt of trees and plants which would grow up all along the banks of the canal where there is water to nourish them. Here and there, where two or three of the canals cross one another, there are broad, round, dark spots. These he calls "oases," like the oases in the desert on our Earth; and he believes that these are the places where the people of Mars gather to live in the fertile land created by the canals.

There is one thing which seems to support this strange idea of Professor Lowell, and that is that as

THE MOON, SEPTEMBER 12, 1903. *Page 35*

From a photograph taken at the Paris Observatory

soon as the white cap at the pole of Mars begins to grow smaller, as if it were melting, the dark lines of the canals nearest to it begin to grow darker, just as though the trees and plants were all putting on their cloak of green leaves; and this darkening gradually spreads down over the whole planet. So you might imagine the people on Mars living in a dry, bare land all the long winter. Then, as the spring comes, the floods begin to rise in the parts near the pole, the sluices of the canals are opened one after another, and gradually the water is led right down to the Equator, bringing new life to the country for miles on either side of all the canals, just as the Nile does to Egypt. Mars is named after the God of War; but if all this is true, then its people must be, not only great engineers, but the most peaceable people you can imagine; for, you see, they cannot afford to quarrel with their neighbours for fear that the water-supply will be stopped.

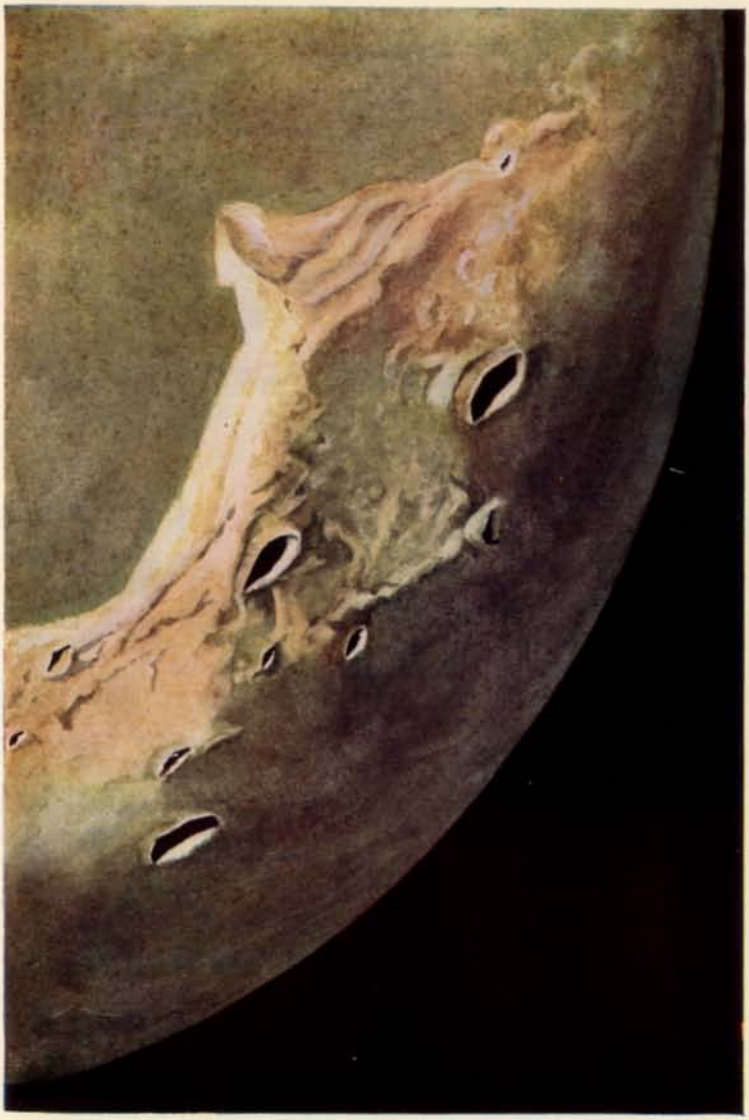
Only, you must remember that this is more or less fancy, for we really know very little about the meaning of these strange appearances on Mars. We can see them, and see the changes happening; but what causes them we do not know, and quite likely may never know. It is not even certain as yet whether there is water on Mars at all, though the polar caps look so like snow, and, of course, where there is snow, and the snow melts, there must be water.

So you see that, even with regard to Mars, we can scarcely say that there must be people living on that

ruddy little world. There may be ; but even if there are, they must be very different from ourselves. For Mars is so much smaller, and so much farther away from the Sun than our world, that people like us could scarcely live comfortably upon him. And as for ever learning what the Martians are like, or getting any messages from them, as some folks have fancied we might, that seems very far away indeed.

Yet, of course, it is not quite impossible, and as long as a thing is not impossible we must not be too sure that it will never happen. Strange to say, Mars gives us a warning about that. Down to the year 1877 the planet was thought to have no moons, and when Lord Tennyson wrote about "The snowy poles of moonless Mars," he was only saying what everybody believed.

But long before, in the time of Queen Anne, Dean Swift wrote a book which perhaps you have read—"Gulliver's Travels"—and in it he told how the astronomers of Laputa were so clever that they had discovered two moons circling round Mars, one of which went round its parent-world in ten hours. Of course, this was looked upon as only another of Swift's wild fancies, for no one ever heard of a moon going round its parent in a shorter time than the parent's day, and Mars takes about twenty-four and a half hours to spin round upon his axis. But in 1877 it was found that Mars had two moons, and that one goes round even faster than Gulliver said, taking only seven hours and thirty-nine minutes to complete its journey. I



THE MOON-MAIDEN. *Page 41*

expect Dean Swift would have been very much surprised if he could have heard how nearly true his careless jest had proved.

These little moons of Mars are very tiny indeed: neither of them can be much more than ten miles in diameter. Astronomers call them "Phobos" and "Deimos," or "Dread" and "Terror." If you happened to live on either of them, you would find that you weighed almost nothing, for the power of gravity, which makes your weight, would be very small on such a little world. You would have to be very careful about jumping or skipping; for if you were too lively you might jump off your world altogether, and how you would get back again I don't know.

Altogether, with his red and green markings, his snow-caps and canals, and his curious little moons, the Red Planet is one of the most interesting objects in the heavens. Every two years, as he sweeps round outside our world, he comes into a position where we can see him well. Whenever that happens, astronomers all over the world watch him eagerly, and try to find out more about him; and we may hope that, since so much has been learned already, we may before long come to understand yet more about this wonderful little world.

CHAPTER VII

A GIANT WORLD

BEYOND the orbit of the Red Planet there stretches a vast space very much greater than any that we have yet travelled over. On our way across it, we pass through a perfect swarm of tiny little worlds which are known as the " Asteroids." The very biggest of them is less than 500 miles in diameter, and some of them are so small that they can scarcely be seen, even with very powerful telescopes. There are hundreds of them, and for the last four or five years fresh ones have been found at the rate of about one hundred a year. How many of them there really may be nobody can tell.

Outside of them, in a great circle which he takes between eleven and twelve years to travel round, rolls the giant world Jupiter, by far the biggest and most splendid world of our family. He is more than 1,300 times as big as our world, and all the other planets of the Solar System rolled into one would not make a world as big as Jupiter. His light is not so brilliant as that of Venus, being more of a beautiful golden yellow, instead of clear silvery white ; but when he is at his brightest, he shines far more brilliantly than any other star in the sky.

But when we look at him with the telescope, we find that we are dealing with a very beautiful and wonderful world indeed. Jupiter is so big that even a

MARS, WITH POLAR SNOW-CAP, CANALS, AND OASES. *Pages 42-43*

small telescope will easily make him look as large as the Full Moon looks to the naked eye, and the broad bright disc which he presents to us is very beautifully coloured, and shows a number of very interesting features. The first thing that you will notice when you look at him with the telescope is that his globe is not round. You know that our own world is flattened a little at the poles; but the flattening of Jupiter is much more easily noticed. Though he is so vastly bigger than the world, he spins round in less than ten hours, and, instead of being made of materials as heavy as our rocks and soil, he is not much more solid than water. And so he has gradually flattened out until he measures about 5,000 miles more from side to side along his equator than he does from pole to pole.

