STARS

SHOWN TO THE CHILDREN

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from

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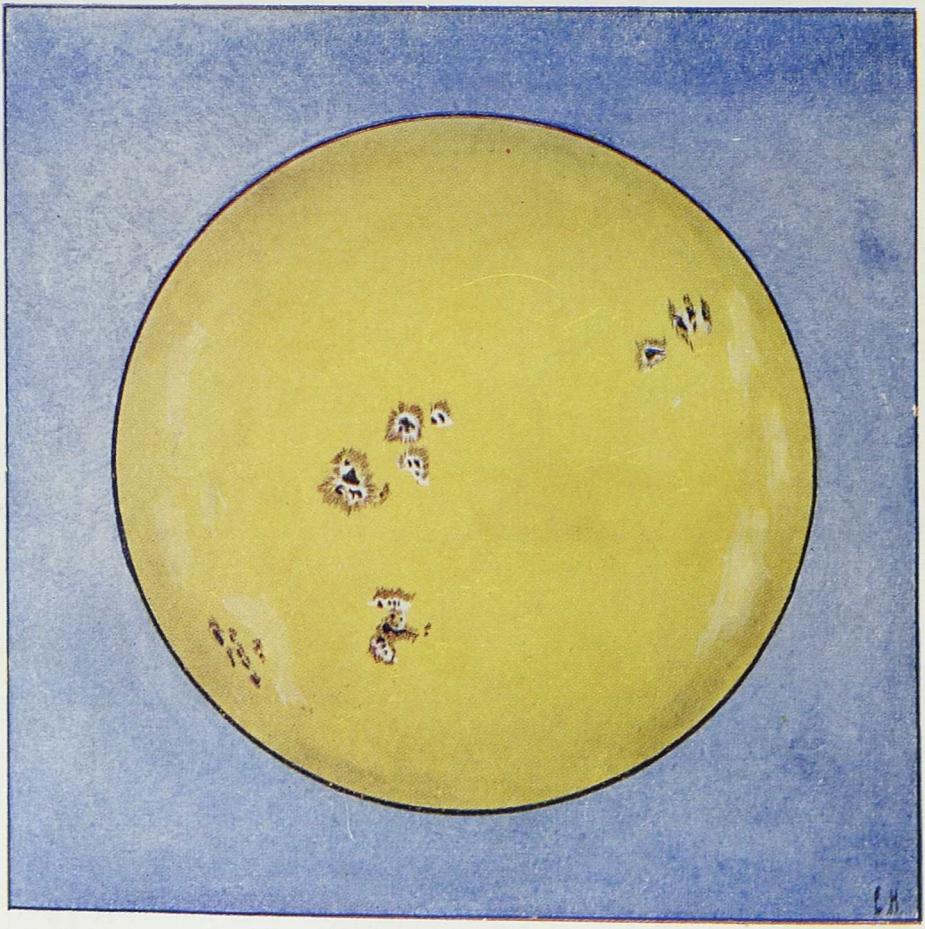
THE "SHOWN TO THE CHILDREN" SERIES

EDITED BY LOUEY CHISHOLM

STARS



From a painting] [by E. Hawks

The sun, showing spots and "faculæ"

STARS

SHOWN TO THE CHILDREN

BY

ELLISON HAWKS

Honorary Secretary of the Leeds Astronomical Society
Member of the British Astronomical Association
Membre de la Société Astronomique de France

ILLUSTRATED

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T. C. & E. C. JACK, LTD.

TO

MY TWO LITTLE FRIENDS

HOLLY AND CICELY

THIS BOOK IS AFFECTIONATELY DEDICATED

ABOUT THIS BOOK

DEAR HOLLY AND CICELY,—Many people think that Astronomy, or the Science of the Stars, is a dry and uninteresting study, and that astronomers are old, grey-haired men with long beards. I am sure you will agree with me that Astronomy is one of the most fascinating of hobbies, and that astronomers are not all old men with grey beards!

We have spent many interesting half-hours together, watching the stars and calling them by their names, and I thought that other children besides yourselves might also like to hear about the wonderful stars. And so I have written this little book, in simple language, in order that they might read for themselves and be able to understand some of the wonderful things that have been found out by astronomers.

It is not necessary to have a great observatory, or even a telescope, in order to study the stars. I know of a gentleman who is to-day one of the greatest of living astronomers. He was once a poor little ragged boy who had to beg for a crust of bread and a night's lodging. He had no instruments whatever, and, on a clear night, he used to look up to the stars and wonder what they were. Little by little he learnt many things about them—he got to know their names and some of the stories told about the

constellations. He became more and more interested, and, after he had succeeded in business, and had become a prosperous man through hard work, he devoted all his spare time to his favourite study, and in this way he became the famous astronomer that he is to-day. And so you will see that it is quite possible to study the stars without a telescope, though if you are ever able to possess one of these wonderful instruments, you should not fail to use it.

I am sure you will join me in thanking my friends who have so kindly furnished some of the pictures for this book—Professor E. E. Barnard, for Plates XIV., XXXVIII., and XLI.; Mr. E. W. Barlow, F.R.A.S., for Plates I. to IV. inclusive; Mr. John Murray, for Plate XII.; Professor E. C. Pickering, for Plate VIII.; M. Puiseux, for Plate X.; Mrs. Proctor-Smyth, for Plates XXI., XXII., and XXIII.; Mr. W. H. Wesley, for Plate VII.; and Professor Max Wolf, for Plates XXIV., XXV., and XL.

I must also express my thanks to Mr. J. M. Field, F.R.A.S., of the City Observatory, Edinburgh, and to Mr. W. H. McCormick for kindly reading the proofs.

Yours truly,

ELLISON HAWKS.

10 GRANGE TERRACE, LEEDS,
October 1910.

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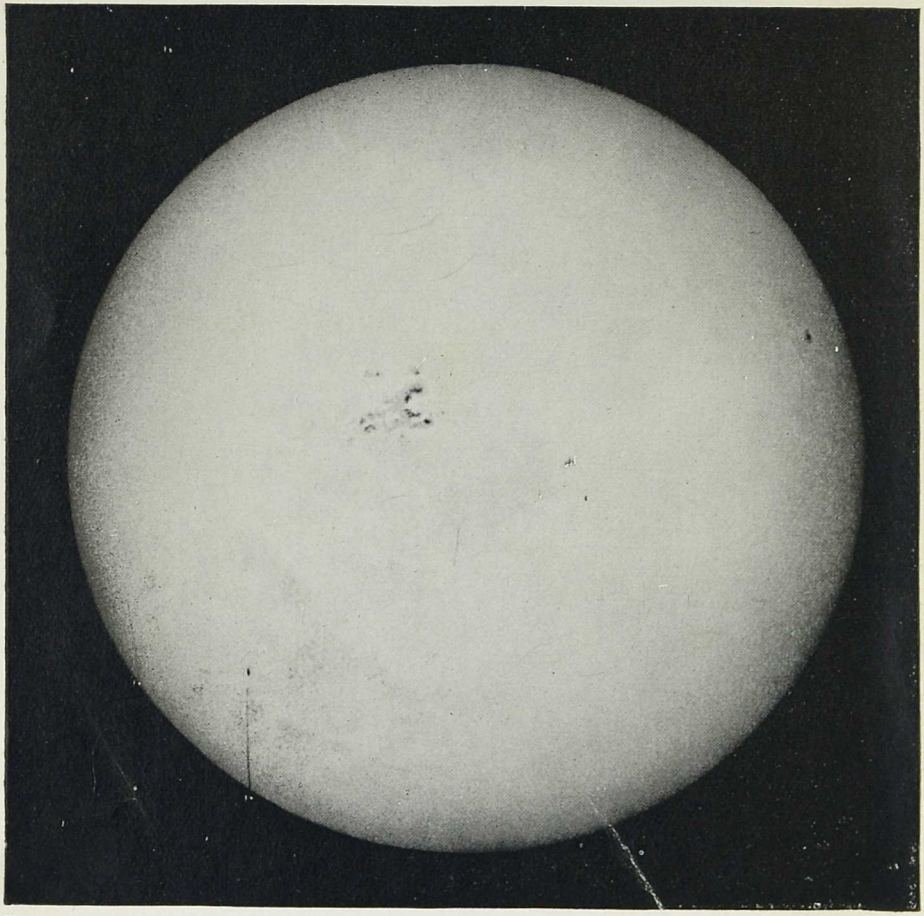
PLATE I



From a photograph by] [E. W. Barlow, F.R.A.S.

The Sun, 19th October 1905

STARS

CHAPTER I

THE SUN'S FAMILY OF PLANETS

WE are always glad to see the sun shining through our bedroom window on a spring morning, not only because it is warm and bright, but also for the reason that it heralds the approach of summer. The trees and plants are glad, too, when the sun shines on them, for it means new life to them, after the long and cold winter. The sun must therefore be a very important thing, and indeed it is, for we depend upon it for our very life; if it were not for the sun we could not live at all.

The sun is the centre of what we might almost call "a family of worlds," and these worlds are called Planets. Our earth is one of this family, and there are seven other worlds, besides the earth, over which the sun rules. Each world, or planet, travels round the sun in its own path; some of these paths are near to the sun, others are further away. The path of the earth lies a great way off from the

sun, but yet not so far away as the paths of some of the other planets.

The sun attracts the planets, just in the same way as a magnet attracts needles, and this attraction, which is called Gravitation, keeps the planets from wandering away from their paths. This family of the sun is called the Solar System.

It has been said that each of the planets moves, or as astronomers say revolves, round the sun. Most of the planets have, in their turn, smaller bodies revolving around them, and these small bodies are called satellites. Now you will understand what is meant when our moon is called the earth's satellite. Besides this revolving around the sun, the planets have also another movement. You have all seen at school a big ball or Globe, fixed on a stand, on which is painted a representation of the continents and oceans of the earth. This ball is only held in position by a metal rod, which runs through its centre, so that it can be made to spin round. This spinning movement is called Rotation, and the rod is known as the Axis of the globe. The globe is thus said to be rotating upon its axis. Each of the planets rotates upon its axis just in the same way as the schoolroom globe, but in their case the axis is not a real rod, but an imaginary one.

The order of the planets, commencing with the one nearest the sun, is as follows:—

Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune.

So that you may be able to remember the proper order of the planets, I have made up the following sentence:—

*M*en	*V*ery	*E*asily	*M*ake	*J*ugs
Mercury,	Venus,	Earth,	Mars,	Jupiter,

*S*erve	*U*seful	*N*eeds.
Saturn,	Uranus,	Neptune.

You will notice that the initial letters of the words of the sentence are the same as the first letters of the planets, in their proper order. Two of the names of the planets begin with the letter M, and in order that you may not get these two mixed up, I have made the first word, standing for Mercury, begin with ME . . ., like the planet's name, and in the same way the word corresponding to Mars begins with MA . . .

CHAPTER II

THE SUN AND ITS SPOTS

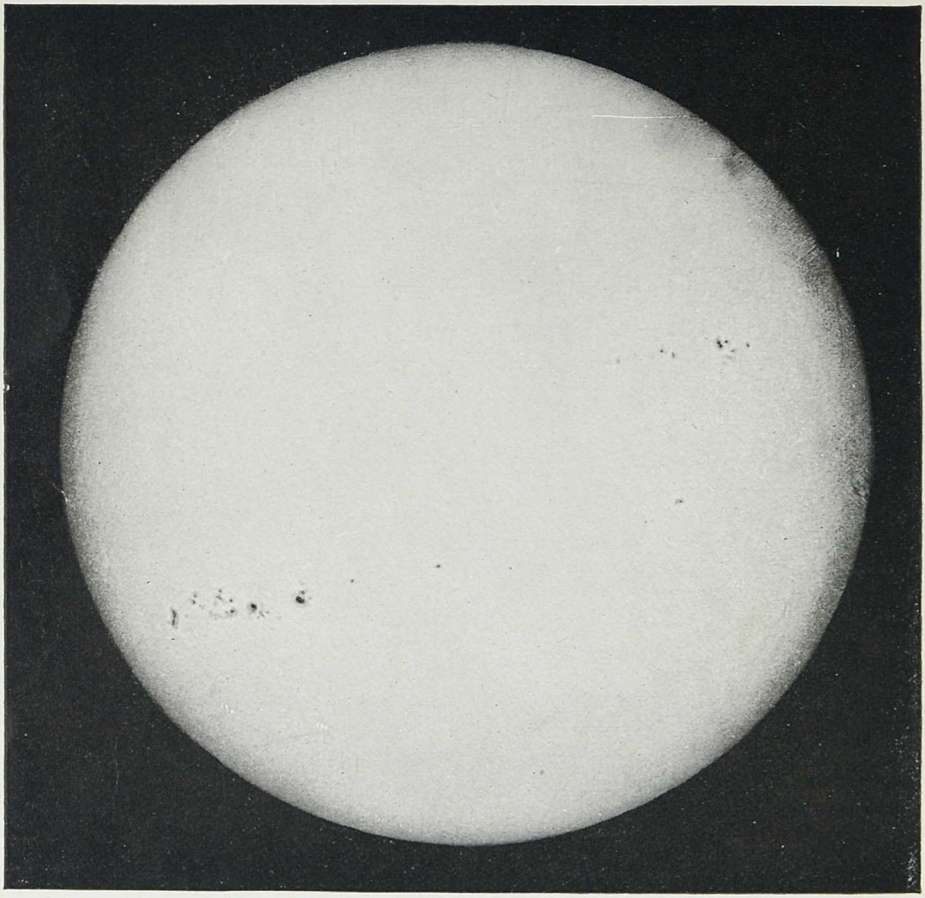
THE sun itself is a very large globe, mostly composed of fiery gases. It is many thousands of times larger than our earth, and, indeed, than all the planets put together. Supposing we could lay a railway round our earth, and set off an express train, it would travel right round the earth in less than three weeks; but if we could lay a similar railway around the sun, it would take an express train *five years* to travel once round it.

When we look at the sun through a telescope, there are often spots to be seen on its surface. Besides the spots there are streaky white markings called "*faculæ*," which is a Latin word meaning "Little Torches"; and this really is a very good name, because the *faculæ* look just like torches when seen at a distance.

If you will glance at the *frontispiece* of this book, you will see some of these *faculæ* near to the edge of the sun. The sunspots you will notice too, surrounded by a sort of fringe, which is generally of a brown colour.

In Plate I. we have a beautiful photograph of the sun, taken on the 19th October 1905. Near the centre of the picture you will see several large spots, forming what is called a "group." Towards the right-hand edge of the sun you will see a single spot.

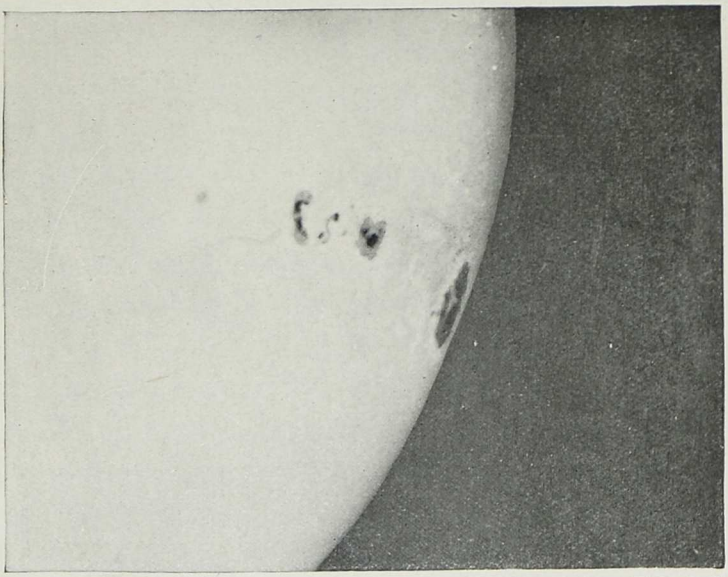
PLATE II



From a photograph by] [E. W. Barlow, F.R.A.S.

The Sun, 27th November 1905

PLATE III



From a photograph by] [E. W. Barlow, F.R.A.S.

Sunspots near the edge of the Sun, 22nd July 1905

Look now at Plate II., which is another picture of the sun, taken five and a half weeks later. You will notice that the spots have quite changed. The big group has vanished, and there is, instead, another group near the left-hand edge, while some more spots are to be seen higher up, at the opposite side of the picture. Why have the spots changed? The answer is that the sun turns on its axis, just in the same way as the earth does. We know that the earth turns round once in twenty-four hours, and that this turning causes night and day. The sun turns round once in twenty-seven days, and the spots turn with him. They are first seen coming round the right-hand edge of the sun, and each day they move a little further towards the centre, and then gradually travel towards the left-hand edge, and at last disappear round it. We cannot see the whole of the sun at one time, just as we cannot see the whole of a ball at one time.

When the sunspots are coming round the edge of the sun we see them edgeways-on, as it were. As they get near the sun's centre we see them full in the face. Suppose we get a very big ball and fasten a penny to it, and get a friend to turn the ball round. If we go and stand some distance off, and watch the ball turning, we shall see the penny gradually come into sight, from the back of the ball. First of all we shall see the penny quite edgeways-on, and it will look almost like a thin line instead of a round coin. Then gradually, as our friend turns the ball, the penny will seem to get more and more circular in shape, until, when it has reached the centre of the ball and is opposite to us, it will appear to be quite round. This is exactly the same way with the

sunspots, and in Plate III. you will see a large sunspot almost on the edge of the sun, and so it appears to us to be sideways-on. The sunspot in the next picture (Plate IV.) appears more round because it is near the sun's centre.