Look a little more closely at the broad yellow globe, however, and you will begin to see some other interesting things. Right across it from side to side stretch several broad dusky bands quite differently coloured from the rest of the planet and from one another. Very often you will see a deep reddish-brown belt on one side of the equator, and a grey-blue one on the other, while the central part of the globe is sometimes pale yellow, flecked all over with what look like little round white clouds. Farther north and south, as you get nearer to the poles, are other narrower belts of different colours, and often the poles themselves are covered with caps of pale blue or grey, or with a number of narrow streaks of these colours. Altogether there is no world in our family that shows so

many beautiful colours as the giant planet does, and this makes him a very pretty picture when he is viewed with a good telescope (Plate X.).

But still more wonderful is the fact that these coloured belts never remain quite the same for very long. They are always changing, more or less, and the face of Jupiter may look very different one season from what it looks the next. You would think it very strange if our world were to behave like that—if our continents and seas were to move about and to change their places. But that is what is always happening on Jupiter. And, of course, it means that what we are seeing on this great world is not anything solid, like our land, but more likely great masses of cloud and vapour that are thrown up by eruptions from the depths beneath, and trail out into long belts as the planet spins round. In fact, I do not suppose that we have ever really seen Jupiter at all. The real planet, very much smaller than the globe we see, and tremendously hot, lies deep down within the shell of clouds that he has thrown up around him. Very likely there is no solid ground at all. The whole surface is more like that of the Sun, and is constantly being torn and disturbed by great eruptions of the fires within.

So that it is not at all likely that Jupiter has anybody living on him. He is a world still in the making, and it may be thousands or millions of years before he becomes fit to be the home of any living creatures. By-and-by, of course, he will gradually cool down and

become more solid. His great cloud-belts will grow thinner, and he will likely shrink down a good deal from his present size; but how long that will take to happen nobody can tell. At present he is much more like a small copy of the Sun than a world such as our own.

Indeed, the likeness is so complete that Jupiter does not spin round all in one piece any more than the Sun does. You remember that the parts of the Sun near the equator spin round in twenty-five days, while those farther north or south take two days longer. Well, if you were to watch one of the white spots on Jupiter's equator, you would find that it goes round in nine hours and fifty minutes; but if you watched a spot half-way to the north or the south pole, you would see that it takes five minutes longer. Five minutes does not seem a great deal, but it means that the spot at the equator is moving, perhaps, hundreds of miles an hour faster than its neighbour farther north.

A number of years ago a great red spot appeared on Jupiter's face, and ever since 1878 it has been very carefully watched by astronomers. During all these years it has been continually changing—sometimes glowing bright, as though a great red fire were being stirred away down beneath it, sometimes fading away until one could scarcely see it at all; and besides changing its colour, it has changed its position and its speed, so that it now takes a little longer to go round about Jupiter than it did when it was first seen

Altogether, then, you see that Jupiter is a very strange world, and very different from any of the other brothers and sisters of the Sun's family that we have yet looked at. But we have not done with his wonders yet. Look at him again, and you will see that there are four bright little stars close beside him, all nearly in line with his equator. These are the four largest of his moons, for Jupiter, instead of having only one attendant, like our world, has nine little moons constantly whirling round him. The four largest were discovered almost as soon as the telescope was invented, and you can see them even with a good field-glass. Even the least of the four is rather larger than our Moon, and the biggest of them is half as big again. The other five have only been found within the last few years, and are very small and faint.

But even the four that can be easily seen make a beautiful picture as they circle round their parent-world. Sometimes one of them will come between Jupiter and the Sun, and then, as you watch, you see a tiny round black dot beginning to creep across the bright face of the planet. That is the shadow of the little moon, and wherever it passes there is a total eclipse of the Sun to that part of Jupiter. In a little while the black dot will be followed by the moon itself —a brilliant white spot, which travels slowly behind its shadow from side to side of Jupiter's broad globe. As this moon is making its transit, another may be seen quickly losing all its light, and disappearing from

JUPITER, WITH ONE OF HIS MOONS, AND A MOON AND ITS SHADOW IN TRANSIT. *Pages 50-53*

view. It is passing into the great shadow which Jupiter throws behind him, and is undergoing a total eclipse. So the four moons go on, perpetually changing their places as they revolve, and one need never weary of watching the giant world and his attendants, for there is always something happening, either on the big globe itself or among its little companions, to arrest the attention and interest the observer.

CHAPTER VIII

THE WORLD WITH THE GOLDEN RINGS

When the first telescope was invented, 300 years ago, Galileo, who made it, discovered one thing in the heavens which was a terrible puzzle to him. He had found out with his new telescope the mountains in the Moon and the spots on the Sun, had watched Venus going through her phases, and had seen the moons of Jupiter and the dark cloud-belts across him; but when he turned his telescope on Saturn, which is the next world beyond Jupiter, he could scarcely believe his eyes, for, instead of one globe, he seemed to see three. For awhile he really believed that Saturn was a triple planet; but a few years later, when he came to observe it again, it

had quite changed, and looked just like a plain single globe.

Poor Galileo was much perplexed, and began to think that perhaps his telescope was playing tricks on him, as his enemies had said all along. Indeed, it is said that he was so vexed and disappointed that he never looked at Saturn again. If that is true, it was a great pity, for in a short time he would have seen the wonderful appearances that had astonished him coming back again, and perhaps might have found out what they really were.

For many years after that astronomers puzzled over the curious appearance of Saturn, which sometimes looked almost like a triple planet, and sometimes like a globe with handles to it. At last a Dutchman called Huygens found out the secret, which was that this great world, nearly 700 times as big as our Earth, has a great ring, or, rather, as we know now, three rings, continually whirling round it. There is no other world in our family that has anything the least like these strange rings of Saturn, and they make him, perhaps, the most wonderful and beautiful sight in all the sky. The picture will give you some idea of his appearance, but no picture can ever be half so beautiful as the actual sight of the great shining globe lying in the centre of its golden rings (Plate XI.).

In himself, Saturn is not at all such a remarkable object as Jupiter, though he is very like his big neighbour in some respects. He is even less solid than Jupiter, and, in fact, is so light that if you could get

an ocean big enough to hold him, he would float in the water like a piece of wood. Like Jupiter, too, he seems more like a small copy of the Sun than a solid world, for he does not spin round in one piece. He has great cloud-belts stretching across him, very much like his neighbour; but, as he is smaller, and twice as far away from us, we cannot see them so well. His colours, too, are not nearly so bright or so varied as those of Jupiter.

But the wonder of the rings more than makes up for everything else. They do not touch the planet at any point, but are separated from it by a space of about 6,000 miles. Beyond this gap there comes, nearest to the globe, a dusky, greyish ring, looking almost like a piece of crape against the sky. At its outer edge the crape ring brightens a little, and passes into a great broad bright ring, the brightest part of the whole system. Then comes a narrow dark gap, very sharp and black, looking as if you had drawn a broad line with a pen and ink right round on the bright surface of the ring; and beyond this gap lies the outermost ring, not so bright as its neighbour, but brighter than the crape ring. Beautiful as the rings look, we are so far away from them that we can scarcely realize how huge they are. If you could put a motor-car on the outermost one, and run right round it at the speed limit, keeping close to the outer edge, it would take you more than three years to complete your journey. Yet they are so thin that, when they turn edgewise to us, only the most powerful telescopes will show

them at all. They measure 172,000 miles from side to side, nearly as much as seven times round the world; but they are not more than fifty miles thick. This page is thicker compared to its breadth than Saturn's rings compared to theirs. So, you see, it is quite impossible that these great rings should be solid. If they were, they would fall to pieces at once, even though they were made of the toughest steel. Instead of being solid, they are made up of millions of little moons, each circling round Saturn in its own orbit, but all keeping so close together that from our distance they look like a solid mass.

It is rather difficult for us to imagine anyone living on a world which is not so solid as water, and which, in all probability, is intensely hot. But if there are any inhabitants living on Saturn, they must have a very wonderful sky to look up to at night. The stars they see will, of course, be very much the same as those we are familiar with. But the rings will be the marvellous sight—at least, from those parts of the planet where they can be seen high up in the sky. They will stretch from horizon to horizon like a great triumphal arch of bright golden light, with the great shadow of the planet lying dark across it, and shifting gradually as the night goes on. Of course, this brilliant arch can only be seen when the sun is shining on that face of the rings which is turned towards the observer on Saturn. At other times the rings will be quite dark, and will seem to blot out the stars in those parts of the sky across which they stretch. And there

are some parts of the planet where the great arch will shut out the sunlight for nearly six years, except for such glimpses as can be got through the great gap between the outer and middle rings. One fancies that it would be rather dull to have to live on these parts of Saturn, and that even the beautiful sight of the golden arch can scarcely make up for the long months of darkness.

Besides his rings, Saturn has no fewer than ten moons continually circling round him. One of these, called Titan, is very bright and big—probably nearly twice as big as our own Moon. Another, called Japetus, always shines much more brightly when he is at the western end of his orbit than when he is at the eastern end, so that it looks as if one side of him must be made of much darker materials than the other. The ninth moon—a tiny little thing called Phœbe, which was only discovered a few years ago—is notable because it goes round in exactly the opposite way from all the others.

You know the way in which the hands of a clock go round. Well, all the worlds of our family that we have seen so far, and all the moons that belong to them, go round the opposite way to the hands of the clock. Both in their journey round their orbits and in their spin upon their own axes they take this counter-clockwise way. Nine of Saturn's little moons do the same; but Phœbe has struck out a way of her own. She travels round Saturn in the opposite direction—the same way as that in which the clock-hands travel round the

dial; and though she is too far away and too small for us to tell how she spins, it is likely that in that also she disagrees with the rest of her companions.

Altogether I do not think that there is a more lovely picture to be seen in all the heavens than Saturn, with his three rings and his moons; and it would be well worth your while to take some trouble to get a glimpse of him. You would never forget the sight. The broad golden globe, with faint shadowy bands stretching across it, and the wonderful triple ring like a girdle around it, moves slowly and majestically across the field of the telescope. On either side the moons, like faint dots of light, steadily pursue their journey round the great world to which they belong. Sometimes, when the ring is turned nearly edgewise to us, and seems like a bright rod standing out on either side of the planet, you can watch the little moons travelling along in a line with it, and looking like pearls strung on a golden wire, while now and again they pass into the shadow of their parent-world, and fade away out of sight for a time in eclipse. It is all so unlike anything that we can see elsewhere in the heavens that it never loses its charm.

Saturn's year is equal to about twenty-nine of our years; but his day is much shorter than ours, though not quite so short as that of Jupiter. He takes a little more than ten hours to spin round upon his axis. As he travels round the Sun, we see the rings at all sorts of different angles. Sometimes they turn their edges to us, and then they gradually tilt towards us again,

and seem to become broader and broader, till, when they are most widely opened, Saturn seems to lie in them just like a pudding in a plate. Just now, and for some time to come, they can be very well seen, as they are pretty widely opened, just as you see them in the picture.

CHAPTER IX

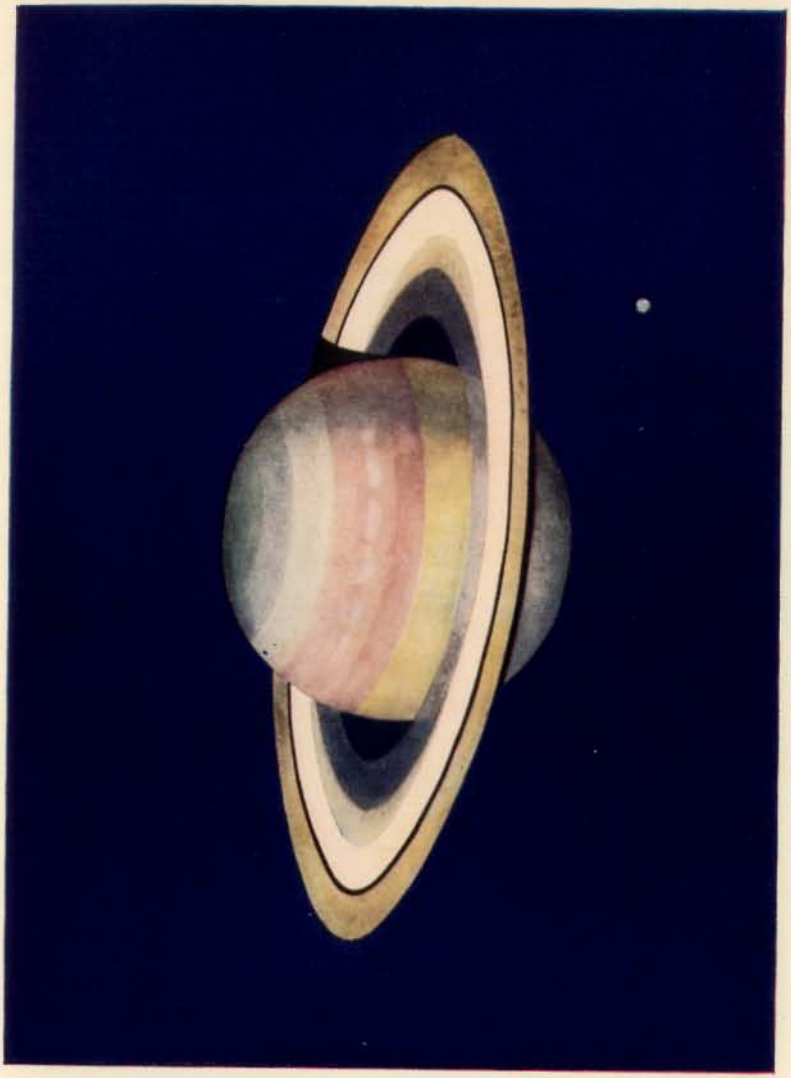
TWO LONELY WORLDS

THE various worlds that we have been looking at were all known to star-gazers as far back as there is any history at all; but no one ever suspected that there were any more worlds in the Sun's family until the night of March 13, 1781. At that time there lived in England a Hanoverian musician named William Herschel, who was organist of the Octagon Chapel at Bath. He was very fond of astronomy, and when his musical work was done, he used to come home and get out his home-made telescope and scan the starry sky. On this night of March 13 he was looking at the stars in the constellation called "Gemini," or the "Twins," when his attention was fixed by one small star which seemed a little different from the others.

You know that the fixed stars are so far away that even the most powerful telescope cannot make them

seem any bigger. It will show you far more stars than you can see without it ; but each star remains just a tiny round dot of light, brighter or fainter, as the case may be. On the other hand, the planets, though they are far smaller than the stars, are so much nearer to us that a telescope makes their broad globes quite visible. Now, this star which Herschel saw seemed to be bigger and hazier than its neighbours, and so he at once suspected that, whatever it might be, it was not a fixed star. Observing it again on the nights which followed, he found that it was moving among the other stars. Still, he never imagined that he had found a new world, but merely thought that the strange star must be a faint comet. Very soon, however, it became plain that Herschel had found something much more important than any comet, and the self-taught astronomer of Bath had the honour of having widened the bounds of the Solar System by the discovery of another world.

Strange to say, when astronomers began to inquire whether the new planet had ever been seen before, they found that it had been observed no less than nineteen times, but nobody had ever suspected that it was anything out of the common. One French astronomer had actually seen it on twelve different occasions, and, if he had only taken the trouble to compare his observations with one another, he would have had the glory which fell to Herschel. But the poor man had been very careless about his records. One of his observations of this very object was actually



SATURN, WITH ONE OF HIS MOONS. *Pages 54-58*

written on an old paper-bag which had once held the powder with which people in those days used to whiten their wigs! And so, through his carelessness, he lost the honour that he might have gained.