Now what are sunspots? The sun is surrounded by a covering of gases, which is called the *photosphere*. This word is made up from two Greek words: *photos* means "Light," and *sphere* means "Surface," so that the *photosphere* is the surface which gives forth light. The sunspots seem to be holes, or rents, in the *photosphere* of the sun. Look at Plate V. and you will notice that it seems as though we are looking right through a great opening in the bright surface of the sun; and this is indeed the case. We do not know what causes the sunspots, but perhaps the violent storms, which are always raging on the sun, have something to do with these great breaks in the light-giving surface, just as a great wind will often cause a break in the heavy rain-clouds in our sky.

Sometimes there are scarcely any spots on the sun, but at other times the sun's surface is covered with them. In the same way, the spots are sometimes so small that it is difficult to see them even with a powerful telescope. On other occasions there are spots so large that they can be seen with the naked eye, by using a piece of smoked glass to protect the eyes from the dazzling sunlight. But although spots may sometimes look small, they are really of a very great size, and if we could see them closely, they would appear absolutely enormous. You see, the sun is a long way off, and even what we know must be a very large spot looks small at such a distance. Supposing you placed a very large ball, say a football, at one end

of a street, and looked at it from the other, it would look very small, although you yourself would know it was quite big. It is the same with the sunspots, and, indeed, with all other objects, whether they are on the earth or in the sky.

There is another peculiar fact about sunspots, and this is that they are more numerous at certain times than at others. You know we only get snow in winter, and just in the same way there is a time when the sun has many spots and a time when he has few. Sunspots are not formed all at once; the astronomer first of all sees that there is something happening in a certain part of the sun's surface, for the little *faculæ* are seen all about this particular region. In this locality, during the course of a few days perhaps, a little spot is formed.

Nearly all sunspots are round at first, but they gradually lose their circular shape and become twisted into all manner of peculiar forms. After a while—it may be a few days, or it may be weeks—the spot seems to begin to break up, and there may be seen, shooting across it, streams of white matter. These gradually cover over the spot, and in the course of time it disappears from our sight. So the sun goes on, spots breaking out, and covering over again, and there is quite an interesting work for those astronomers who like to watch these wonderful sunspots, in their formations and disappearances. A great deal of time is devoted to the study of the sun, and a most marvellous study it is, yet many people never give a thought to the wonderful things which are to be seen on our sun, and the interesting facts to be learnt from them.

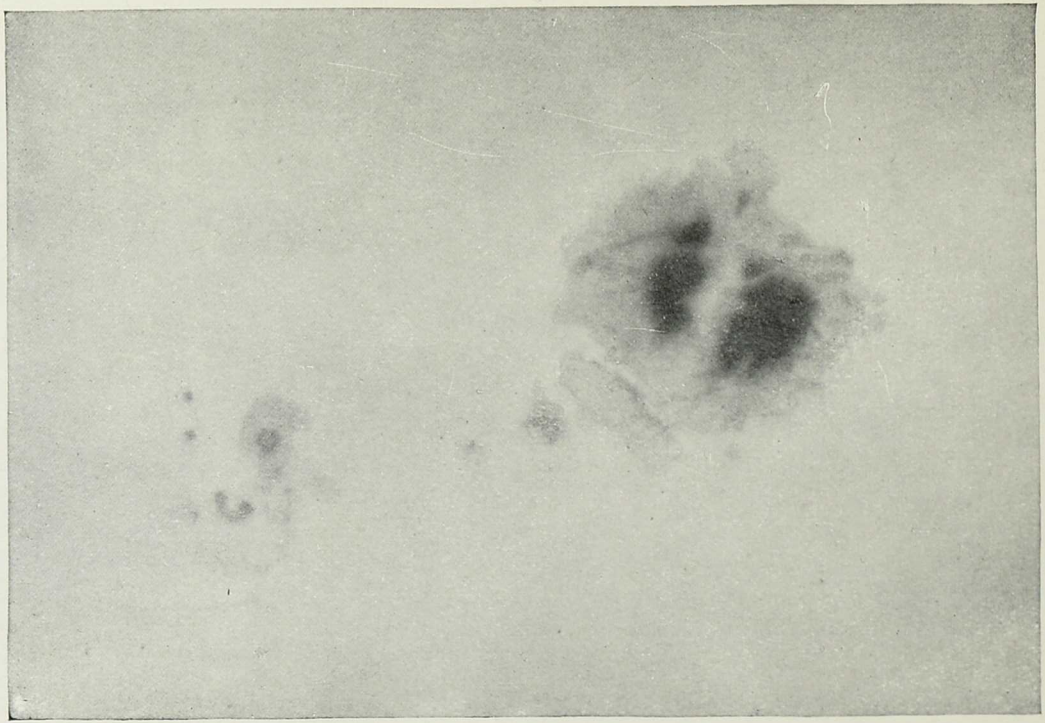
CHAPTER III

ECLIPSES

SOMETIMES there takes place what is called an Eclipse. The word eclipse comes from a Greek word meaning "to fail." When an eclipse occurs the light fails and becomes weak, and so you see how the eclipses got their name.

The eclipses we see are either of the sun or of the moon, and are of two kinds—Partial eclipses, where only part of the light of the sun or moon is cut off; and Total eclipses, where all the light is cut off. Eclipses of the sun take place when the moon comes in between the earth and the sun, thus cutting off more or less of the sunlight.

If you look at Plate VI. you will see a drawing of partial eclipses of the sun. In Fig. 1 on this plate is shown an eclipse which took place on the 30th August 1905, and you will notice that quite a large part of the sun is covered by a black object. Look now at Fig. 2 below, and you will see how the eclipse is caused. The moon, travelling across the sky, comes in between the earth and the sun, and cuts off the sunlight from our view. Fig. 3 shows an eclipse which took place on the 28th June 1908, and its explanation is to be found in Fig. 4. Here you will see that only a tiny part of the sun's light is cut off, and this is because the moon is not so high up as in the 1905 eclipse.



From a photograph by] [E. W. Barlow, F.R.A.S.

A large Sunspot, showing bridge across the dark umbra, 16th July 1905

PLATE V

From a drawing by] [E. Hawks

A Sunspot, 4th April 1909

Though we may hope to see many Partial eclipses of the sun, it is not often that we can see Total eclipses in this country, as they more often are only visible in countries nearer the equator. A Total eclipse is a very beautiful sight, and astronomers will willingly travel to far-off parts of the earth in order to see an eclipse of this kind.

When a Total eclipse of the sun takes place, the moon comes exactly in between the sun and the earth, cutting off all the sun's light, and the sky is dark. In fact, it is so dark that hens go to roost, and sensitive flowers close their petals, thinking that night has come. The eclipse may last for a few minutes, and after it is over the sun shines once more, the hens wake up, and the flowers open their petals.

Many savages are terribly afraid of a Total eclipse of the sun, for they do not understand its true cause. They think that some great monster is coming to swallow up the sun, and they imagine that by making a great noise they will be able to frighten him away. When they see a black object creeping over the sun they beat furiously on their gongs, loudly blow their horns, and add to the general noise by shouting and wailing. When the dark body has passed away from the sun, they imagine their efforts have been successful and that the monster has been frightened away.

When a Total eclipse is about to take place, the first thing that is seen is the dark edge of the moon just touching the sun, and resembling, in this respect, a partial eclipse. Gradually, as the moon travels along, the black part moving across the sun grows bigger and bigger, looking as though some one had bitten a piece out of the sun.

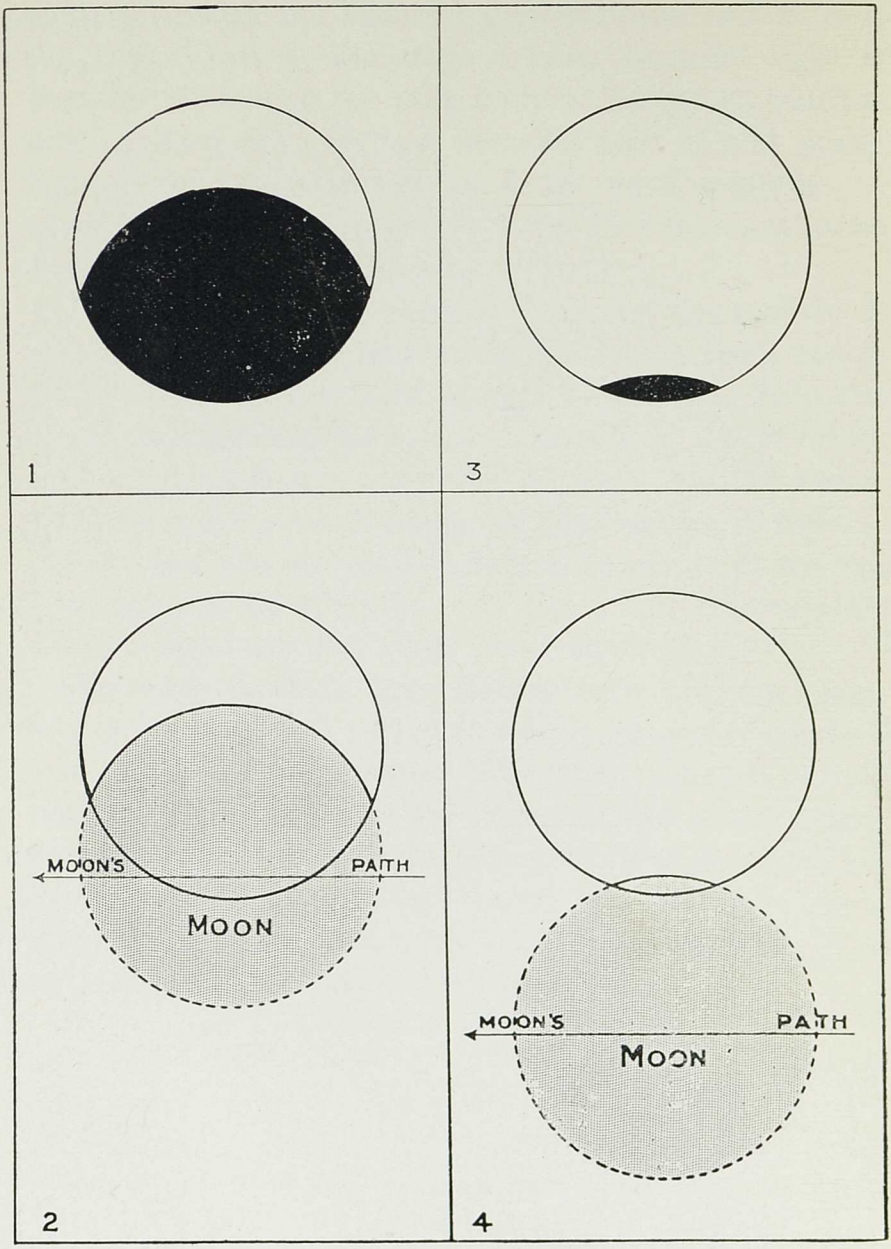
This gets larger and larger until, at last, the moon has entirely covered the sun, and then darkness sets in over the land. Just at this stage a most beautiful sight is seen, for all around the dark body of the moon, which is now covering the sun, is a beautiful halo of soft pearly light, called the "*corona*," a Latin word meaning "a crown." This name is very suitable, for the *corona* forms a very lovely crown to the eclipsed sun.

The *corona* is always round the sun, but the sunlight is so bright and dazzling that we are not able to see it except during the time of a Total eclipse of the sun, when the moon exactly covers the sun, and by cutting off the bright light, renders the *corona* visible. In Plate VII. the *corona* is shown as it appeared during the Total eclipse in 1882.

I am sure you will all wish to see an eclipse of the sun at some time or other in your lives; but unfortunately Total eclipses do not often occur in England.

The earth throws a long shadow behind it into space, just in the same way as a ball will throw a shadow when held in the light of a lamp. The earth's shadow is only visible when it falls upon the bright surface of the moon, thus cutting off the moon's light and causing what is called an eclipse. Eclipses of the moon can only take place when the moon is at the "full," and, like eclipses of the sun, may be either Total or Partial.

PLATE VI



Partial Eclipses

CHAPTER IV

THE PROMINENCES

I HAVE mentioned that at the time of a Total eclipse of the sun it is almost as dark as night, and indeed if it were not for the *corona* it would be quite dark.

Stars are in the sky during the daytime as well as at night, but the sun's light is so strong that we cannot see them during the day. However, when an eclipse of the sun takes place and it is dark, the stars are seen shining in the sky just as though it were night, and in this beautiful picture, Plate VII., you will see a streak of silvery light close to the sun. This is a comet, and you will read of these wondrous objects in a later chapter of this book. The comet shown in the picture was unknown before this eclipse took place, for it could not be seen in the dazzling sunlight, and it was only when the moon cut off the sun's rays that it was discovered.

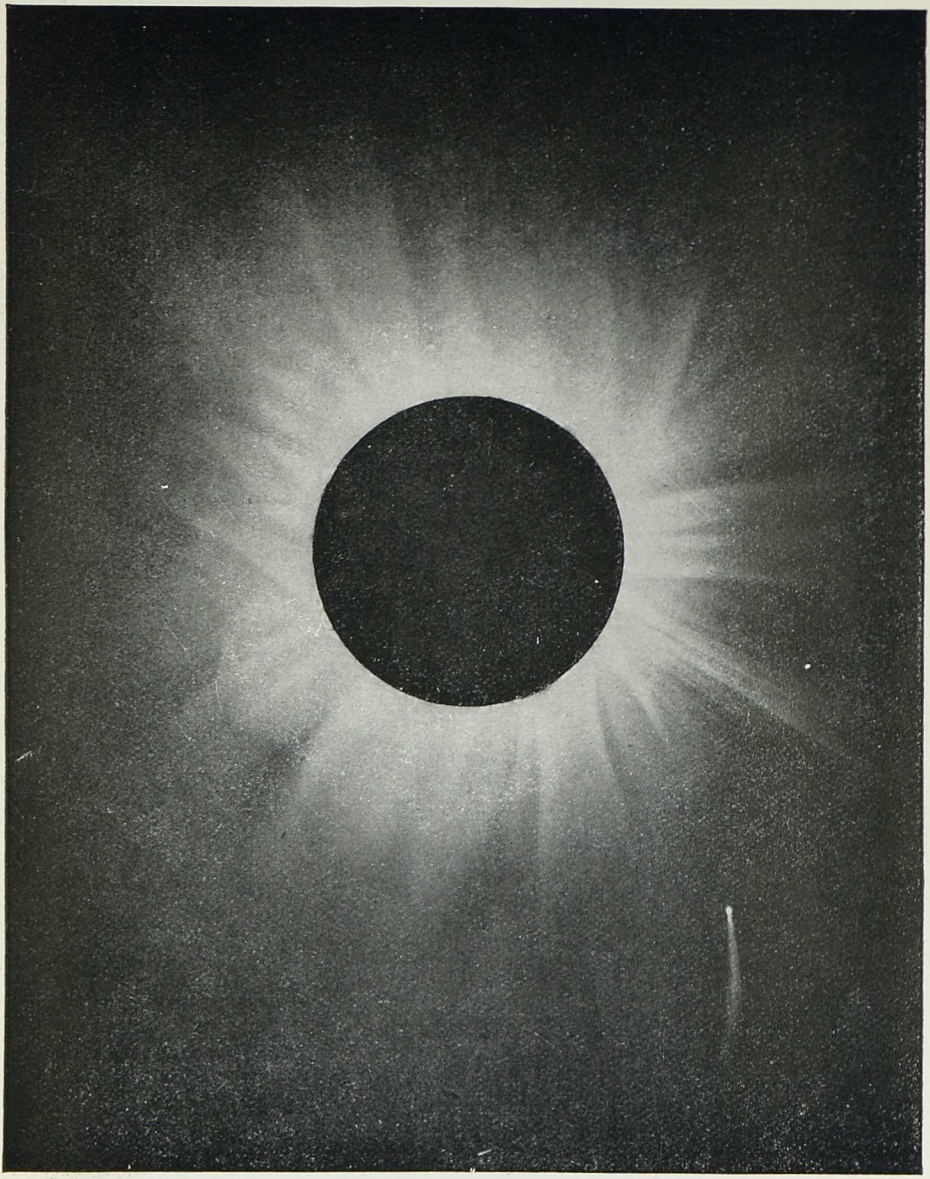
If you look carefully round the edge of the black moon, in Plate VII., you will see what appear to be little spikes standing out from the edge. These are called Prominences, or sun-flames, and in Plate VIII. we have two enlarged views of some of these wondrous objects. Although they may not appear to be very large, they are indeed tremendous, and up in the left-hand corner of Plate VIII. you will see

a round spot which represents the size of the earth on the same scale as that on which the prominences are drawn. As mentioned in a previous chapter, the sun is a very long way off, and objects look small at such a great distance, even though they may be very huge. As a matter of fact, our distance from the sun is so great that if we were to lay a railway from the earth to the sun, and started off a fast train along the line, it would take it about 275 years to reach the sun, even though it travelled day and night! If King Charles II. had started off in such a train, he would not have reached the sun yet! So you will see that at such a tremendous distance the prominences look only like small spikes, sticking out from the edge of the sun. Some of these great sun flames are so huge that, even were we to place thirty worlds as large as our earth, one on top of the other, the prominences would still be higher!

There are all kinds of prominences, both large and small, and of differing shapes. Some look like sharp spikes, like those in the top picture of Plate VIII., while others resemble beautiful plumes having artistic curves, similar to those shown in the bottom picture of the same plate. Sometimes we may see these objects floating above the edge of the sun, just as the clouds float above the earth. Very often, too, the prominences will resemble huge flames which flicker up and down, like the flames of our fires. Formerly the prominences could only be seen at the time of a Total eclipse, but two astronomers, named Janssen and Lockyer, found that by the aid of a wonderful instrument, called the Spectroscope, they could be seen at any time in broad daylight.

This was a great discovery, for up to that time astro-

PLATE VII



From an engraving by] [W. H. Wesley

Total Eclipse of the Sun, 17th May 1882

Prominences or Sun-flames

(From "Astronomical Engravings," published by the Harvard College Observatory)

nomers had known very little about the prominences, because it was only possible to see them for a few seconds during a Total eclipse, and they were thus unable to make many accurate observations of their appearances. But when the spectroscope allowed the prominences to be observed at any time, it gave astronomers more opportunities of watching these wonderful objects, and it soon became known that the prominences were really great flames of gas, probably caused, to some extent, by the storms which are always raging on the sun. It may be that the same outbursts have a connection with the sunspots, but this we cannot yet say. When we look at the sun calmly shining over some beautiful landscape, or sinking beneath the horizon amidst glorious sunset clouds, we might imagine that of all things it is the most calm and peaceful; yet this is not so, for it is the seat of furious storms and raging tempests. These storms are not made up of wind and rain, like those of our earth, but are composed of giant flames, each possessing a heat so terrible that it would scorch the earth to a cinder, should it come into close contact with one. There is no fear of this, however, for the sun is such a long way off that, although we may feel his heat on a warm summer day, the heat of the prominences themselves is indistinguishable.

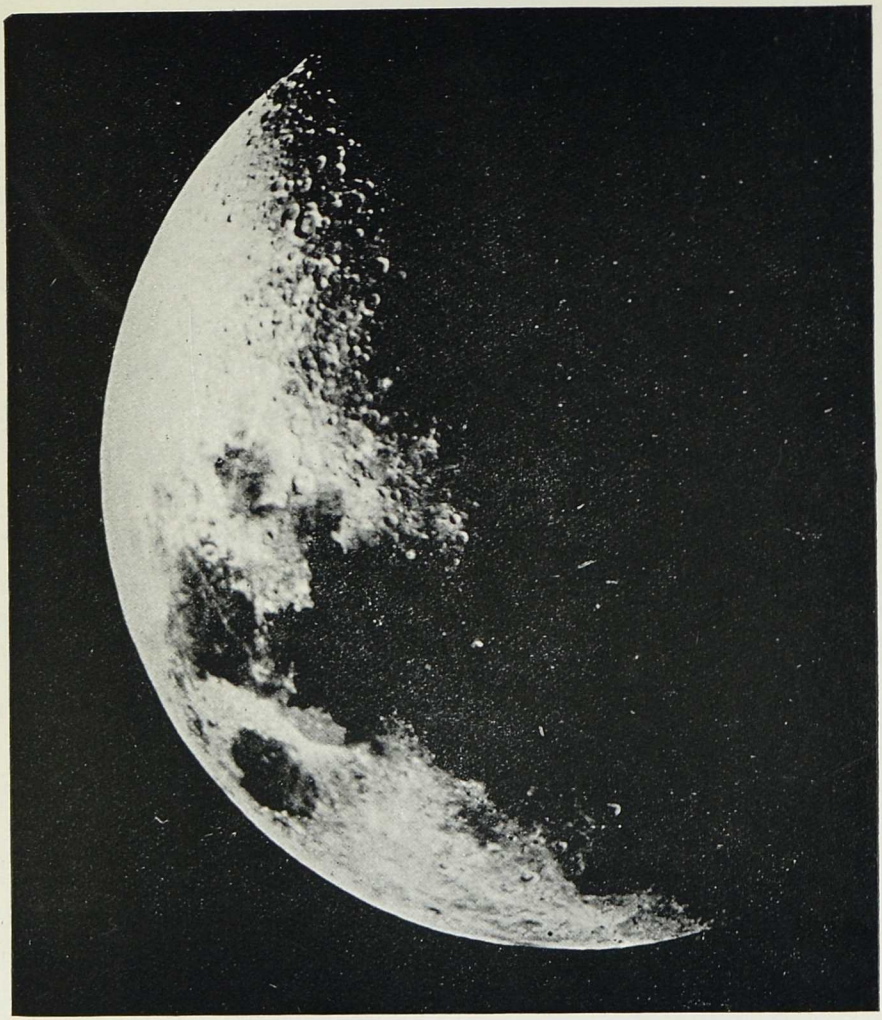
CHAPTER V

THE MOON

WE all know how beautiful the moon looks when it is seen as a thin crescent in the western sky, just after sunset. It looks very lovely, too, in the south, when it is "full moon," as we call it. Often it makes the darkest night quite light, and on a moonlight evening people may be heard to say: "What a lovely night; it is almost as light as day!" My telescope has shown me many wonderful things on the moon, and I shall presently mention some of them.

You all know that a telescope is like a big magnifying glass, and that when you look at a newspaper through a magnifying glass the print appears much larger. Just in the same way, when we look at the moon through a telescope, we see it larger, and so we can make out features which are quite invisible to the naked eye. When the night is fine, and the clouds are not in the way, I open the observatory and take off the covering which keeps the dust from the telescope. Then I point the instrument to the moon and look through the eyepiece. I wish you could look with me, for the sight is very beautiful. All over the moon's surface I can see great mountain ranges, while there are also a great number of volcanoes. It is one of the most beautiful sights imaginable to watch the sun-

PLATE IX



From a photograph by] [E. Hawks

The Moon when a week old

rise on these wonderful mountains; and it is our own sun which lights up the moon, for the moon is another world, something like the earth, though considerably smaller. In one respect, however, the moon differs greatly from the earth. *The moon is a dead world.* Its great seas are now all dried up, and its volcanoes no longer shoot forth fire as we believe they once did, long ago. On the moon there are no towns and cities, no people and children, and of course there can be no schools and lessons. There are no trees, no flowers, and, worst of all, there is no air. I think none of us would like to live in a world like this, although it would be really grand to see the moon mountains close at hand.

Astronomers have carefully watched the moon mountains for many years, but so far they have not found a single mountain to change to any extent. It is just as though the moon had been put under a glass case years and years ago, and had not altered a bit since.

Many people cannot understand how it is that the moon changes shape so often, and why it is sometimes just a thin crescent, and at other times a "half" moon or a "full" moon, as the case may be.

If you hold an apple exactly between your eyes and a lighted candle, the light falls on the side of the apple turned away from you, and so the part of the apple towards you is quite dark. If, now, you slowly move the apple to one side, the illuminated part will gradually come into view. The candle represents the sun, and the apple the moon, and the illuminated moon gradually appears in the same way. These changes in the moon's appearance are called the "phases."

In Plates IX. and X. you will see the moon photographed in two different positions, taken with large telescopes at two different phases.

You often will have heard people speak of "the Man in the Moon," and although you know that this man does not really exist, it may interest you to hear that the markings on the moon really do seem to represent figures. One of the best known of these, "The Lady," is to be seen on Plate X., and by the aid of the sketch on Plate XI. you will be able to find it for yourselves; but you must first turn the picture upside down, because the kind of telescope, with which these photographs were taken, shows objects wrong way up.

I should like you to look at the "full" moon some clear night, and try to make out the Lady, for she easily can be seen without any telescope at all.

PLATE X

From a photograph by] [Mons. P. Puiseux

The Moon, 6th February 1903

PLATE XI

The Lady in the Moon

CHAPTER VI

THE MOON MOUNTAINS

IN Plate XII. is shown a view such as we might expect to see if we were able to take a journey to the moon and to look around us at the "country" on either hand. Towards the centre of the picture you will see a great ring-shaped mass, in the middle of which is a mountain peak. This is one of the great extinct volcanoes, or craters as they are called, which I have mentioned in the previous chapter. Long ago, at some time or other of the moon's life, the mountain peak in the centre of this crater ring was a great volcano, shooting forth stones, and probably molten lava, just in the same manner as Vesuvius, Etna, and other volcanoes on the earth sometimes do. These great masses of stones and rocks flew up into the air and then fell back to the surface of the moon, forming in this manner the ring which is around the peak of the volcano. They would be shot up in something the same way that the fountains in our parks throw up water into the air, and if you are able to see one of these fountains "playing," as it is called, you will notice that the water falls back round the jet of the fountain. It is in this way that we suppose the great masses of stones, and other materials,

fell around the volcano peaks of the moon, thousands and thousands of years ago.

There are large numbers of these extinct volcanoes on the moon, and they are of all sizes, some being quite big —perhaps as great as Yorkshire, the largest county in England—while others are small in comparison. A large one is well seen in Plate XII., and numerous small ones may be seen scattered around it. You will also see from this plate that the surface of the moon does indeed look beautiful, in a certain sense; yet it is quite barren, and is a desolate world, and there is a death-like stillness over everything, for there is no life upon it. We have in this picture a typical view of what we might call a Lunar landscape, and I should like you to compare it with the next picture (Plate XIII.), which shows an earthly landscape. What a great difference there is between the two pictures, for whereas the moon's surface has no signs of life upon it, the mountains of the earth are covered with vegetation, water is to be found in abundance, and the valleys are filled with trees and animal life.

The craters of the moon are so numerous that astronomers have had to give each one a name, in order that they may be referred to without any confusion. Some of the craters are called after mountains of the earth, while others are named after famous astronomers. There is, for instance, a long chain of moon mountains called the Alps, another the Apennines, while there are craters bearing the names Copernicus, Plato, Tycho, and Theophilus. These latter names are those of learned men who lived long ago. Astronomers have devoted a great deal of time to studying the moon and maps have been made of the objects on

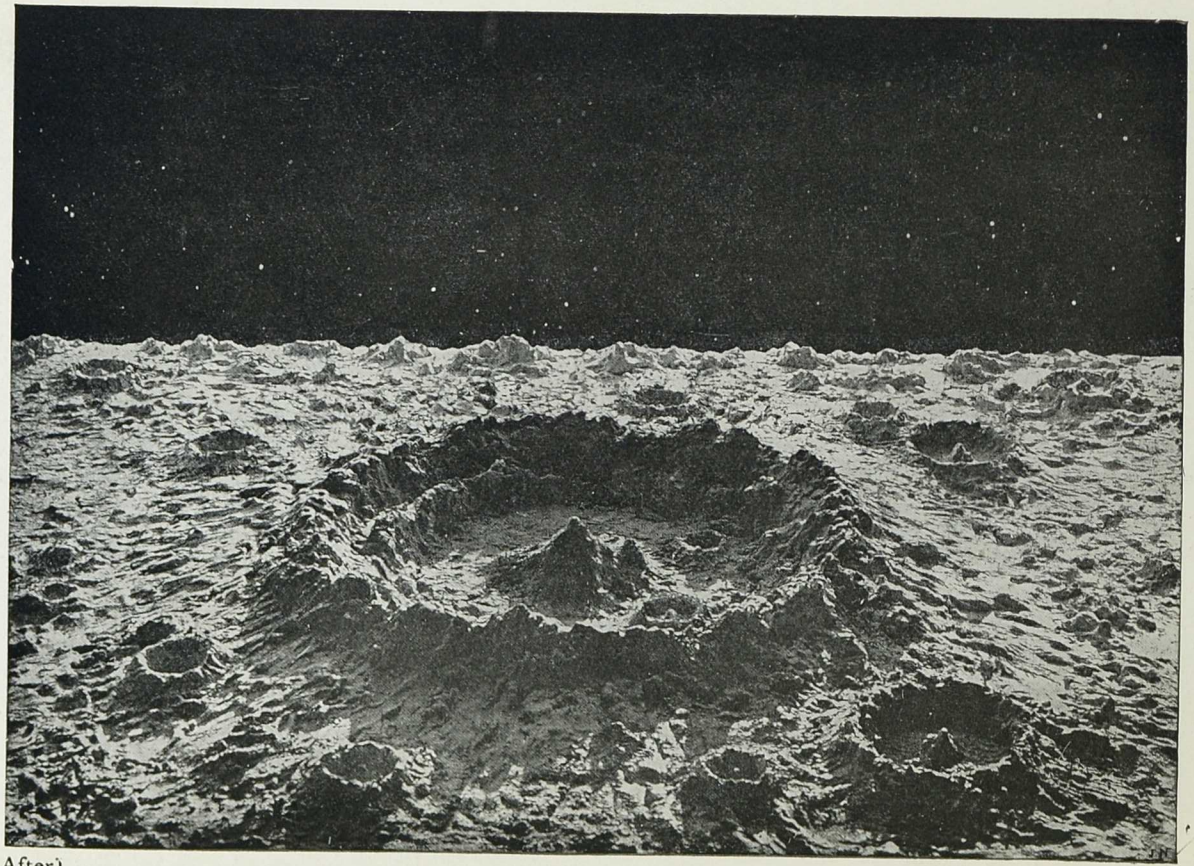


PLATE XII

After] [Nasmyth

A view on the Moon, showing a large crater-ring

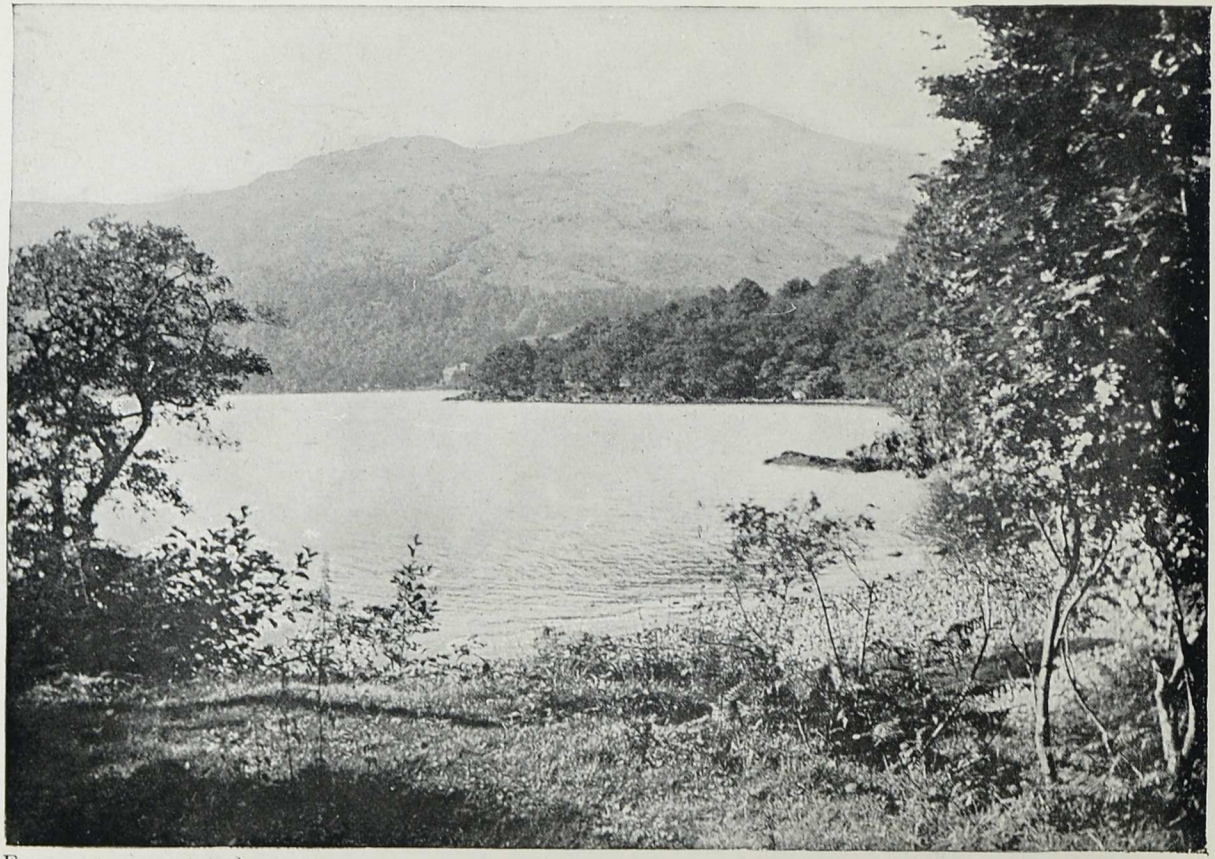
its surface. It has been said that we know the moon's surface even more accurately than the surface of the earth, because we can never really *see* the features of the earth, while the details of the moon's surface may be seen any clear night with the aid of a telescope.