Herschel wished to call his new planet the "Georgium Sidus," or the "Georgian Star," in honour of King George III., who was reigning at the time; but nobody liked this clumsy name, and at last the new world was named "Uranus," after the god whom the Greeks believed to be the father of Saturn. Uranus is so far away from the Sun that he takes eighty-four of our years to complete his great annual journey. His distance hinders us from seeing him very well, and, besides, he is not nearly so large as either Jupiter or Saturn, though much larger than our own world.

The curious thing about him is the way in which he spins round. The other planets of the Sun's family spin very much like tops, standing nearly erect; but Uranus turns round like a top rolling on its side.

Herschel not only found out the new planet, but quickly discovered that it had two little moons, and thought that he had found four more. But these other four did not really belong to Uranus, and must have been only faint stars which happened to be near him at the time. Since then, however, astronomers have found two more moons attending on Uranus, so that he has four altogether.

Once this new world had been found, of course it was watched very closely. The orbit in which it should travel round the Sun was carefully mapped out, and before very long it began to be plain that there was something wrong. Uranus was not travelling round his path exactly as he should have done, and, though the differences were small, it was evident that there must be something to account for them. Now, the only thing that could make the difference was that some other planet, not yet discovered, must be circling round beyond him, and drawing him out of his proper path. So astronomers began to calculate where such a planet ought to be in order to produce the effect which they saw.

A young Cambridge student called Adams began the calculation on this side of the Channel, and a Frenchman called Leverrier undertook it on the other side. Neither of them knew what the other was doing, and yet they both arrived at almost exactly the same result. Adams was the first to be finished with his work; but there was some delay in accepting his results, and when at last the great telescope at Cambridge was used to search the part of the sky where he supposed the unseen planet to be, the observer in charge of it took a very slow, though a very sure, way of searching. And so, before the search was completed, Leverrier had finished his calculations, and sent them to the Berlin Observatory, and Dr. Galle had found the new planet. It was a great disappointment to the English astronomers, but, all the

same, it was a very wonderful thing that these two young men, quite independent of one another, should have been able, merely by calculation, to find out the existence and the position of a world that no human eye had ever yet seen.

The new world was called "Neptune." Apart from the romance of his discovery, there is nothing very wonderful about him—at least, nothing that we can see across the enormous distance which separates us from him. That distance is so great that, if we could travel towards Neptune at the rate of sixty miles an hour, it would take us more than 5,000 years to reach him. He is much the same size as Uranus, and spins round in a very similar fashion; while, like all these large outer planets, he is made of very light materials. It takes him 165 years to sweep round the Sun, and one fancies that both Uranus and he must be rather lonely worlds, away out there in the depths of space, with no near neighbours in the sky.

If you lived on Neptune, for instance, instead of seeing all the other worlds that I have been telling you about, you would not be able to see any planet nearer to the Sun than Jupiter. Even Jupiter you would only see like a morning and evening star—much as we see Mercury. Saturn and Uranus would be the only worlds that you would see fairly well.

It has been suspected that there is another world away out beyond Neptune, and searches have been made for it several times; but, if it exists, it is still undiscovered. So far as we know, Neptune is the

most distant member of our family—a lonely sentinel, keeping watch and ward over the frontiers of the Solar System, with only his one moon for company, and travelling his long round in what would seem to us almost utter darkness, for the Sun can only give him about one nine-hundredth part of the light that it gives to us.

CHAPTER X

PILGRIMS OF THE SKY

One day in January, 1910, a telegram came from South Africa, saying that a bright comet had been discovered there, and that it was visible to the naked eye. Watching the evening sky close to where the Sun had set, one soon saw a faint, long, narrow beam of light stretching upwards, and gradually fading away into the blue of the heavens. Night after night for some time it grew longer and brighter, and, as the skies were fortunately clear, it could be seen every evening after sunset, looking more and more like a great ostrich feather. With the telescope one could see the bright round dot which formed its head, and the fiery mist streaming out from the head towards the Sun, and then swept away backwards to form the tail, just as the foam is driven up from the bows of a

GREAT COMET OF 1910. *Pages 64-70*

steamship and swirls away behind into her wake. But the naked-eye view was far prettier than anything that could be seen with the telescope. Venus was shining close beside the comet in the frosty winter sky, and her clear silvery light made a most lovely contrast with the faint creamy feathery tail of the stranger. This beautiful visitor is known as the "Great Comet of 1910," or, as astronomers call it, "Comet *a* 1910," and it was the finest that has been seen in our country since 1882, though our friends at the other side of the world have seen some others that we have missed (Plates XII. and XIII.).

Now, no one who saw this comet of 1910 could help wondering at it, and asking what it was, where it came from, and where it was going. So I must try in this chapter to tell you a little about comets, these strange pilgrims of the sky that come wandering in towards the Sun, sweep round him, and then wander away again, some of them to distances so great that we can scarcely imagine how far they go.

The word "comet" just means a hairy star; and the idea that most people have of a comet is that it is like our visitor of January, 1910—a hairy star, with a great long tail streaming behind it through space. But there are comets of all sorts and sizes. Most of them can never be seen with the naked eye at all. They are faint little fuzzy balls of light, which come drifting in towards the Sun, sometimes shooting out a faint tail as they come near him, sometimes scarcely managing to make a tail at all, and never getting very

bright. Then, when they have passed round the Sun, they gradually drift away from him, losing a great deal of the little light they had, and are soon lost to sight altogether.

Nearly every year several of these little comets are found, but they are so dim that no one notices them except the astronomers who are interested in such things. Yet they are of the same nature as the great fiery streamers that astonish the whole world; and sometimes more has been learned from a very small comet than from some of the biggest ones. But certainly the big ones are more interesting to look at.

A great comet is so big that it is difficult for us really to get an idea of its size. The January comet of 1910 had a tail that reached for more than 100,000,000 miles across the sky. If its head had touched the Sun, its tail would have reached right across to our world, and the end would have waved 7,000,000 miles beyond us. And there have been comets with tails far longer than that. Long ago, before people knew so much about the heavens, it used to be thought that comets were sent to foretell all sorts of dreadful things—plagues, and earthquakes, and wars, and the death of Kings, and so forth. One old poet has given us quite a list of the terrible things threatened by them:

"A Blazing Star
Threatens the World with Famine, Plague, and War;
To Princes, death; to Kingdoms, many crosses;
To all Estates, inevitable losses;
To Herdmen, rot; to Ploughmen, hapless Seasons;
To Sailors, storms; to Cities, civil treasons."

And another wise man says that "a comet like a sword, portendeth war; and an hairy comet, or a comet with a beard, denoteth the death of Kings."

Then, when men ceased to make the comets into bogies in that fashion, they grew afraid that perhaps some day a great comet would dash against the world, and that everything and everybody on earth would be destroyed in the collision. But I think we can set our minds at rest about that, too; for comets are made of such extremely thin and light materials that, if we did meet one, the chances are that it would suffer far more than the Earth. In fact, we did once pass right through the tail of a very big one—the comet of 1861—and it made not the slightest difference to our world.

But, instead of believing all these foolish things about comets, men have been studying them, and learning more and more about them; and, though there is a great deal still unexplained, we know a number of very interesting things about these strange visitors. We know, for instance, that many of them—possibly all of them, but certainly very many—come back again and again to the Sun. In fact, they travel, each one on a certain path of its own, which must bring it back again, however far away it may go. The comets which do this are called "Periodic Comets," because they make their journey in a fixed period. And when once that period has been calculated, astronomers can tell you the time when such and such a comet will pass round the Sun again almost

as certainly as you can tell from a time-table when your train is due.

The first comet that was actually found to be a regular visitor to the Sun was Halley's Comet, which made such a stir in the spring of 1910, and disappointed so many of us. In the year 1682 a fine comet was seen, and Halley, a famous English astronomer, though he only saw it once, and not very well then, was much interested in it, for this reason: that, when calculating the paths of a number of comets, he found that either this one or else one which followed exactly the same path, had appeared three times in the 200 years before. Soon he became sure that it was the same comet which came back every seventy-six years, and ventured to prophesy that it would return in 1759, saying: "If the comet returns in accordance with my prediction, posterity will not forget that this first prediction was made by an Englishman."

Halley did not live to see the return of 1759, though he died not very long before; but the comet duly appeared up to time, and rounded the Sun within a month of the date predicted. It came back again in 1835, this time coming within a few days of the time-table which had been drawn up; and in 1910 the time-table proved more accurate still.

But we know now that this wonderful wanderer was not making its first appearance at the time to which Halley traced it back. It has been followed for century after century, and records of its appearance

PLATE XIII

GREAT COMET OF 1910. *Pages 64, 65*

From a photograph taken by Professor Lowell, Flagstaff Observatory, U.S.A.

have been found which go as far back as 240 B.C. Of course, it may have been coming and going for long before that. But at least for more than 2,000 years this strange visitor has been travelling through space, coming up to our Sun every seventy-six years or so, and then wandering away again into the darkness, growing dimmer and smaller as it goes, till it is lost to sight once more.

One of its returns is very interesting to us. In 1066, when William of Normandy was getting ready to invade England, a wonderful flaming star appeared in the sky, and people were greatly terrified by it. After the Battle of Hastings everybody believed that it had been the herald of William's victory and Harold's overthrow. So, when the Bayeux Tapestry was worked, which tells in needlework the whole story of the Conquest, the flaming star was pictured on it—a wonderful thing, with a head of red and blue, and fiery streamers of different colours, while people stand below pointing to it, and the words are written beside it in Latin: "These are wondering at the star." Now we know that this terrible star of the Conquest was one of the returns of Halley's Comet.

Very likely you saw Halley's Comet in the spring of 1910, and thought very little of it. Though it was not very well seen in this country, it was a fine sight in some other lands, as the photograph will show you (Plate XIV.), and it had a tail of tremendous length—one of the longest that has ever been seen. But, after all, it is not the appearance of the comet that is so

wonderful ; it is the fact that it comes back so regularly from its long journey.

Just think what a journey it is ! The comet passed the Sun in April, 1910. Already it has travelled away out beyond where Jupiter rolls on his great path. About twenty years hence it will cross the lonely track of Neptune. But it will not stop even then. For sixteen more years it will travel on, always going slower and slower, and growing dimmer and dimmer, as it gets farther away from the Sun. Then it will turn, and begin to retrace its steps, gradually gathering speed again as it draws nearer, until the astronomers of 1986 welcome its return once more.

Of course, there are some comets which do not make nearly such a long journey as this. One little thing, called " Encke's Comet," travels round and round, like a suburban train, in a path that only takes three and a half years to complete ; and, though this is the shortest period known, there are many other comets which take quite a short time on their journey. But, then, there are others which travel very much farther than even Halley's Comet. The great comet through whose tail we passed in 1861 takes 409 years to make its long voyage through space ; and even that is far from being the longest period known.

In 1858 there appeared a splendid comet, known as " Donati's," from the name of the Italian observer who discovered it. It was, perhaps, the most beautiful,

though not the largest, comet that has ever been seen. When its path through the heavens was traced out, it was found that it takes more than 2,000 years in the tremendous journey. Donati's Comet was lost to sight more than fifty years ago, as it hurried away back to the cold depths from which it came; but still it is only at the start of its great voyage. A thousand years hence it will be just ready to turn and come back, and if there are still astronomers on the earth watching the heavens about A.D. 3900, they may see it again, with its magnificent plumy tail stretching across half the sky! One cannot imagine the depths of space in which it is plunged.

So you see that comets are very wonderful pilgrims indeed. The worlds that go round our Sun are called "planets," or "wanderers"; but the name might be far more truly given to the comets, for they are the real wanderers of the heavens.

But what is a comet really? Well, I expect that, if we could get near enough to one to see how it is actually made, and what happens to it, we should see something like this: The head of the comet, which looks like a bright star, would really be like a great swarm of bees; only the bees would be things something like pebbles, and while they all travelled along together, there would be wide spaces between them. When it was far away from the Sun, the comet would be nothing but this swarm of pebbles, and would look quite dull and faint. Then, as it came nearer, it would begin to glow and get brighter; and then, in some way that

nobody quite understands, the Sun would begin to send an electric current through it, and the swarm would throw up great jets of fiery mist, which would stream away behind it, just as the smoke of a steamer is driven back by the wind. If we could follow our comet century after century, we should see it gradually wasting away, and perhaps splitting up into two or three little comets. And by-and-by it would vanish, and never be seen again at all—at least, not as a comet.

But it would still leave something behind it to remind us of it. You have seen a shooting-star flashing across the sky at night, like a bright streak of light. Well, sometimes these shooting-stars, instead of coming singly, come in showers. In November, for instance, there is a shower which sometimes sends us hundreds of these bright visitors in a single night. And we know that this shower which comes in November from the constellation called "Andromeda," or the "Chained Lady," is all that is left of a comet that came several times round the Sun, and was last seen, split up into two, about the middle of last century.

I think that is what happens to all comets in the end. The great swarm that makes up the head gets gradually scattered out along the path in which it travels, till at last we cannot see it any longer as a single mass. It is just a long string of pebbles, stretching for millions of miles, perhaps, along its old track. But when our Earth, as it rolls along through space,

crosses the path where these pieces of the old, worn-out comet are travelling, it draws them to itself ; and they rush down through our air, getting hotter and hotter as they rub against it, until at last they are quite burnt out. And so a shooting-star is just one of the pieces of what may once have been a great and wonderful comet.

Of course, there are some shooting-stars which do not seem to have ever belonged to any comet. The big ones that come singly, and that sometimes fall down upon the earth, still quite hot from their rush through the air, seem to travel through space on their own account, and nobody can tell where they came from to begin with. But the great showers where hundreds of little shooting-stars are to be seen darting across the sky, and all getting burnt out before they reach the earth, are all relics of old comets that have been wandering for no one knows how long, and have gradually got worn out with their long journey.

CHAPTER XI

THE CONSTELLATIONS

Now that we have had a peep at all the worlds in the Sun's family, it is time to look for awhile at the stars. You must remember that now we have to think, not

of worlds, which may be bigger or smaller than our own, but of great fiery globes like the Sun. And though you may think that the distances we have been talking about are very great, they are nothing compared with those that we have to deal with when we come to the stars. All that, however, we shall speak about later.

In this chapter I want to tell you a little about some of the chief groups of stars in the sky, and how you may know them when you see them. We can only mention a few of these groups, but once you have learned these, you will find it easy to trace out the others from them. Whenever you look at the sky, you see that the stars are not spread out evenly over the whole space : they are gathered into groups of all shapes and sizes.

Many hundreds of years ago people who studied the stars fancied they saw all sorts of figures among them—figures of men, and beasts, and dragons, and ships. They named the star-groups after the figures which they imagined they could trace, and these names of the constellations, as they are called, have come down to us, and give us the handiest way of referring to any star we want to speak about. Just as you refer to a town by mentioning its name and the country that it belongs to, so you refer to a star by mentioning either its name, or, if it has not got a name, the letter of the Greek alphabet, or the number by which it is known, and the constellation to which it belongs. Some of the constellations are not very like the things whose

names they bear, and some are ridiculously unlike them ; still, there are a few which have a likeness, and, anyhow, the names have got so fixed to these particular groups of stars that nobody would dream of changing them now.