If you will look again at Plates IX. and X:, you will notice a great number of ring-like objects near the right-hand side of the picture, and these are the great craters of which I have just spoken. When we look through a telescope at the moon, it seems as though we are looking at it from above—in fact, we are getting a bird's-eye view. You will notice, about half-way down on the right-hand side of the picture, in Plate X., a great crater ring which seems to be all by itself, surrounded by darkness. This is the crater Copernicus, and it is one of the largest and most beautiful of all the moon mountains. A larger photograph of this crater is to be seen in Plate XIV., and here we see Copernicus in all its beauty. You can almost imagine that you are looking down on this great crater from a balloon, which, you might suppose, is far above the moon's surface. When this photograph was taken, the sun had just risen upon Copernicus, and you can imagine that it is shining on the picture from the left-hand side. Inside the crater you will see a black marking, in the form of a rough crescent. This is the shadow which the left-hand wall of the crater casts, and you will notice a similar feature in a crater towards the top of the picture. To the left of Copernicus there are many little crater pits, scattered about the surface of the moon, while a strangely dark marking is seen towards the left-hand corner of the photograph. There are many of these dark patches on

the moon, but astronomers have not yet found out their true nature.

To all who have telescopes the moon mountains are a most interesting study, and many astronomers spend a great deal of time drawing and measuring the craters, while others devote their time to photographing the moon under different aspects.

In many cases we know exactly how high the moon mountains are, and I daresay you will be puzzled to know how astronomers have been able to measure the mountains of another world, which they have never been able to see close at hand. You will know that a flagstaff throws a shadow when standing in the sunlight, and a man who is clever at figures could very soon tell you how high the flagstaff was, without bothering to climb to the top and measure it with a tape measure. He would measure the length of the shadow, and then, by a simple calculation, he would tell you exactly how high the flagstaff was. The moon mountains throw long shadows too, and astronomers have measured the length of these shadows; and just as the man of figures tells how high the flagstaff is, so too can the astronomer tell how high the moon mountains are.



From a photograph by] [E. Hawks

A view on the Earth. (Loch Lomond)

PLATE XIII

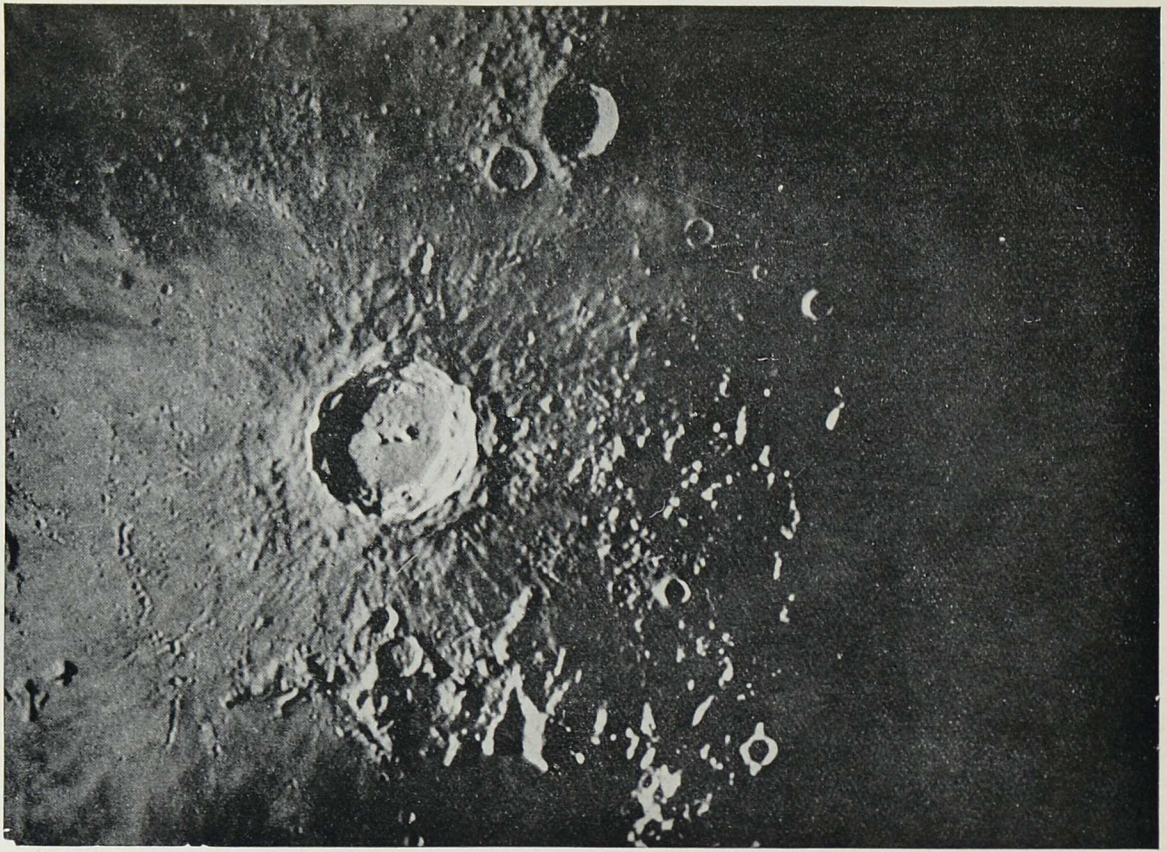


PLATE XIV

From a photograph] [taken at the Yerkes Observatory

The great lunar crater Copernicus

CHAPTER VII

MERCURY AND VENUS

WE have seen that there are other worlds besides the earth, which travel around the sun and depend upon him for light and heat. These worlds are called planets, and I am now about to tell you something of these interesting objects.

We cannot say whether there are people living upon these other worlds or not, for although our telescopes magnify a great many times, the planets are so far away that even the largest telescopes in the world could not show us living creatures, supposing that they were there.

In Plate XV. you will see mapped out the paths of the four "Inner" planets, as they are called; these are the four planets nearest the sun, and our earth is one of them. In the centre of the diagram you will see the sun, next to which is the path of the planet Mercury. Outside the path of this planet is the path of Venus, and it is of Mercury and Venus that I am now going to write.

Mercury is the smallest planet of the sun's family, and is not often seen, because it keeps close to the sun. It is small and not very bright, and is best seen in the clear air of the country, and then only at certain times of the year.

Venus, however, seems to make up for Mercury's lack

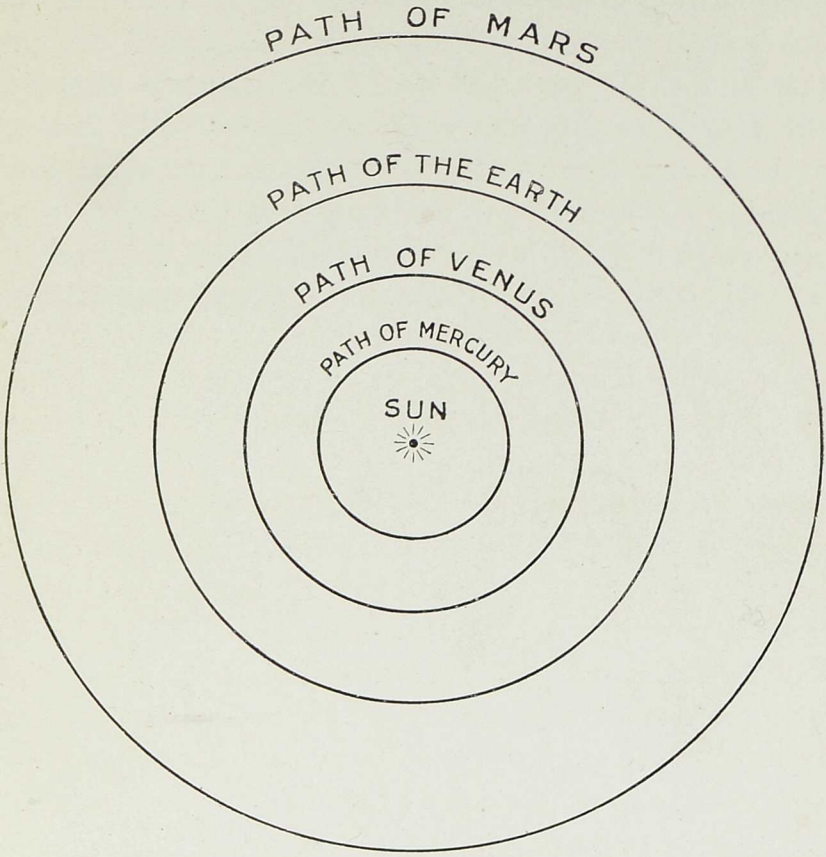
of brightness, for it (Venus) is the brightest of all the planets. It is a most lovely object, looking like a very bright star, outshining all other heavenly bodies, except of course the moon. Venus is about the same size as the earth, and so Venus and the earth are often referred to as "The sister planets." When Venus happens to be in our evening skies near Christmas time, numbers of people think that it is the star of Bethlehem come again; but this is not so, for though no one knows what the star of Bethlehem really was, it certainly was not Venus. You will remember, we are told that the star of Bethlehem moved along in front of the wise men of the East, and of course Venus, or any other planet or star, could not move about in that manner. Besides being a beautiful object to the naked eye, Venus is also a lovely sight as seen through a telescope.

For the reason that Mercury and Venus come in between the earth and the sun, they resemble the moon in the fact that sometimes, seen through a telescope, they appear as thin crescents of bright silvery light, like the moon when it is "new." At other times they resemble 'half' moons, or even "full" moons. The cause of these changes is just the same as that of the moon's changing shapes, which has been explained in Chapter V.

The two pictures on Plate XVI. will show you the appearance of Venus as seen through a telescope at different times, one appearing as a "half" Venus and the other as a thin crescent.

Venus is very brilliant even to the naked eye, and through the telescope it is brighter still. It is supposed that this great brightness is caused by clouds which sur-

PLATE XV



The paths of the four Inner Planets

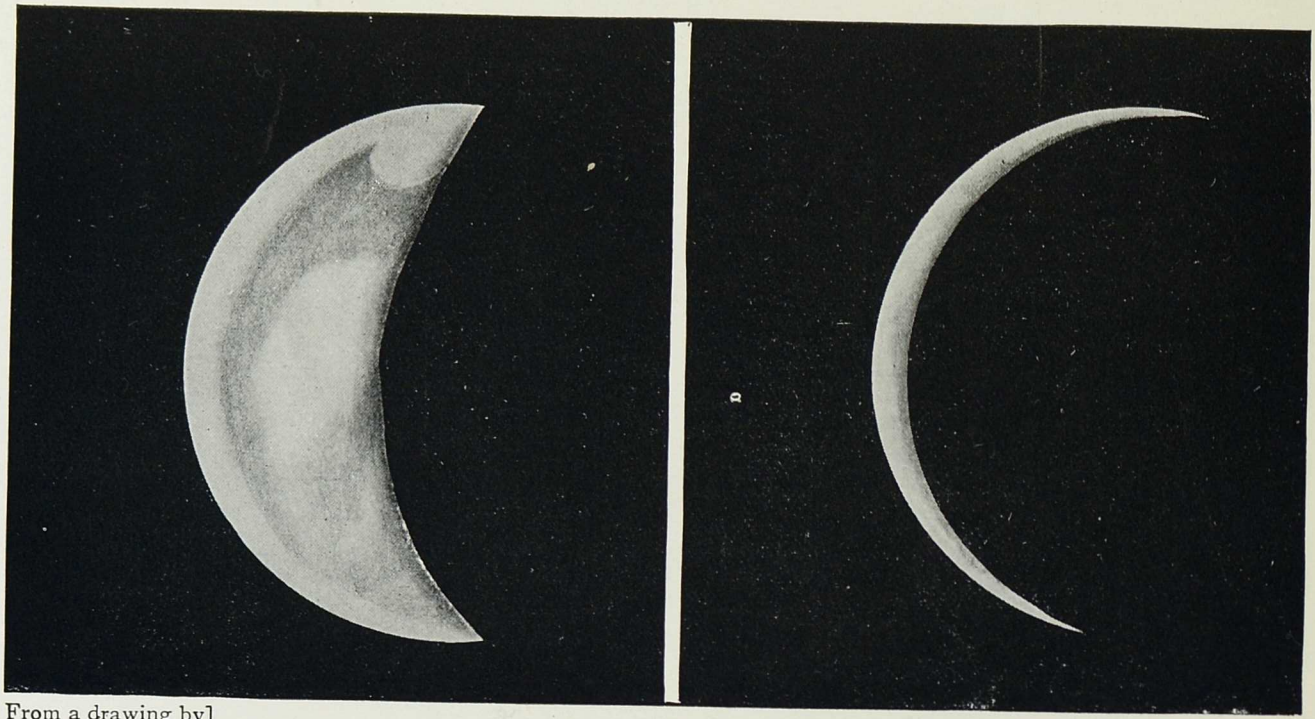
round Venus, and reflect the sun's light, just as a looking-glass does. Our clouds reflect the sunlight also, and you often will have seen those great white masses of cloud, looking like snow-mountains, reflecting so much light that they dazzle our eyes. The thick covering of clouds which surrounds Venus effectively prevents us from seeing any continents or oceans which may be there. It is true that now and then we can see faint shadings, as though the clouds sometimes thinned out a little, and allowed us to peep through and to see markings on the planet beneath, and some of these faint markings will be seen on the accompanying picture, Plate XVI.

CHAPTER VIII

THE EARTH AND THE PLANET MARS

IF you will look again at the diagram of the planets' paths, Plate XV., you will see that outside the path of Venus lies the path of the earth, while beyond that of the earth is the path of the planet Mars. The earth is a planet just as Venus is, and although the earth may seem like a great flat field to you and to me, yet we know that it is round, as are all the other planets. We know also that the earth travels around the sun, and takes $365\frac{1}{4}$ days to make the journey. As you know, 365 days make a year, and so each year there is a quarter of a day left over. In four years, therefore, there will be a whole day extra, and as February is the month with the smallest number of days, astronomers put the extra day into the month of February every four years, and that year is called Leap Year. It seems hard to believe that the earth reflects light just as the moon does, and as the other planets do. We can scarcely imagine our fields and seas reflecting back the sun's rays, but if we were to stand on the moon and look towards the earth, we should no doubt see it shining like a great moon in the sky.

Outside the path of the earth are the paths of five other



From a drawing by] [E. Hawks

December 1909 January 1910

Two views of Venus

planets, and the nearest of these is the planet Mars. Mars was called by the people of old "The Fiery Planet," because it shines with quite a red glare, almost like a watchman's fire when seen from a distance.

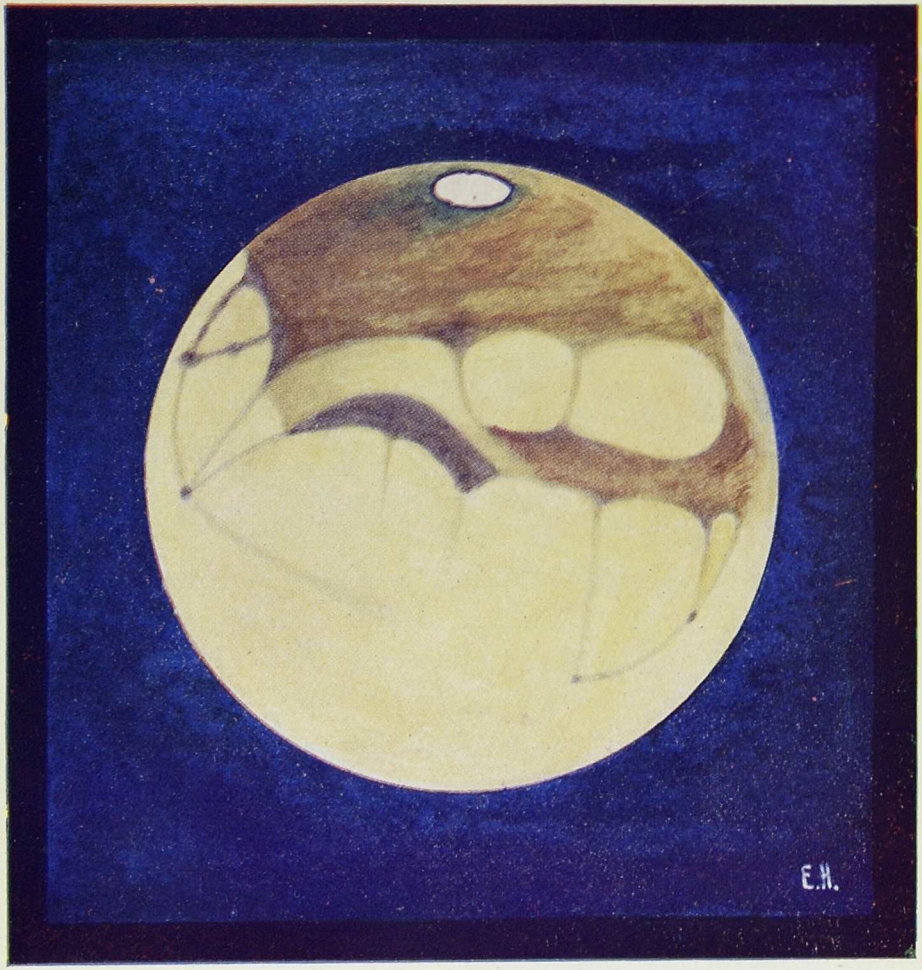
Looking at Mars through a telescope, we find that it is not so dazzlingly bright as Venus, and we can see markings on its surface. On Plate XVII. is shown a painting of Mars, and you will notice that there are two kinds of markings to be seen, dark and light. It was at one time supposed that the dark markings were seas and the light markings land, but whether this is so or not we cannot tell. Some people think there are no seas there, and if this is the case it is a great pity, for if there are any children on Mars they will not be able to enjoy a holiday at the seaside in summer-time!