If you turn to the first little map inside the cover, you will see three of the star-groups that are easiest to learn, and that are always to be seen when you look to the northern sky. First of all, look at the group called the " Great Bear." Of course, you must remember that there is no figure the least like a bear to be seen in the sky. What you will see at once is the set of seven bright stars which begins at the end of the Bear's tail. It is generally called the " Plough," and, really, it is not unlike the shape of a plough, with the long handle sticking out to the left. Some people call it " Charles's Wain," and the Americans call it the " Dipper." Now look at the two stars at the front of the Plough which are marked the " Pointers." If you draw a line from one to the other, and continue it upwards, you will find that it leads you quite close to a fairly bright star which is in some ways the most important in all the sky. It is the Pole Star, and, as you learned in the first chapter, it never seems to move, but all the other stars appear to turn round about it. The Pole Star is the last star of another group which is just like a small copy of the Plough, only turned the opposite way, and this group is called the " Little Bear."

On the opposite side of the Pole Star from the

Plough, and about the same distance from the Pole, you will see a group of bright stars shaped like a W. This is part of the constellation called "Cassiopeia," or the "Lady in the Chair." These are all the constellations shown in our little map; but it is easy to trace out some others which are near them. Cassiopeia, as you will see when you look for the W in the sky, lies on the course of the Milky Way. If you follow the Milky Way to one side, you come to Cepheus, which is not a very interesting group; but if you go to the other side, you come upon a bright group of stars called "Perseus," and beside Perseus, but outside of the Milky Way, lies Andromeda, or the Chained Lady. Andromeda is rather badly marked, but you may know it by a line of three pretty bright stars which lead to a great square formed by four bright stars. The great square, which you will easily recognize, is part of the constellation called "Pegasus," or the "Winged Horse."

Now, all these names belong to an old Greek story which tells how Andromeda, the daughter of King Cepheus and Queen Cassiopeia, was chained to a rock on the shore, to be devoured by a sea-monster, and was saved by the hero Perseus. Cetus, the sea-monster, has also been made into a constellation; but he has no very conspicuous stars. Most likely you have read the story of Perseus and Andromeda, and it may interest you to see the figures in the heavens that represent the beautiful old tale.

Following the track of the Milky Way in the

PLATE XIV

HALLEY'S COMET. *Pages 68, 69*

From a photograph taken by Professor E. E. Barnard, Yerkes Observatory, U.S.A.

opposite direction, you pass Cepheus, and then you come upon a group of stars which looks like a great cross in the sky. This is Cygnus, or the Swan. Not far from it you will see a very bright white star—far the brightest in this part of the heavens. Its name is Vega, and it marks the constellation Lyra, or the Lyre. Vega is a very beautiful star, but the most interesting thing about it is that it marks the point of the sky towards which our own Sun, with the Earth and all the other worlds of our family, is travelling at a speed of more than 1,000,000 miles every twenty-four hours.

Turning again to the Plough, we find that a line drawn through the last two stars in the handle brings us to the constellation Boötes, or the Herdsman, and not far from its brightest star, Arcturus, about which we shall hear more later on. Close to Boötes lies a pretty little group of stars in the shape of a half-circle. It is called "Corona Borealis," or the "Northern Crown," and is one of the very few constellations which really do look a little like the objects from which they get their names.

But now we must turn to our other map. Right in front of you, as you look south on a midwinter evening—say in January—you will see the most beautiful constellation in the heavens. Three bright stars, at equal distances from each other, make a slanting line across the sky, and mark out the constellation at once. They are supposed to be the belt of a great giant, whose shoulders are marked by two stars higher in the

sky. Two others, about the same distance below the belt, mark his knees, while a little group of three faint stars stands for his head, and a curved line of twinkling jewels below the belt makes his sword. This is the figure of Orion, the Great Hunter.

Draw a line downwards through the three stars of his belt, and you are led to where Sirius, the leading star of the Dog, and the brightest star in all the sky, sparkles above the horizon; while to the east, and higher up, the bright yellow Procyon shines in the group called the "Little Dog." Above Procyon are two fine stars of much the same brightness. These are Castor and Pollux, the leaders of the constellation Gemini, or the Twins. Castor, the upper one, is a most beautiful double star—two white suns, which take 347 years to circle round one another.

Over the left shoulder of Orion you will notice a group of stars looking like a V lying on its side, with the open end of the letter turned towards the east. This group is called the "Hyades," and it is a part of Taurus, the Bull. Close above the Hyades, and also in Taurus, shines one of the most interesting little clusters of stars in the heavens. You cannot mistake it, for the six stars which compose it are very close together, and make a very pretty picture. This is the cluster called the Pleiades, about which I shall have more to tell you in another chapter.

These are only a few of the constellations, but they are, perhaps, enough for you to begin with. After all, the best way is for you to search them out

for yourself. Get a small set of star-maps, and go out with a lantern, and compare your maps with the actual face of the sky. You will find that it is not at all difficult to learn the figures of all the constellations. And when once you know them, it is a constant pleasure to see them coming up one by one in the evening sky as the seasons roll on, just as it is a pleasure to recognize old friends again after a long absence.

CHAPTER XII

THE STARRY HOSTS

When you go out and look up to the sky on a clear dark night, when the heavens look like dark blue velvet, and the stars like diamonds, it seems as though there were no end to the number of twinkling points of light. You would think that it was quite impossible to count the starry hosts, and that it would be just about as easy to count the grains of sand on the sea-shore. Really, however, there are not nearly so many stars to be seen with the unaided eye as you would imagine. They have often been counted, and the result is that the number of stars that an ordinary eye can see at any one time is somewhere about 2,000. If you have very keen eyes, you may be able to see

another 500 or so; but there are not many people who can see 2,500 stars, and if you can see 2,000 you do fairly well.

That does not seem a great many when you think of the great space of sky over which they are scattered. But you must remember that the stars which you can see with the eye are only a handful compared with the numbers that actually exist. Whenever you look through even a small telescope, you will see, perhaps, a hundred stars for every one that you could see without it, and the bigger the telescope you use, the more stars you see.

In the last chapter I mentioned the Pleiades—that little cluster of stars that shines above Orion. Some people call the little group the "Seven Sisters," and you can scarcely mistake it because the stars are so close together. Try to count them on a clear night. Probably you will find that you can just see six stars clearly, though I have known people who could count eleven, and some have been able even to see fourteen. But whenever you look at the Pleiades with a telescope, you will see scores of bright little points twinkling among the bigger stars which you could see with the eye, and when the number on a photograph taken with a big telescope came to be counted, it was found that there were 2,326 (Plate XV.). So that in this tiny group, which covers only a very small part of the sky, there are more stars than you can see in the whole heaven without the help of a telescope.

Of course, there are some parts of the sky where

the stars are not quite so thickly scattered as they are among the Pleiades, but there are other parts where they are far thicker. In fact, it is believed that, if we could count all the stars which can be seen in one of the great telescopes that astronomers now use, there would be hundreds of millions of them! So, you see, the starry host is a very great army indeed. There are probably far more stars in the sky than there are human beings in the world.

The next thing that you will notice about the stars is that they are all different from one another. The Bible says that "one star differeth from another star in glory," and you can see that at once for yourself. Some stars shine very brightly indeed, and others are so faint that you can just see them, and no more; and between these are others of all degrees of brightness. Astronomers have divided up the stars into different classes, according to their brightness, and these classes are called "Magnitudes." About twenty of the very brightest are called "stars of the first magnitude"; about sixty-five, not quite so bright, are "of the second magnitude," and so on, down to the very faintest ones you can see, which are of the "sixth magnitude." The lower you go down in the scale, the more stars there are in each class.

Now, you would naturally think that the very bright stars are brighter than the others because they are nearer to you. But it has been found that this is not so. You cannot tell, merely by its brightness, whether

a bright star is nearer to you than a faint one or not. As a matter of fact, the star which, so far as we know, is nearest to our world, happens to be a very bright star of the first magnitude which can never be seen in our sky, but only from the Southern Hemisphere. But the next nearest is quite a faint star, and some of the very brightest in all the sky are tremendously far away from us—so far that it is impossible for us really to have any idea of their distance.