One of the most interesting objects on Mars is the white spot seen at the top of the picture. You will have heard that at the north and the south poles of the earth there are great plains of ice and snow, which are called, respectively, the Arctic and the Antarctic regions. If we could stand on the moon and look back at the earth, these polar regions would no doubt appear as white spots. When we look at Mars through a telescope we see just such a white spot, at the pole, and we believe that this spot is really a great mass of ice and snow. As summer advances on the earth the ice and snow of the polar regions melt, and you will sometimes read in the newspapers of great icebergs being seen from ships in the Atlantic Ocean. These icebergs are really portions of the great mass of ice at the north pole of the earth, which have become detached during the melting, and have been carried southward by ocean currents.

During the Martian summer we can see the white cap growing smaller and smaller, and we believe that this is due to the melting of the ice and snow on Mars, in the same way as on our earth.

This and other things lead us to suppose that Mars is a world something like our own earth. There is, however, one great difference between the two planets, and this is that, whereas the earth has an abundance of clouds, Mars has practically none. It therefore must be continually fine weather on Mars, for if there are no clouds there cannot be any rain. Whether any people exist there, to enjoy this beautiful state of things, we do not know, nor, indeed, can we ever hope to tell. Mars is such a vast distance away from the earth that even our largest telescopes will show nothing more than the different-coloured markings on the surface of the planet, and of course the polar regions, too.

Our earth has only one moon, but Mars has two, though they are both much smaller than our satellite.



From a painting] [by E. Hawks

Mars

CHAPTER IX

THE PLANET JUPITER

HAVING seen something of the four Inner planets, we shall now proceed to view the four Outer planets. In some respects these are even more interesting than those of which I have already told you; and on Plate XVIII. you will see their paths round the sun. The sun is in the centre of the diagram, and the little circle round it represents the path of the earth; outside this again is the path of the planet Mars, of which we have just read. You will notice that in this picture the path of Mars is much smaller than on Plate XV.; the reason for this is that the paths of the four Outer planets are very much larger than those of the four Inner ones, and if we were to try to draw them on the same scale as Plate XV., we should require a very much bigger sheet of paper than this book allows.

Outside the path of Mars lies that of the planet Jupiter, or the "Giant Planet," as he is often called. Jupiter is the biggest planet of the sun's family, and is more than 1300 times as large as our earth. That is to say, if we had a great pair of scales, and we placed Jupiter in one pan, we should have to put 1300 worlds as heavy as our earth into the other pan, before we could weigh Jupiter

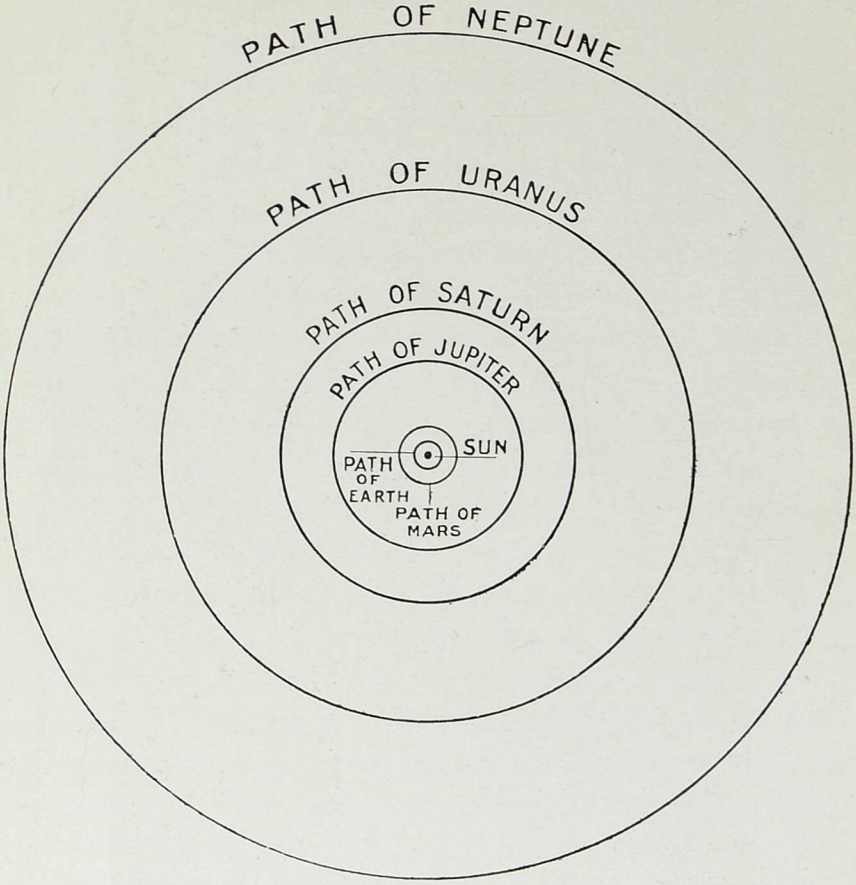
down. Now you will see how Jupiter came to be called the "Giant Planet."

Perhaps the most interesting feature about Jupiter is his moons. Whereas the earth has only one moon, and Mars two, Jupiter has no fewer than eight. It would indeed be a beautiful sight to see eight moons in the sky at one time, but Jupiter is even further away from us than Mars, and four of his moons are very tiny and thus difficult to see. The other four, however, are large, and can be well seen with even a small telescope, and are shown in Plate XIX.

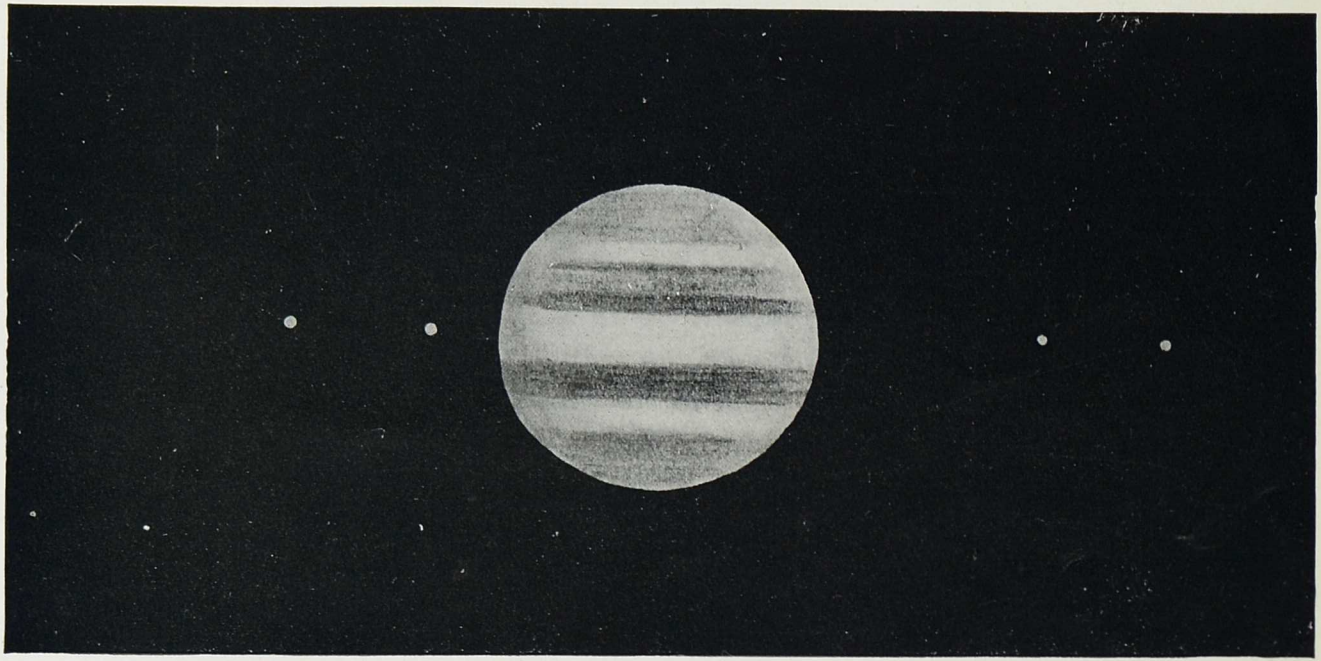
Just as the moon travels round the earth, so too do Jupiter's moons travel round him, and through a telescope we can see them slowly moving. It is a most beautiful sight to see this planet and its moons, because, for one thing, it is almost like a model of the sun's family.

When you grow older you will perhaps read of a famous astronomer named Galileo, who lived many years ago in Pisa, the town which you will remember is famous for its Leaning Tower. Galileo was one of the first to use a telescope, and one night he directed his instrument to Jupiter. There he saw the wonderful sight of the moons travelling round the great planet, and he called his friends to look with him. But at that time people really thought that the earth was the centre of everything; they even believed that the sun travelled round the earth, instead of the earth round the sun. Galileo had tried to show them that the earth was not the centre of all things, and that there were other worlds as well as the earth travelling around the sun. The people, however, looked upon him as a magician, and he was cast into prison, undergoing many trials and hardships. After some time he was allowed

PLATE XVIII



The paths of the four Outer Planets



From a drawing by] [E. Hawks

The giant planet Jupiter, showing the cloud belts and the four principal moons

to go free, and it was during this part of his lifetime that he applied the telescope to the stars and the planets. When he saw Jupiter, and the moons travelling round it, he again put forward the theory that the earth travels round the sun, and he used Jupiter and his moons as an illustration of how this could be accomplished. At first people would not believe him, and said that there must be something the matter with his telescope, so he asked them to look for themselves. They looked, and were forced to admit that there was a system of moons travelling round the great planet, but they then said that Galileo had bewitched either the telescope or their eyes, thus putting forward every objection they could think of, in order to try and make themselves still believe that the earth was the centre of all things. After some time, however, many other learned men took up the subject, and the people had to give in. It was clearly shown that the earth did travel round the sun, and Jupiter and its moons helped to prove it. Therefore it is very interesting to be able to look through a telescope and see these same moons travelling round Jupiter, in an exactly similar manner as in the far-off days when Galileo saw them.

CHAPTER X

THE CLOUD BELTS OF JUPITER

YOU will notice on Plate XIX. that there are several streaky lines across Jupiter's disc, and on Plate XX. there is a better view of these features. They are really great belts of cloud which lie across the planet. You will remember that when writing of the planet Venus, I mentioned the fact that it is probably surrounded by a mass of cloud. Jupiter, too, is surrounded by clouds; but while the clouds of Venus do not show any definite shape or any pronounced markings, the clouds of Jupiter range themselves in great belts across the planet. Very often they are seen to have peculiar shapes resembling, in some degree, the beautiful "snow-mountain" clouds of our own skies.

Though Jupiter's cloud belts change their shapes very often, they nearly always lie in straight lines, as you see them in these pictures. For the most part they are of beautiful colours, and are so delicate that only a trained eye can perceive them. The colours vary from bright yellow, or a reddish-brown, to perhaps chocolate colour, and sometimes there have been seen faint blue and green clouds too. Very often great white clouds are seen lying

near to the delicately coloured clouds, and as you may imagine, many beautiful pictures are formed.

Towards the centre of Plate XX. you will see a sort of spoon-shaped marking. Some years ago, in the centre of this peculiarly shaped feature, a wonderful object was to be seen. It was of a bright-red colour, and was known as Jupiter's Great Red Spot. During recent years the Red Spot has faded, and is now only to be occasionally seen as a faint grey marking. The Great Red Spot has been seen for more than forty years, and during this time it has been one of the most interesting objects to astronomers. What it is, no one can tell, and although many theories have been put forward, none of them has been generally accepted as satisfactory.

You will notice that Jupiter is not perfectly round, but bulges out slightly at the equator. We have seen that the planet is a very big world, and it rotates on its axis very quickly. The earth turns once in twenty-four hours, but Jupiter turns in a little less than ten hours. As it is a much bigger world than the earth, it has therefore to turn at a very much greater speed, and it is this great rate of turning that makes the planet bulge out at the equator.

Sometimes Jupiter's moons come in between the sun and the planet. If you pass an apple between the gas and the wall, you will find that the apple throws a round black shadow on the wall. In just the same manner the little moons, passing between Jupiter and the sun, throw tiny round shadows on the planet.

For many years astronomers have been looking at Jupiter through their telescopes, and they have made careful

drawings of the cloud belts, as well as notes of their colour and of the positions of the moons, so that we have come to know a good deal about this interesting planet. Because Jupiter is such a giant among the planets, it is a very suitable object even for a small telescope. If you ever have the opportunity of looking through a large telescope, ask the astronomer to show you Jupiter, if it is to be seen, and you will be delighted by watching its four largest moons and by observing the cloud belts which cross the planet's disc.

CHAPTER XI

SATURN, THE PLANET WITH THE RINGS

I AM now to tell you of what is perhaps the most beautiful object that we may ever hope to see in the heavens. This is the planet Saturn, whose path lies beyond that of Jupiter. Saturn differs from all the other planets of the sun's family and is quite unique, for there is no other object like him in the whole sky. The reason for this is the fact that the round ball of Saturn is encircled by a beautiful series of rings. These rings can only be seen through a telescope, and although they extend right round the globe of Saturn, we see them sideways and they look something like a plate would do, if it were held edgeways. You will gain some idea of what I mean from Plate XXI., which is a very beautiful drawing, showing the round globe of Saturn encircled by the rings.

It was a complete mystery to the people of old as to how a planet could be surrounded by rings which had no means of support, for they do not touch the planet anywhere. It has lately been shown, however, that Saturn's rings consist of multitudes of little moons, each travelling in its own path around the planet, just as the larger moons of Jupiter travel around it. The moons forming Saturn's

rings are so tiny, and so far away from us, that even with our greatest telescopes we cannot see each one separately, but they appear as a beautiful ring of light surrounding the planet. As will be seen from the pictures, there are dark rings as well as bright rings, but these dark rings are really blank spaces in the bright rings, where the little moons have been taken away, as it were, thus making a gap in the bright ring. The two chief bright rings are called the Outer and the Inner, and you will notice that the Outer ring is not quite so bright as the Inner ring, while a well-marked division separates them. This division is called the Cassini Division, because in 1675 a famous astronomer of that name was the first to notice the division in the rings. If you will look at the space between the Inner bright ring and the planet, you will see there a beautifully fine ring, which is neither bright nor dark. It looks, indeed, as though it were composed of gauze, and for this reason it is known as the Crape Ring. You will notice also that we can see through the Crape Ring, for the edge of the globe of Saturn is clearly visible through it.

If, now, you will turn to the next two pictures, Plates XXII. and XXIII., you will see that the rings are here shown under different aspects, and their altered appearances are due to the fact that Saturn tilts himself towards us at certain periods, and consequently at one time we are looking at the rings almost from above, at another we appear to be looking at them when they have turned a little further upwards, and at another time we see them exactly edgeways. It is at this period that the rings look like a thin line extending for a short distance on each side of the planet. You will be able to see

From a painting] [by E. Hawks

Jupiter

how this extraordinary change takes place by holding a plate at arm's length, and by gradually lowering the front edge until it seems only to be a thin line of porcelain in front of you. When the rings are exactly edgeways, as shown in Plate XXIII., they are almost invisible; and indeed, unless a powerful telescope is used, the rings do disappear, which shows that they must be very thin.

When Galileo turned his telescope upon Saturn, three hundred years ago, he was much puzzled by the changes of Saturn's rings which have just been described. His telescope was one of only low power, and it did not show objects sharply and clearly. It was for this reason that he could not see the true nature of the rings, and they were most mystifying to him. Through his telescope Saturn seemed to be composed of three bodies, which appeared to touch one another and to keep in the same positions, being, in fact, almost in a straight line. Of the three bodies, the centre one looked the largest, and writing of Saturn, Galileo said: "I have observed with great admiration that Saturn is not a single star, but three together, which, as it were, touch each other . . . the middle being much larger than the lateral ones" (the side ones). He goes on to say that "Saturn has an oblong appearance and is somewhat like an olive," and so Galileo died without solving the mystery of the rings of Saturn.

It was not until forty years later that another clever astronomer, a follower of Galileo, called Huygens, saw the rings of Saturn in their true form.

Saturn's rings do not shine by means of their own light, but, like the moon and the other planets, they reflect back

to us the light of the sun. The globe of Saturn is surrounded by cloud belts, something like those which encircle Jupiter; but the details of Saturn's clouds are not nearly so distinct, as seen through the telescope, as those of the Giant Planet, because Saturn is so much further away from us than is Jupiter.

The further away from the sun a planet is situated, the longer it takes it to travel round. The earth travels round the sun once a year, and Jupiter, being further away, takes twelve of our years to go round. Saturn, however, takes a little less than thirty years to complete one journey around the sun, and long though this period may seem, we shall presently see that there are members of the sun's family which take even longer to go round the sun.

We have read that Jupiter has eight moons, but Saturn has even more, being attended by no less than ten satellites. Just imagine what a grand sight it would be to see ten moons in the evening sky; and if we were able to journey across space to Saturn we should see, not only this sight, but probably also the lovely rings, stretching across the sky, and looking like a beautiful arch of bright light.

If you ever have the chance of looking through a telescope, be sure you make the most of your opportunity and gaze upon Saturn, and though you may not be able to see all its moons, you will never forget the sight of the exquisite rings, which encircle the most lovely planet of the sun's family.

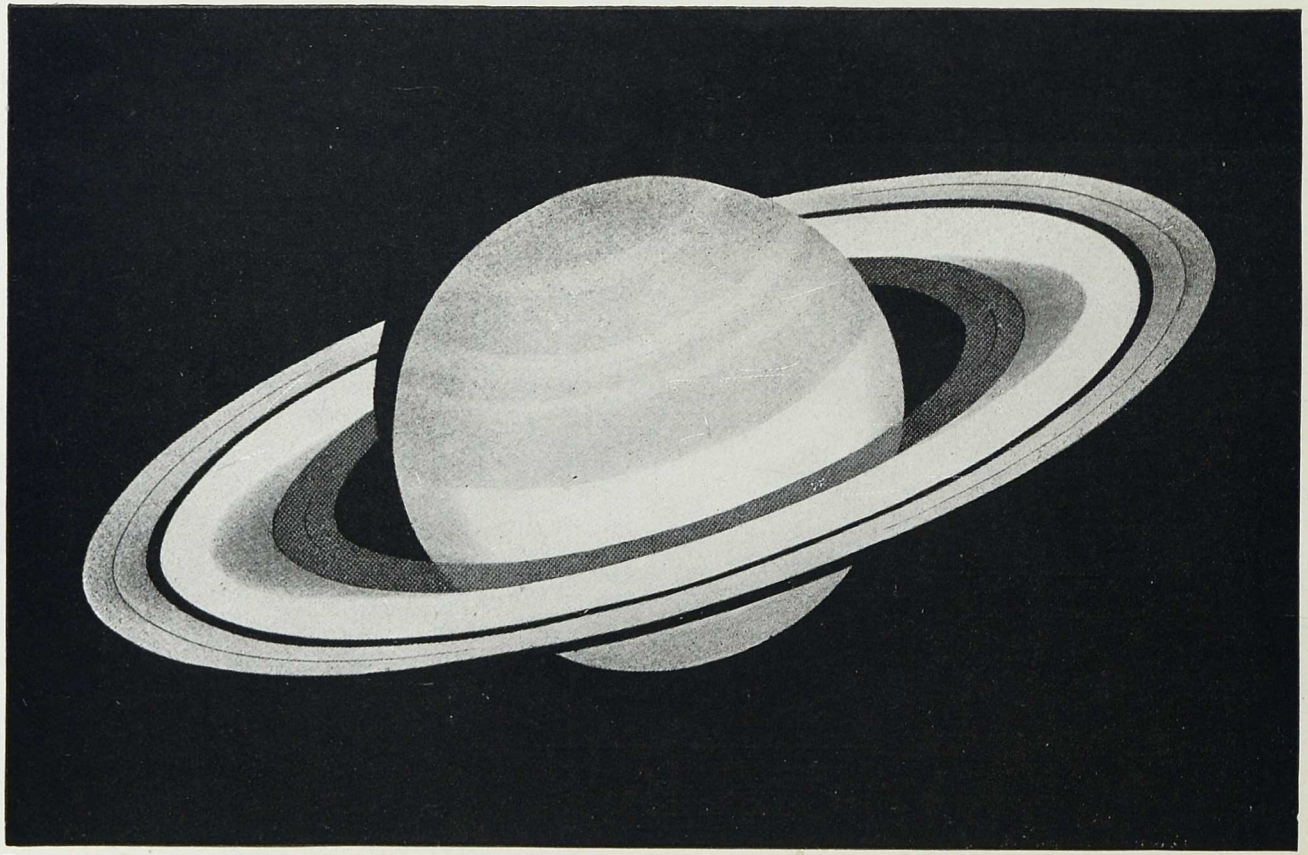
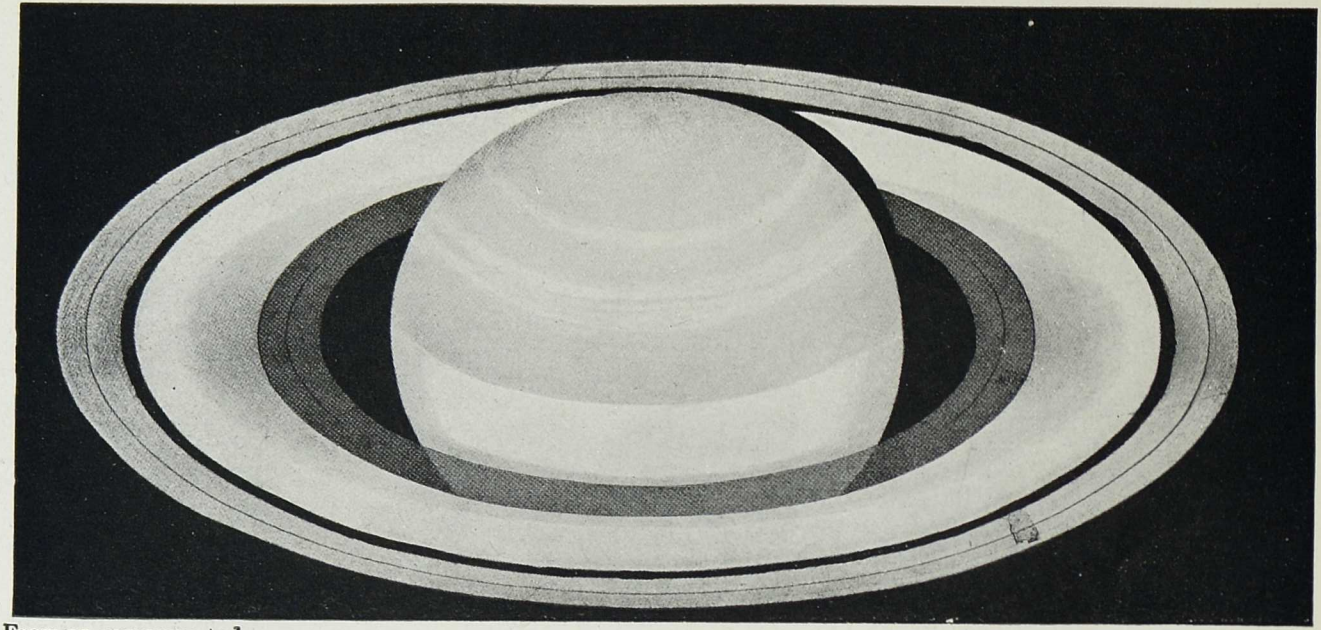


PLATE XXI

From an engraving by] [R. A. Proctor

Saturn, showing the rings half open



From an engraving by] [R. A. Proctor

Saturn, showing the rings wide open

CHAPTER XII

THE PLANET URANUS

BEYOND the beautiful planet Saturn, there are still two other planets, called Uranus (pronounced "You-ran-us") and Neptune. These two members of the sun's family are so far away that we know very little about them. Even in a large telescope they seem very small indeed; and though it has been supposed that they have cloud belts resembling perhaps those of Jupiter, yet we cannot state this with certainty. One of the most interesting things about Uranus is the way in which it was discovered. As I have already said, this planet is so far away that it appears almost invisible to the naked eye, and so in the days of old, before telescopes were invented, Uranus was unknown, as was also Neptune. The people believed that Saturn was the outermost planet of the sun's family, but in this they were mistaken, as we shall see.

One of the greatest astronomers who ever lived was William Herschel; but before he became an astronomer he was a soldier in the Hanoverian army. At that time a war was going on, and one night, just before a great battle, Herschel and some other soldiers had to sleep as best they could in a wet and muddy ditch. Herschel did not like this a bit, and so he ran away and left the army,

or, as we should say, he deserted. Herschel was very fond of music, and he came to England, where he thought he would be safe from capture. He studied music diligently, and after a little time he became the organist of the Octagon Chapel at Bath. He was exceedingly studious, and every minute he could spare he devoted to music. Intending to master his subject thoroughly, he commenced the study of Mathematics, which is the science of figures. This study deals with measurements of distances, both great and small, and it was in this manner that Herschel was brought into touch with Astronomy. Though he had often admired the stars on a clear night, he probably never thought much about them until he came to study Mathematics. Once Astronomy had roused his interest he saw what a wonderful and splendid science it was, and he began to give much time to a study of the heavens. So interested did he become in his new hobby, that there soon came a time when he liked Astronomy even better than music, and the organ and his music pupils were all but forgotten. He commenced to make telescopes, small ones at first, and then, as he explored the wonders of the heavens, he wanted larger instruments, and these he set himself to make. Not only were the stars he saw with his naked eye shown more distinctly in his telescopes, but he soon found that there were hundreds of stars to be seen with his instruments which, without them, were quite invisible.

And so the months passed by, Herschel teaching his music pupils in the daytime, conducting concerts at night, and after they were over, sitting up observing the stars with his telescope, or, if the night was cloudy, making bigger instruments. It is said that he would even run

out during a concert interval, in order to do a little more work at the telescope he happened to be making. In this way Herschel began the study of Astronomy, little thinking that he was shortly to become famous throughout the world. He had one companion in his long night watches, and this was his devoted sister Caroline, who would sit in the little shed near his telescope and write down the observations he made at the instrument. One hardly knows to which of these two there is more credit due; to William for his persevering and scientific mind, or to Caroline for her painstaking and accurate notes of her brother's observations.

There came a time when Herschel decided to possess a large telescope, and he not only determined to have one, but to have a good one, too. He could not afford to buy one of the size he wanted, so the only solution to the difficulty was to make one for himself. Thus he set himself about the great work, and his home was transformed into a work-place. His drawing-room he used as a carpenter's shop, and his best bedroom was furnished with benches, while tools of all descriptions were scattered about. He would rush home after conducting a brilliant concert in Bath and commence working at his great telescope, without even waiting to take off his lace collar and cuffs, which were the fashion in those days. After much hard labour the great telescope was finished, and Herschel set himself to observe all stars of a certain degree of brightness. It was whilst carrying out these observations that he came across what appeared to him a strange object. In a telescope the stars seem to be only points of light, but the planets appear as round globes—like little worlds,

in fact. This strange object, which Herschel found on the night of 13th March 1781, did not resemble a star—indeed it looked more like a planet; and after several nights of watching, the observer found that it had moved among the stars. Not daring to suppose that he had found a new planet, Herschel announced to the world that he had discovered a comet, and he sent his observations to some mathematicians. These men of figures, however, soon made it known far and wide that the object Herschel had discovered was not a comet, but was indeed a new planet.

Then at once did Herschel become famous, and King George was so pleased with his discovery that he made him Astronomer Royal. This enabled him to leave his music and to give all his attention to Astronomy. Afterwards he was knighted, and continued his observations up to the time of his death, being always accompanied by his faithful sister Caroline. So we see how, from the poor Hanoverian soldier, Herschel gradually became the famous astronomer and the discoverer of Uranus.

CHAPTER XIII

NEPTUNE, THE FARTHEST PLANET

IF Sir William Herschel's discovery of Uranus was wonderful, so, too, was the finding of Neptune, which is the eighth and outermost planet of the sun's family. I have said that the mathematicians had calculated the path of Uranus, and they were able to predict the exact place in the sky where the planet should be, in order that the astronomers would know where to point their telescopes to observe it. However, it was soon found that there was something wrong with the mathematicians' calculations, for the planet Uranus was not always to be found at the exact place the predictions said it should be. The figures were gone over time after time, and although no mistakes were found in the work, Uranus was still not where it should have been, according to the mathematicians. Sometimes the planet was a little late in reaching a certain position in the heavens, or at other times it was too soon, and this sort of thing went on for a considerable time, until at last two very clever men of figures, Mr. J. C. Adams and Monsieur Le Verrier, set themselves to look into the matter.

It was thought that there must be still another planet

outside the path of Uranus, and that this other planet was acting like a great magnet upon Uranus, sometimes pulling it back and making it late, and at other times pulling it forward and making it too early. The question that the two mathematicians had to answer was: Is there another planet; and if so, where is it?

Now you will easily understand that, even with a planet that is quite well known, calculations with regard to its exact place in the sky must indeed be very difficult. But how much more so must be the finding of the position of a planet that has never been seen and about which nothing is known? This was the task which Adams and Le Verrier set themselves to work out, and it was a curious thing that neither of these two gentlemen knew that the other had undertaken the calculation; but it soon became known that Mr. Adams in England, and Mons. Le Verrier in France, were both working at the task. More extraordinary still was the fact that they both got almost the same results to their calculations, but it was not until Le Verrier came to make his results known to the world that they found that they had both been engaged in trying to solve the same problem, unknown to each other. Adams had the great sum done first, and he sent his answer to Greenwich Observatory, but the Astronomer Royal of that day did not think much about it, for he did not seem to understand what a long time it had taken Mr. Adams to work out the calculations. When he received Mr. Adams's result, which gave the position in the sky of the supposed new planet, instead of immediately setting his assistants to work to look at the place Mr. Adams signified, the Astronomer Royal put the figures in a drawer and forgot all about

them. Soon after this, however, the French mathematician, Le Verrier, also sent his calculations to an astronomer, but not to Greenwich Observatory. He sent his answer to a German astronomer called Galle, at the Berlin Observatory. Now Galle saw that Le Verrier's work seemed to be worth looking at, so he did not put it into a drawer, as the English Astronomer Royal had done, but he began to observe the stars in that part of the sky where Le Verrier had stated the new planet might be found.

On the night of 23rd September 1846 Galle found a strange object among the stars, just in the same way as Sir William Herschel had discovered the planet Uranus. In a similar manner it was proved, soon afterwards, that the object that Galle had found was indeed another planet, and this was called Neptune.

Great was the rejoicing when the discovery of Neptune became known, and of course Le Verrier was delighted that his calculations should be so correct. But what of Mr. Adams's calculations? He had done the work and got just the same answer, but had not got any credit for his labours, because, you will remember, all this time his workings were lying forgotten in the drawer at Greenwich Observatory, where they had been placed by the Astronomer Royal. But if the Astronomer Royal had forgotten about Mr. Adams's results in the past, the news of Mons. Le Verrier's triumph aroused him, and he suddenly remembered Mr. Adams's calculations, which were still lying in his drawer. Taking up the calculations, the Astronomer Royal soon saw that Mr. Adams's result was practically the same as Mons. Le Verrier's, so he

hastened to make known to the world that Mr. Adams had sent his calculations to him, correctly worked out, some months before Mons. Le Verrier had worked out his figures. Although at first Mons. Le Verrier was not at all pleased with this news, later on he came to see that there really was some credit due to the English mathematician, and he determined to share the glory of Neptune's discovery with Mr. Adams.

If it had not been for the forgetfulness of the Astronomer Royal, and one or two other matters, Mr. Adams would have been the first to solve the great mystery of the strange movements of Uranus, and so would have been able to have sole credit for the discovery of the farthest planet of the Solar System. As the matter stands, however, the discovery was a great achievement, and it will long be remembered in the history of Astronomy.

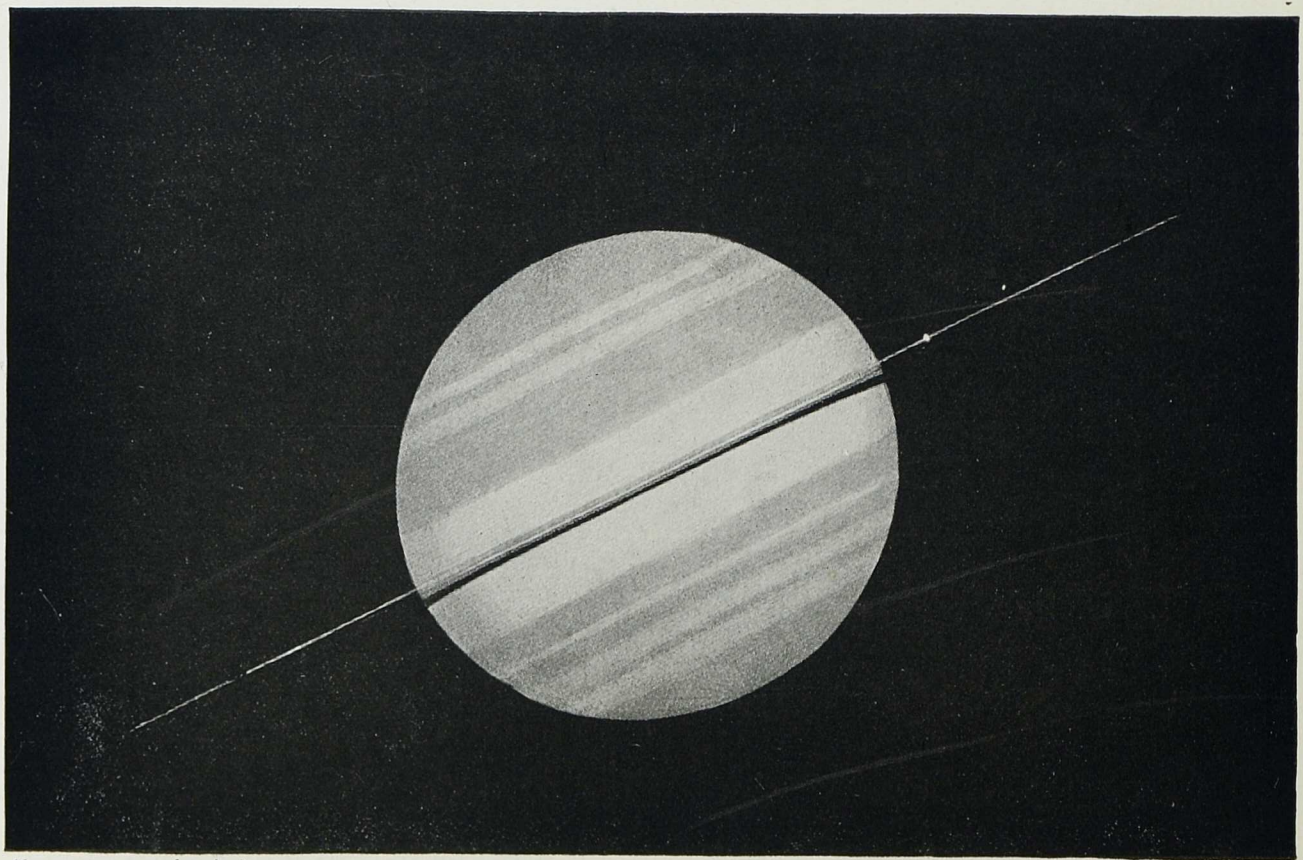


PLATE XXIII

From an engraving by] [R. A. Proctor

Saturn, showing the rings as they appear when seen edgeways

PLATE XXIV

[From a photograph by] [Dr. Max Wolf

The Morehouse Comet, 10th November 1908, showing stars shining through the tail of the Comet

CHAPTER XIV

COMETS

AT some time or other during our lives we may expect to see one of those wondrous objects called Comets. The word "Comet" comes from a Latin word meaning "a Hair," and, when seen at night, a comet certainly does look like very fine silvery hair, hanging against the dark sky. Sometimes very large comets are to be seen, and these prove to be beautiful sights. Unfortunately it is but seldom that we are able to look on a really large comet, although there are on an average as many as five comets in a year. These are, for the most part, small ones, and only to be seen through a telescope.