Actually we cannot understand how far away even the nearest star is. You remember that it would take us more than 5,000 years to travel to Neptune with one of our fastest trains. But when you think of travelling to a star, you must forget all about trains and sixty miles an hour. The fastest traveller that we know is light. A ray of light covers 186,000 miles in a single second. It would go more than seven times round the world in that time, and it would carry you to Neptune in about four hours. But even light takes more than four *years* to come from the very nearest of the stars ; and there are countless stars so far away that their rays take thousands of years to come to us !

So when you go out and look at the stars at night, you are seeing them, not as they are now, but as they were years ago—perhaps before you were born. What you see is the light that left them, perhaps ten, perhaps a hundred, perhaps a thousand, years ago ! For all we know, some of the stars that we are looking at may have ceased to exist many long years ago ; but we still see the light that they sent out, and it might be

hundreds of years yet before anyone would be able to tell that a star had been blotted out of the sky.

When you think of these tremendous distances, and see how bright the stars still shine across that great gulf of space, you begin to understand that they must be very big. Jupiter seems a giant to us, but if you could put him as far away from us as the nearest star, he would be lost to sight altogether. In fact, the only thing we know that would shine brightly to us from so great a distance is the Sun. And the truth is that all the stars are suns. Some of them are smaller than our Sun, but some are very much bigger.

You remember the very bright star called Sirius, which shines in the constellation of the Dog, below Orion. Well, Sirius is so far away from us that light takes eight years to come to us from him, so that, if you are eight years old, you are seeing him as he was when you were born. But he is so bright that, if our Sun were put beside him, Sirius would outshine the Sun twenty-nine times; and, though he is not very big in proportion to his brightness, he would weigh nearly two and a half times as much as the Sun. And Sirius, though he is the brightest, is by no means the biggest of the stars. Some of them may be scores, and some of them hundreds, of times as big as our Sun. Remember what you learned about the Sun's heat, and the furious storms that tear him, and the great red flames that rush up from his surface for hundreds of thousands of miles, and try to imagine, if you can, what a star one hundred times as big as the Sun must

be like! If our Sun could be moved away from us till it took its place among the other stars, you would see it gradually growing smaller and dimmer, until at last, when it was at the distance of an ordinary first-magnitude star, it would look very commonplace indeed. There would be hundreds of stars far brighter, and it would be so dim that you would think it of very little importance.

But the stars are not only suns in size and brightness. It has been found that, on the whole, they are made of much the same sort of materials as our Sun. It seems a very strange thing that we should be able to find out what the Sun is made of, and still more strange that we can make the stars tell us what is in them. But, though it would take too long to tell you how it has been done, astronomers have found that the Sun, though he is so unlike the world, is made of very much the same stuff. We know that iron, lead, nickel, lime, and a lot of other things that are quite familiar to us are glowing in his great globe. And, in the main, the stars are very like the Sun in this also. There are, of course, as you would expect, differences among them: some of them show that they have more of the gas called hydrogen than others; some have more of our metals in their composition; and some have more carbon and lime. But still, taking them all together, we can say that when we are looking at a star we are looking at something that is made of much the same materials as the Sun; and the Sun is made of much the same materials as our own world.

THE PLEIADES. *Page 80*

From a photograph by Dr. Max Wolf, reproduced in "Through the Depths of Space" (Macpherson)

PLATE XV

CHAPTER XIII

COLOURED STARS AND TWIN SUNS

You cannot help seeing that the stars are not all of one brightness, but perhaps it takes a little more careful watching before you find out that they are not all of one colour. However, if you look at them carefully and compare them with one another, you will soon find that instead of all being white, or pale yellow, as they seemed to you at first, there are differences among them. Of course, you are not to think that the colours are very deep, for star-colours are nearly all faint shades, but at the same time it is quite easy to see them.

Some of the very brightest stars in all the sky are brilliant white, with a cold bluish glitter like steel. Sirius, the brightest of all the stars, is one of these; not very far from him, in the knee of Orion, is another very beautiful white star called Rigel; and Vega, the star towards which we are travelling, is a third. Then there are numbers of the stars which are of a lovely golden yellow. Arcturus, the first-magnitude star not far from the end of the handle of the Plough, is a very good specimen of a yellow star; and almost overhead on a midwinter evening you will see another beautiful yellow gem called "Capella," in the constellation called "Auriga," or the "Charioteer."

The next colour that you will notice is orange-red. You remember that group of stars, just above Orion,

called the "Hyades," which is shaped like a V lying on its side. At the lower end of the open V there is a fine star called "Aldebaran"; and if you look at it on a clear night you will see that it is quite orange in colour. In the right shoulder of Orion there is an even finer reddish star; it is called "Betelgueux," and I think it is almost the prettiest star that you can see with the naked eye in all the heavens. There are some stars of a much deeper red than these, but they are mostly too faint to be easily found.

White, and yellow, and orange-red are pretty much the only colours that you can see among the stars without a telescope. But when you use a telescope you begin to see that there are many other colours among them. Some faint stars are of quite a deep red; one of them has been described as looking just like a drop of blood against the dark sky. And some are of a most delicate and lovely blue or green. But the strange thing is that a blue or a green star is never found alone, so far as we know. Some of the solitary white stars have a bluish tinge; but a really blue star does not seem to be able to exist without another star to keep it company, and the other star is very often, though not always, red or orange.

Nobody can tell why it is that a blue star cannot bear to be lonely, or why it should so often have a red star for its companion, though there must be some reason for it; but certainly it is so. And when you get somebody to show you one of these double stars through a good telescope, and see the bright red star

and the smaller blue one shining so close to one another that they seem to be almost touching, I think you will agree with me that it is a very pretty sight.

Sometimes, again, you will find a bright orange star with a small green one in company with it. And sometimes you will get a little cluster of stars in which there are all sorts of colours. There is one cluster in the southern sky, which, unfortunately, we in the Northern Hemisphere can never see, which consists of 110 small stars. Among the principal ones of this number, two are red, one is greenish-blue, two are green, and three others are pale green. The great astronomer, Sir John Herschel, who observed this cluster with a great telescope at the Cape of Good Hope, says that it looked like a superb piece of fancy jewellery. There are other little groups, not quite so fine as this, but still with enough variety of colour to make a very pretty picture in the telescope.

Now, what do all these beautiful colours mean? Well, to a certain extent, they tell us something about the history of the stars. Stars of the same colour are generally found to have much the same materials in them, and are supposed to be at much the same stage of their long lives. Our Sun, for instance, is a yellow star, and it is found that the other yellow stars have much the same composition as he has, while the white stars are rather differently composed, and the blue or green stars are different from them again.

Very likely a star, as it gets older, gradually changes its colour, just as a man's appearance changes with

age. Nobody has ever seen a star actually change colour, for, of course, the very longest life is only like a moment compared to a star-life ; but there are one or two stars which astronomers many centuries ago described as being of quite a different colour from that which they have now. Sirius was long ago called a red star, but now, as you can see any clear evening, he is brilliantly white. If the old astronomer who called Sirius red was not making a mistake, then Sirius must have got hotter since those days, for a star that glows white must be hotter than one that only glows red, just as white-hot iron is hotter than red-hot iron.

You have seen that the blue and green stars are always found in close company with some other star of a different colour. And that leads us on to think of another wonderful thing. Thousands and thousands of stars that look to the naked eye to be single, are found, when you turn the telescope upon them, to be double. The two stars are so close together that the eye sees them as one ; but the telescope splits them up, and you see the two little dots of light shining quite separate from one another. Sometimes the single star divides up into three or four, all differently coloured.

Now, this might mean either of two things. It might mean that the two stars are only very nearly in the same line as we look at them, while in reality they are very far away from one another, and not connected at all. If you walk at night down a long

straight street, you will sometimes see two lamps which look very close to one another so long as you see them from a distance ; but when you come up close to one of them, you see that the other is really far away from it. They looked so close together merely because they were very nearly in the same line from the distant point from which you first saw them. May it not be the same with these stars ?

Well, very likely that is the case with a number of them, but it is not the case with all. There are many hundreds which not only look near to one another, but are near, and really belong to one another. They are twin suns. An astronomer looking at our world and the Moon from Venus or Mars would see them like twin worlds circling round the Sun. Just so, numbers of these double stars are twin suns which go on constantly circling round a point somewhere between them. Of course, since we see them from so far away, they are not nearly so close to one another as they look. The distance between them is very great indeed, but, still, they are really connected, and they can never part company.

Now, that makes us think of a state of things that we should never have dreamed of had we not seen these twin suns. Our own Sun is a single star, and we can understand how he keeps our world and the other worlds of his family circling round him and getting their light and heat from him. But it is very strange to think of the worlds, if there are any, that circle round these double stars. How do they

manage to get along with the two stars pulling them sometimes in opposite directions ? And how curious it will be to have sometimes to do without any night at all, as they must ! for at times, as soon as the one sun has set, the other will be rising.

Of course, we cannot say that there are worlds going round these stars, for they are so far away that we cannot see such small bodies as even the greatest worlds of our system. Still, we do know that there are great dark globes going round some of these stars, and it is quite likely that there are far more of them than have yet been found out.

You can try to imagine how curious it would be to live on a world which belongs to one of these pairs of coloured suns—say to a double star which is red and blue. One day you might have the red sun shining, and then everything would look red ; another day, when the blue sun was in the sky, everything would look blue ; and sometimes you might have both of them in sight at once, and then, perhaps, your whole world would look purple. Only, you must remember that a good deal of this is only fancy, for nobody can tell how worlds could exist in such circumstances or how it would feel to live upon them.

CHAPTER XIV

STAR-CLUSTERS AND FIRE-CLOUDS

You can scarcely help noticing that the stars are not at all equally spread over the sky. Here and there are great dark patches where hardly any stars are to be seen ; and, again, there are other parts where they seem to be very thickly spread. Everyone is familiar with the Milky Way, or Galaxy, which runs right across the sky, and on a winter night looks just like a great shining river flowing through the heavens. Though there are many bright stars dotted up and down its course, the most of its light comes from stars which are too faint and too close together to be seen as separate points of light, and what one sees with the naked eye is a misty stream of brightness, with the brighter stars shining out from it.

But when you follow its course with a large telescope, it is a wonderful sight indeed. The whole background of the sky is powdered over with thousands upon thousands of tiny little stars, so that the field of the telescope seems to be covered over with gold-dust. Here and there the stars are packed so closely together that you cannot distinguish them separately, and the Milky Way looks, as Sir John Herschel says, as though someone had strewed handfuls of golden dust with both hands upon the dark sky. This great shining stream does not run straight across the sky or keep an equal breadth in its course. It bends and twists

hither and thither, just like a river; sometimes it spreads out into broad reaches, and sometimes narrows down again; while at several points it sends out little wisps and streamers of light into the darkness, as if the golden river were making creeks and backwaters.

But, besides the Milky Way, there are other parts of the sky where the stars gather close together, and some of these make, perhaps, the most beautiful star-pictures that can be seen in the heavens. You remember that I have told you already about the little cluster of stars called the "Pleiades," which shows six stars when you look at it with the naked eye, but 2,326 when it is photographed with a large telescope. This little group is the easiest to find and to see of all the star-clusters; but there are others which, though they are fainter, and not quite so easily found, are even prettier.

You will not have forgotten the constellation Cassiopeia, which lies right on the line of the Milky Way like a great W of diamonds. Follow the Milky Way from Cassiopeia towards the other bright constellation called "Perseus," and about half-way between the two you will see quite easily a faint misty spot of light, looking just like a tiny patch of bright cloud. In the telescope this misty patch is one of the loveliest sights you can imagine. There are two bright clusters of stars close together, so closely packed that it looks as though someone had dipped both hands into a heap of gold-dust and squeezed the shining grains together

THE LOOPED OR "SPIDER" NEBULA. *Page 94*

From a photograph taken with the Victoria Telescope, Cape Observatory, Jan. 29, 1903

into a mass, while the whole of the rest of the field is full of small stars more widely scattered.

Then there are other parts of the sky where the stars cluster together, not in heaps, as in this group, but as though they had been carefully arranged in patterns, curves and squares, semicircles and triangles. One of the prettiest of these is in the constellation Auriga, or the Charioteer; but it requires a pretty good telescope to show it well. But perhaps the most wonderful of all the star-clusters are those in which hundreds upon hundreds of faint stars are all gathered together in the shape of a globe. The finest of these that we in the Northern Hemisphere can see is the Great Cluster in Hercules. Hercules is not a very striking constellation, nor is it very easily traced; but, if you once get someone to show you the Great Cluster, I am sure you will never forget it. When you look for it with the unaided eye, you see only the faintest little patch of light, just like a dim little fuzzy star; but a big telescope shows you that this tiny spot is a great globe of stars, packed so close that it is only on the very edges of it that you can make out the separate stars at all. More than 5,000 stars have been counted on a photograph of this wonderful cluster, or twice as many as you can see in the whole sky without a telescope.

Now, there are thousands of these faint patches of light dotted all over the sky, and when astronomers found that their telescopes turned a number of them into clusters of stars, they began to think that it would

be the same with them all. They imagined that it was only because these spots of light were so far away that it was impossible to see the separate stars in them, and that, if we could only get telescopes powerful enough, the whole of them would turn out to be made of stars.

But now it has been proved that this is not the case. The spectroscope, that wonderful little instrument which can tell us what the stars are made of, has taught us that a great number of these misty spots of light are not composed of stars at all, but are huge masses of glowing gas, fire-clouds, we might call them. No doubt at some time in the far future, hundreds of thousands, or perhaps millions, of years from now, they will gradually shape themselves into stars; but at present they are just the rough material out of which stars may at last come to be made. It is wonderful to think that, when you look at these fire-clouds, you are seeing the stuff that, ages and ages after our world has passed away, may be used to make the stars which will shine down upon other worlds that have not yet begun to be made.

Most of these fire-clouds—or "Nebulæ," as astronomers call them—are too faint to be seen without a telescope, and only a large telescope will show them well. But our picture (Plate XVI.) will give you some idea of one of the finest of these strange objects—the "Spider Nebula," as it is called, one of the sights of the southern heavens, which we, unfortunately, cannot see. The grandest of them all is, however, easily

found, and you can see, even with a small telescope, what a wonderful thing it is.

If you look at the constellation Orion on the map inside the cover, you will see that down below the three bright stars which mark his belt there hang three fainter ones, which form his sword. Watch the middle one of the three on a clear dark night, and you will see that it is not like the others, but seems to have a sort of haze round about it. Look at it with a field-glass, and you will see the haze clearer still ; and when you try it with a telescope, you will find that the whole field is full of a strange greenish, fiery mist, which has a most fantastic shape. It looks just like the open mouth of some great dragon or monster of the deep, and from the tip of the upper jaw a great misty horn of light rises up, and spreads away till it loses itself in the darkness. Just where the jaws meet, four little stars twinkle through the haze, and a few others are scattered up and down over it.

This strange fire-cloud is called the " Great Nebula of Orion," and I do not think there is a more wonderful sight in all the heavens—not so much because of its brightness, but because of its mystery. It is so far away that light takes a thousand years to come from it to us, so that when you look at it you are seeing it, not as it is, but as it was more than a hundred years before the Norman Conquest. It is so huge that the tremendous circuit of our Solar System would seem only like a point in comparison with it ! And yet it is nothing but gas—a great cloud of glowing

gases of different sorts gleaming there in space, against the time when it shall gradually be shaped into stars and worlds.

Some time, long after you and I and our great world are gone and forgotten, God may shape that great fire-cloud into mighty suns and beautiful worlds, far more wonderful, even, than those we have been thinking of. No doubt the preparation for that is going on there even now, though we cannot see it because we are so far away, and because the changes are so slow. And when you see a sight like the Great Nebula of Orion, and try to think of all that it may mean, you begin to understand a little of what Scripture tells you about the Creator, when it says that with Him one day is as a thousand years, and a thousand years as one day.

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