No doubt your fathers will be able to tell you of some of the comets they have seen, and perhaps you will hear accounts of a most beautiful one, called Donati's Comet, seen in the autumn of 1858. Although this is a very long time ago, people tell me they can distinctly remember this comet, because it was such a brilliant object in the sky—so bright, indeed, that it considerably frightened several people. If you read the poems of Oliver Wendell Holmes, you will find that he speaks of a comet as "The spectre of the skies," and spectre, you know, is another name for a ghost. Although I have never seen a ghost, I am told by

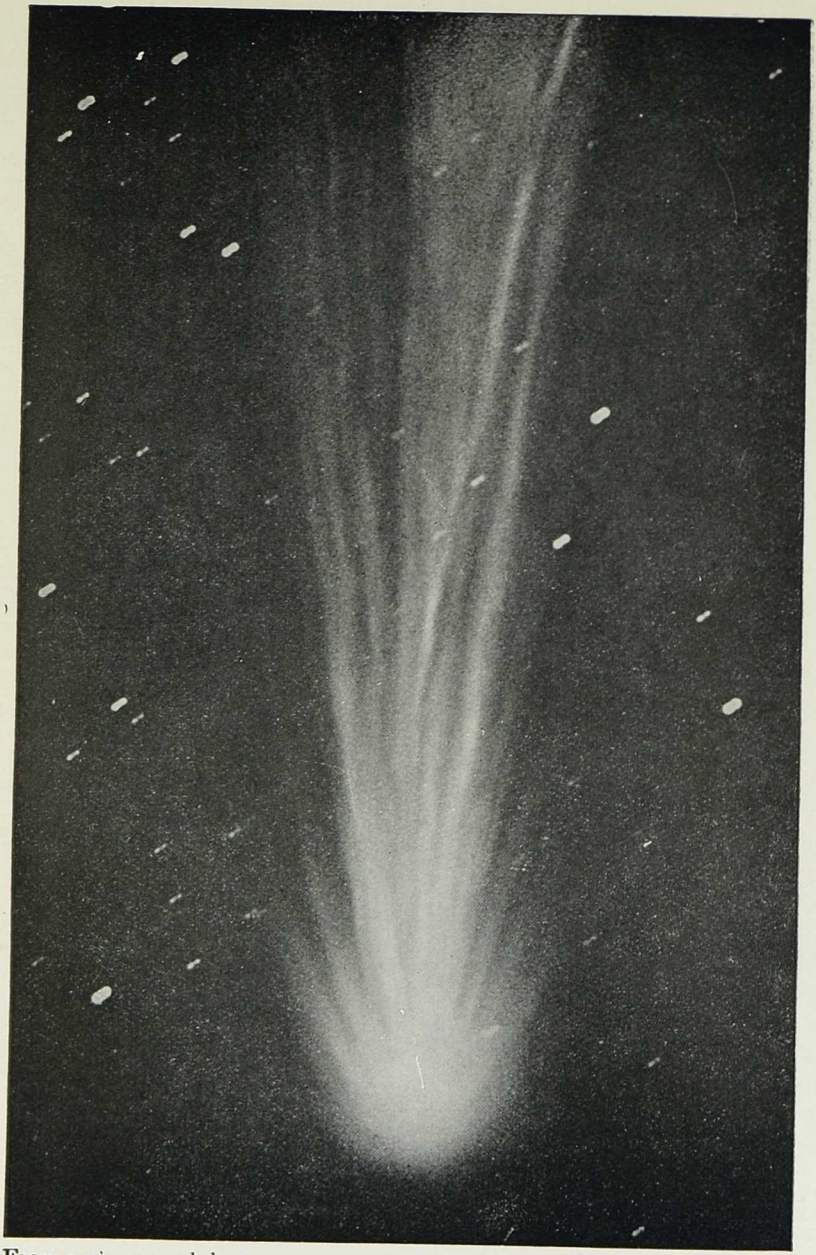
people, who say they have seen one, that chairs and tables may be seen through a ghost's body. Just in the same manner we can see stars shining through a comet's tail, and this is probably one reason why comets have been called "Spectres."

Comets travel round the sun, just in the same way as planets do, and although the path of a comet is not the same shape as the path of a planet, yet the comets obey the same laws, and are ruled over by the sun. There was a most interesting comet in November 1908, called the Morehouse Comet, pictures of which are to be seen on Plates XXIV. and XXV. It was very faint, only being visible through a telescope, and was chiefly remarkable for its tails, which underwent many changes. A comet's tail looks something like the steam which comes out of the funnel of a railway engine, but we do not know sufficient about these bodies to be able to say of what they are composed.

On a certain night the Morehouse Comet had one long tail, but when I looked at it through my telescope on another evening I found it had suddenly developed no fewer than six tails, and on another night, later still, I was surprised to find that it had no tails at all. In this mysterious way a comet can puzzle astronomers, and baffle all their attempts to find out of what it is made, or from whence it came.

A comet may be said to be composed of two parts—the head or nucleus, as it is called, and the tail. The nucleus is really the comet itself, but people who know little about Astronomy think that the tail is by far the most important part about a comet; but this is not so, although it is quite true that a fine tail makes a comet look far more imposing

PLATE XXV



From a photograph by] [Dr. Max Wolf

The Morehouse Comet, 16th November 1908

in the sky. Just as the tail of a comet may undergo changes, so too the head or nucleus may alter, though not to such a great extent. Let us look at the two beautiful photographs of the Morehouse Comet shown on Plates XXIV. and XXV., two pictures taken on different dates. You will notice the fiery-looking spikes shooting out from the nucleus, and forming small tails, behind the comet. The great tail itself streams far and away behind the head of the comet, and seems to twist and curl just as smoke from a chimney does on a windy day. The little white streaks you see, around the comet, are not faults in the photograph, but stars which the comet seems to be passing as it travels in the sky.

We do not know what a comet really is, for there have not been very many bright comets since our large telescopes were made. It is only during comparatively recent years that observatories have been built and fitted up with costly instruments. We can hardly expect, therefore, to know very much about comets when there have not been many bright ones to examine with modern instruments. From what has already been learned, however, it seems probable that comets are largely composed of gaseous matter; or, to put it in another way, they may be simply clouds of gas, which in some manner are held together as they travel round the sun. Some comets journey round their paths in a few years, like that called Encke's Comet, which takes about four and a half years to go once round the sun. Others take longer—perhaps many thousands of years, like Donati's Comet, which takes 2400 years to travel once round the sun!

When a comet is first seen through a telescope, it looks

like a faint misty star, or tiny patch of delicate light, but as it draws nearer to us its brightness increases, until it is seen in all its glory, and may then be a magnificent object in our skies. After that it fades away, until it is once more a misty patch of light, and, getting gradually fainter and fainter, it is lost in the depths of space, and cannot be seen even with the greatest telescopes in the world. There is one thing, however, from which the comet cannot escape, and that is the pen of the mathematician; for although the comet may be invisible for years, yet the mathematicians can calculate exactly where it is in the depths of space, and they can also tell when it will return.

CHAPTER XV

HALLEY'S COMET

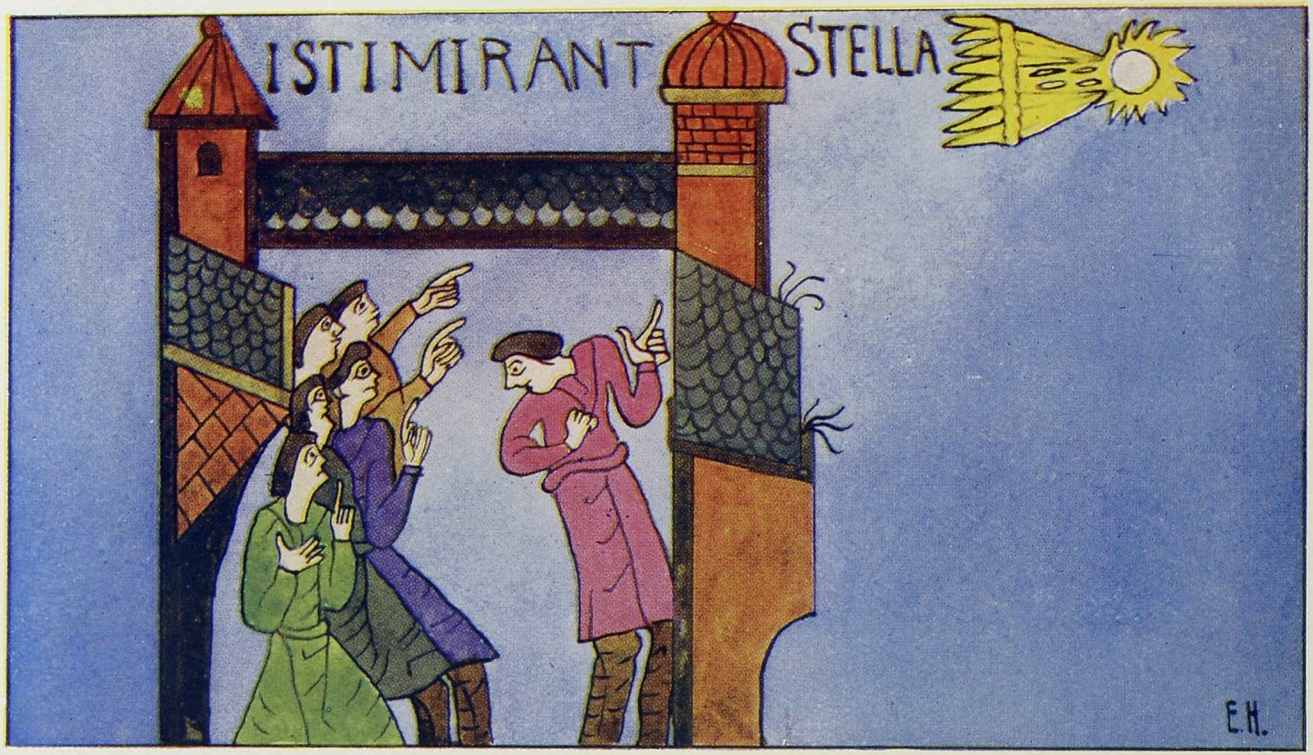
ONE of the most interesting of all the comets is that known as Halley's, and this comet was to be seen in May 1910. Halley was a renowned astronomer, and at one time occupied the position of Royal Astronomer, at Greenwich Observatory. Comets interested him greatly, so he determined to investigate their mysteries. Very little was known at that time about these objects, so that Halley had to find out almost everything for himself. After working away at the subject for some time, he thought there was a certain comet which seemed to appear once in about every seventy-five years; but at that time it was not even supposed that comets travelled around the sun, and it was, therefore, a very daring thing for Halley to say that this particular comet came back every seventy-five years. He was so certain of the fact, however, that he predicted the comet's return for the year 1758. Unfortunately, before that year came, Halley died; but the comet came back true to his prediction, and the astronomers, who had been expecting it, named it Halley's Comet, as a tribute to the work that Halley had done in connection with comets in general, and with this one in particular. The fact of this comet's returning every seventy-five years

proved that comets obey the same laws as the planets, and that they travel, each in its own path, around the sun. As Halley's Comet comes to the sun every seventy-five years, and as the earth is comparatively near to the sun, it follows that the comet will be visible to us every seventy-five years. It is only natural to suppose that it would have been seen on many occasions *before* Halley's time, and by looking up back records of comets we can trace this particular object for hundreds of years—indeed, up to a time long before the birth of Christ. Some of these records are made on parchment, but those records of the comet which were made before parchment became known are made upon clay tablets, such as have been found in the land of ancient Egypt. Of all the records, those of the Chinese have been the most useful in tracing back Halley's Comet. The Chinese thought that the stars represented countries on the earth, and they imagined also that they could tell what was about to happen to the nations of the world by watching the stars in the sky. Of course, when a strange object, like a comet, appeared among the "kingdoms of the sky," it was a cause of great excitement among the Chinese people, for they thought that it was a sign that an ambassador was about to visit that particular country on earth which corresponded to the stars in the sky through which the comet passed. Comets were therefore looked upon as very important objects by the Chinese, and very careful records were kept, not only of their appearance, but also, what is more important still, of the stars near which the comets passed on their journey through the sky. The Chinese thought that by keeping these accounts they would be able to predict happenings on the earth,

little thinking that these very records would be most useful to twentieth-century astronomers in finding out the former appearances of Halley's Comet.

In olden days, too, people were very much frightened when a comet made its appearance in the sky. At Bayeux, a town in Normandy, there is a most interesting tapestry. You will know that a tapestry is a needlework picture, worked in wool, perhaps, on canvas or other suitable material. The tapestry of Bayeux has all sorts of pictures worked upon it, tradition says, by Queen Matilda, William the Conqueror's wife, but it is somewhat doubtful if she really did make the tapestry. At any rate the Bayeux Tapestry has been very useful both to historians and astronomers, for its pictures have shown us how the people of those days used to dress, and they have also taught us many other things which might otherwise have remained unknown. One of these pictures, shown on Plate XXVI., shows the people watching a comet in the sky; there is inscribed over it the words, "ISTIMIRANT STELLA," which means, "These (people) wonder at the star." It has been proved that the comet shown in this picture is indeed Halley's Comet, as seen on its 1066 return. This date you will all remember as being famous for the invasion of England by the Normans, and the battle of Senlac, near Hastings, at which King Harold was killed. When the people of Britain saw the great comet in the sky they were very much afraid, and you will see, from the expression on their faces, that they seem to be expecting something awful to happen. The people of Normandy were frightened too, but William himself was not afraid of the comet, and told his frightened soldiers that the comet

was a sign that a kingdom wanted a king. Thus reassured, the soldiers set out in the ships for England, ready to help their leader to win the kingdom. As we know, the Normans defeated the English, Harold was slain, and William got his kingdom. It was only natural that the English people should then feel quite convinced that these misfortunes were caused by the comet, for they had predicted dreadful things from its appearance. One writer goes so far as to say that if the comet had not appeared and frightened the English, William would never have been the conqueror. Whether this is so or not we cannot say, but it is very interesting to think that Halley's Comet, which many of us have seen, is exactly the same comet as was seen by William the Conqueror and by the English people before the invasion of the Normans.



From a painting] [by E. Hawks

Halley's Comet in 1066. From the Bayeux Tapestry

From a painting] [by E. Hawks

The Daylight Comet, 21st January 1910

CHAPTER XVI

OTHER COMETS

THERE are many other comets, besides Halley's, of which we have records, and of which the mathematicians are able to tell us the whereabouts, although we cannot see them, even in the largest of our telescopes. So clever are the calculators that they are able to tell us when each comet will appear, and also the exact place to which we must direct our telescopes to discover them. On an average there are about five comets a year, but most of them are not visible to the naked eye. To the astronomers, however, they are all interesting, whether large or small, but people generally think that a comet is not worth looking at, unless it is very bright and topped with a great tail.

Sometimes comets get lost and do not come back when expected, as, for instance, that called Lexell's Comet, which in 1779 disappeared from our view and has not been seen since. Then, again, comets may appear in quite different forms from those in which they were last seen from the earth, on their previous visits. There was a comet in 1826, known as Biela's, because of its discovery by an Austrian soldier, Wilhelm von Biela by name. This comet took a little over six years to traverse its path around the sun, and in

1846 it actually split up into two pieces, which travelled along together like two friends out for a walk!

The next time they came back, which was in 1852, they were still separated, but they have now got lost, for they have never been seen since. Where they have got to no one can say, but these facts go to prove that comets, although governed by the same laws as the planets, are always unreliable, and may do all kinds of unexpected things.

I cannot leave the subject of comets without referring to the beautiful and ever-memorable comet (Plate XXVII.) which appeared in our skies during the month of January 1910, and which, I have no doubt, many of you would see. It was called the "Miner's Comet" by some, while others named it the "Daylight Comet." As a rule, astronomers do not bother with fancy names for a comet, but simply give it a number, or rather a letter, which is placed after the year in which the comet is discovered. For instance, this Daylight Comet was the first comet to be discovered in 1910, and consequently astronomers called it "Comet 1910 *a*." The second comet to be discovered in the year will be called "Comet 1910 *b*," and so on. The Daylight Comet was indeed a beautiful sight, and I shall never forget the first time I saw it. The sun had just set, and the sky was a beautiful primrose-yellow colour; a low bank of purple cloud hung near the horizon, while high up to the left was the planet Venus, shining with great brilliance. Somewhat below and to the right of Venus was the great comet itself, looking like a sheaf of golden fire, its beautifully curved tail stretching across the sky for a considerable distance, and resembling a curved sword.

Although, as I have said, the mathematicians are able to tell us a great deal about the comets, and when to expect them, they can only give us information of comets which are already known, or which have been seen before by astronomers. There sometimes appear comets which are quite unknown, and these are indeed "surprise comets," for they appear suddenly and quite unexpectedly. The Daylight Comet was one of this class, for it was discovered suddenly one morning in January 1910, just after sunrise, by some miners in South Africa. They espied a strange-looking object in the eastern sky, which afterwards turned out to be the Daylight Comet. The miners telephoned to the nearest observatory, and the astronomers there sent cables all over the world, and so we in England soon had news of the unexpectedly discovered comet. A few days later it was seen in several parts of England, first by those who were on the watch for it and knew where to look, and afterwards by thousands of other people.

To the unaided eye the tail of the Daylight Comet appeared as a beautiful curve of golden light, but the photographs which were taken of it showed that it was really fan-like and very much broader than was supposed. After a few days of brilliance the comet gradually faded away, until it became but a faint speck in the telescope. It had lost its beautiful tail, and was travelling away into space, from which it will never return.

I have mentioned that in years gone by people imagined comets to be a sign that something of an evil nature was about to happen, such as a plague or a famine. One would imagine that in modern times superstition of this sort would have been given up, but there are still a few

people who seem to believe in it, for when the Daylight Comet was visible in our evening skies, some said that it was the cause of the great floods that were taking place in Paris at the time. These people quite forgot that at the same time as there were floods in Paris there was also a "water famine" in Egypt, and the comet could hardly cause both, although the Arabs also blamed the comet for causing their water-supply to dry up! Other people thought that the comet was a sign that the world was coming to an end; but, far from a comet being looked upon as an object of fear, we should be only too glad to see one of these interesting visitors and try to obtain all the information we can about it, so that we shall be able to know more about these mysterious objects.

CHAPTER XVII

SHOOTING STARS

MOST of us have seen, at one time or another, some of those beautiful objects called Shooting Stars. Often on a dark night, when the stars are shining with all their brilliance, there suddenly dashes across the sky a streak of gorgeous light (Plate XXVIII.), which disappears as silently as it came. Although these objects are called Shooting Stars, or sometimes Falling Stars, they are wrongly named. They are not really stars at all, though they certainly do look like them. Several theories have been put forward as to what they are, but we do not know their true nature, and astronomers are, at the present time, making all the observations possible of these beautiful objects, in the hope of being able to learn more about them. If you pay a visit to the South Kensington Museum, you will see large numbers of objects called Meteorites, which resemble ordinary stones to a certain extent. They are of all sizes, from that of a grain of sand to that of a huge mass weighing many hundredweights. These meteorites have fallen to the earth, and it is supposed that there are large numbers of these bodies revolving round the sun and that they come into collision with the earth. You know when you rub a piece of india-rubber on paper, the rubber

becomes quite hot, and the harder you rub the hotter does it become. This is on account of a certain law called Friction, and it is in something the same way that the meteor, rushing through the earth's atmosphere, becomes heated, because each little particle of the atmosphere is rubbing against it, and such a great amount of Friction is caused that the meteor becomes white-hot, and we on the earth see it from below as a shooting star. When a very large meteor enters the earth's atmosphere, however, it may happen to reach the ground before it has all been melted away; so we find, in a few cases, meteorites which have fallen to the earth.

On the 20th April 1876, at about 3.30 in the afternoon, the people who lived in and around the village of Rowton in Shropshire heard a great, rumbling noise. Then came a loud explosion, and a farmer found that a great meteorite had fallen in one of his fields, and it was quite warm when he first saw it. This object weighs about $7\frac{3}{4}$ lbs., and is to be seen in the Natural History Museum at South Kensington. It is not often that one of these stones is seen to fall, although a great number of shooting stars are seen every year. At certain times there are more shooting stars seen than on an ordinary night, and perhaps the best known of these dates are the 10th August and the 13th November each year. If you look out on these nights, and if the sky be clear, you are pretty certain to see several meteors. They will not all come at once, but perhaps first one and then another a few minutes later. Sometimes there will come about half-a-dozen, one after another, and so on. Often meteors leave trails behind them, which may last for a few seconds, or perhaps for

several minutes. There was a very large shooting star seen on the 22nd February 1909, some people saying that it was as big as the full moon. Whatever its size may have been, it was indeed a magnificent sight, and left a trail behind which could be seen for four or five hours after the meteor itself had vanished. Some of the meteors are extraordinarily bright, like this one, while others are so faint that they can hardly be seen. They differ in colour, too, being perhaps white, blue, yellow, or red. Some travel across the sky very fast, while others travel but slowly, and it is all these little points that astronomers have to watch, in order to find out exactly what these shooting stars are, and from whence they come. Sometimes when great displays of meteors are expected, they do not take place, as for instance on 13th November 1899. A great shower of shooting stars was expected on that date, and a crowd of people assembled not far away from where I was observing. They waited expectantly for many hours, but the shooting stars did not come. Still the people waited, till it was long past midnight, and then some University students, who intended to have some fun set off a great flight of sky-rockets—the sort which burst and send out a shower of coloured stars. When the people saw all these beautiful "firework-stars," they cried: "Look! look! There are the shooting stars!" After the fireworks had died away the people went home, quite thinking that they had seen the real shooting stars, and I do not believe they know to this day that what they saw on that night were only fireworks, set off by the University students!

CHAPTER XVIII

THE GREEN FLASH AND THE NORTHERN LIGHTS

SOMETIMES, just as the sun is disappearing over the horizon, we can see its tip turn to a beautiful green colour, and this phenomenon is known as the Green Flash. No doubt you will be able to view the Flash some time for yourself, when the night is fine enough to allow you to see the sun actually disappear over the horizon. You should choose a spot where the horizon is quite clear of houses or trees, and then watch the sun gradually sinking lower and lower. First the bottom edge of the sun will touch the horizon, and then it will commence to slowly disappear until it is half gone. At this stage you must watch carefully, for, as the minutes go by, the sun will get lower and lower until there is only a tiny tip left. Then, just before it finally disappears, you will perhaps see a little green flame shoot up, and the tip of the sun itself will turn green. I do not say that you will always be able to see this Flash, but only on certain occasions. I have known people only see it once out of a dozen times, but it is very interesting to watch the sun disappear over the horizon, and to look for the Green Flash. You will notice, too, that when the sun is low down, near the horizon, it will lose its circular shape and appear oval, like an egg. It will also seem a great deal larger than it does when seen high in the sky. This is because of the extra thickness of the atmosphere near the horizon, which acts as a sort of

From a painting] [by E. Hawks

A shooting star

magnifying glass and enlarges the sun, when it is low down. The moon may also be seen enlarged in the same way, as it rises in the east, when it is full.

Perhaps I may mention in this chapter a beautiful sight which may sometimes be seen in the sky, and which is known as the *Aurora Borealis*, or the Northern Lights. This sight takes the form of a sort of fiery mist of a golden colour, which is seen in the sky towards the north. What the Northern Lights are we do not know, but it seems that they are perhaps due to some electrical influences, and it is remarkable, too, that the Aurora has a connection with the sunspots. When a great storm takes place on the sun, there are often beautiful displays of the Northern Lights seen from the earth; but what their connection with the sunspots really is, astronomers cannot yet tell. During the summer months the northern sky is lit up nearly every clear night, but this must not be mistaken for the Northern Lights, for it is the "Sun-Glow." In summer the sun does not dip very far below the northern horizon, and so it throws up a sort of reflection which makes a beautiful primrose-coloured Glow appear in the north, during the nights of summer. Occasionally this Glow is so strong that it makes the sky quite light, and one can even read a newspaper by it. Though this spectacle is very beautiful, it must not be confused with the *Aurora Borealis*, which does not give off any great amount of light, but appears more like arches of fiery mist in the sky.

I have now mentioned something about the Solar System, and the planets and comets which belong to it. I have also touched upon the meteors and the Aurora, and I shall now proceed to tell you about the stars themselves, which are quite different from anything about which we have yet read.

CHAPTER XIX

THE STARS THEMSELVES

I CAN well remember that when I was a very little boy, my mother taught me a verse which, I have no doubt, you also have learned. It runs like this:—

"Twinkle! twinkle! little star,
How I wonder what you are;
Up above the world so high,
Like a diamond in the sky."

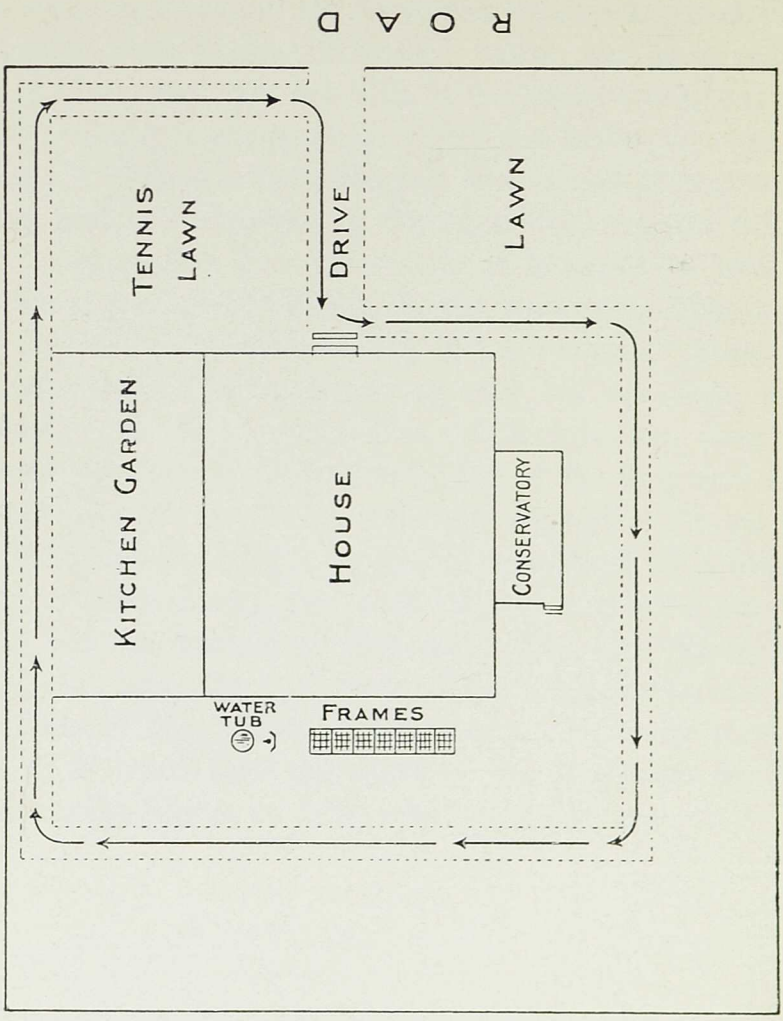
I used to say or repeat it like a parrot, without giving an instant's thought to what it might mean, and I wonder how many of you have thought about the stars. When we go outside on a clear night, we can see a great number of these shining points of light in the dark sky. Some look quite big and near, while others look very small, or else far away.

Long ago, before people lived in towns and cities, as they do now, there was a race of people called the Chaldeans, of whom you will no doubt have read in the Bible. These people, for the most part, followed the occupation of shepherds, and when they were out on the hills with their sheep, they generally had to sit up all through the night, guarding their flocks from the prowling wolves and

other animals which were always hanging about, ready to carry off the young lambs, or even the sheep, at the first opportunity. The Chaldean shepherds were no doubt very lonely during these long night watches on the hills, for they had no lamps to lighten the darkness. Even if they had had lamps they would not have been able to do much to relieve their loneliness, for they did not know how to read or write. There was one thing, however, which the shepherds loved to do during the long nights of watching, and this was to look at the stars sparkling with great brilliance, as they do under those far-off skies, where smoke-clouds are never seen. The shepherds would often imagine to themselves quaint figures, or pictures, among the stars, just as we sometimes imagine we can see faces in the red-hot coals of a fire. Not only did the shepherds imagine these star figures, but they also gave them names, some of which, it is wonderful to relate, remain to the present day, though hundreds and hundreds of years have passed since the star figures first received their names. The shepherds did more than merely give names to these star figures, which we call the constellations, for they also made up stories or legends about them. I am sorry to say, however, that nearly all these interesting stories have been lost, because, as I mentioned before, the Chaldeans did not know how to write, so that all the stories of the constellations had to be carried in the head, just as we remember a verse of poetry or a song. Although most of the stories have been forgotten, there still remain one or two which have come down to us with the names of the constellations, and these I shall presently tell you. You will then, perhaps, be able to learn some of the Chaldean

legends and to find, in the sky, the star figures to which they refer. You will be interested to know that the star figures you are able to see at nights are exactly the same as those upon which the Chaldean shepherds gazed while minding their flocks. Although many ages have passed since then, the stars are still in the same positions, and will probably remain as they are for many ages yet to come. When you have learned the names of the bright stars, and the positions of the constellations, you will be surprised to find how interesting it becomes to look up at the sky on a clear night, for the stars seem like friends as we see them twinkling away in the heavens. Indeed a friend of mine, when observing with his telescope, does actually talk to the stars just as though they were his personal friends. When one thinks of the long and cold hours that the astronomer spends, observing the planets or the stars, one might be apt to think that he is lonely, in the observatory; but such is not the case, for the stars are the friends of the astronomer, and loneliness, cold, and other discomforts are quite forgotten amidst the wonders of the heavens. So, too, on a lonely road at night, the stars take the place of the landscape by day, and are the friends of those who know their names.

PLATE XXIX



The walk round a garden

CHAPTER XX

THE GREAT BEAR

NEARLY all the star-figures have their names in Latin, and in mentioning each one I shall first give the Latin name and then the English meaning, for astronomers generally speak of the constellations by their Latin names. The stars rise and set, just as the sun does, and they change, too, at different times of the year, for the earth travels round the sun in somewhat the same manner as you might walk along a garden path. Suppose we start to walk from the front door, shown in the accompanying sketch, Plate XXIX., and walk past the conservatory, the cooling frames, and the water-tub. Passing the kitchen garden, we arrive at the tennis lawn, and by continuing the walk, come back again to the front door. Now we shall have noticed that, when we got to the conservatory, the front door could not be seen, while from the kitchen garden we could not see the conservatory. Just in the same way, the earth travels along its path, and some of the stars cannot be seen except as the earth is passing them, as it were. Of course, after these stars have been passed, they remain unseen until the same time of the following year, when the earth has again reached that particular point in its

path. So you will see that we have the stars of spring and of summer, and the stars of autumn and of winter.

Although most of the constellations are visible only at certain times of each year, there are some stars which are visible all the year round. The reason for this is that they are what we may call over the top of the earth, but the other stars, which disappear from our view at certain times, are lower down, as it were, in the sky. It is as though there was a very high tree in the garden we have just referred to. This tree, we will suppose, is higher even than the house-top, and it can thus be seen from all parts of the garden.

The stars which may be seen all the year round are found in the northern part of the sky, and perhaps the best known of these is the constellation called *Ursa Major*, or the Great Bear. If you will go out of doors some fine, clear night, and look towards the northern sky, you will soon find the seven bright stars which form this group. In shape they resemble the picture on Plate XXX., and are sometimes called King Charles's Wain, or Wagon, because their shape resembles, to a certain extent, the body of a wagon with its shaft. Each star of the constellations is known by a Greek letter, and these you will see close to the stars in the picture. The two stars marked "α" and "β" are called "The Pointers," because they always point to the Pole Star, as shown in the picture, Plate XXX.

The Pole Star is what we may call the centre of the stars of the sky, for they all appear to move round it. Those which are near to it make small circles around it, while those that are further away make bigger circles. If we could journey to the North Pole of the earth, we

should see the Pole Star exactly overhead, because it is over the North Pole. In spring you will find the Great Bear almost above your heads, but in summer it will be between the Pole Star and the north-west horizon. In autumn it will again be found to have changed its position, and will be found between the Pole Star and the northern horizon, while during the winter months it will be found between the eastern horizon and the Pole Star. It is necessary that we should learn well the position of the Great Bear, and also of the Pole Star, for these two figures will help us considerably in finding many other constellations. There is an old rhyme which says :—

"He who would scan the figured skies,
Its brightest gems to tell,
Must first direct his mind's eye north
And learn the 'Bear' stars well."

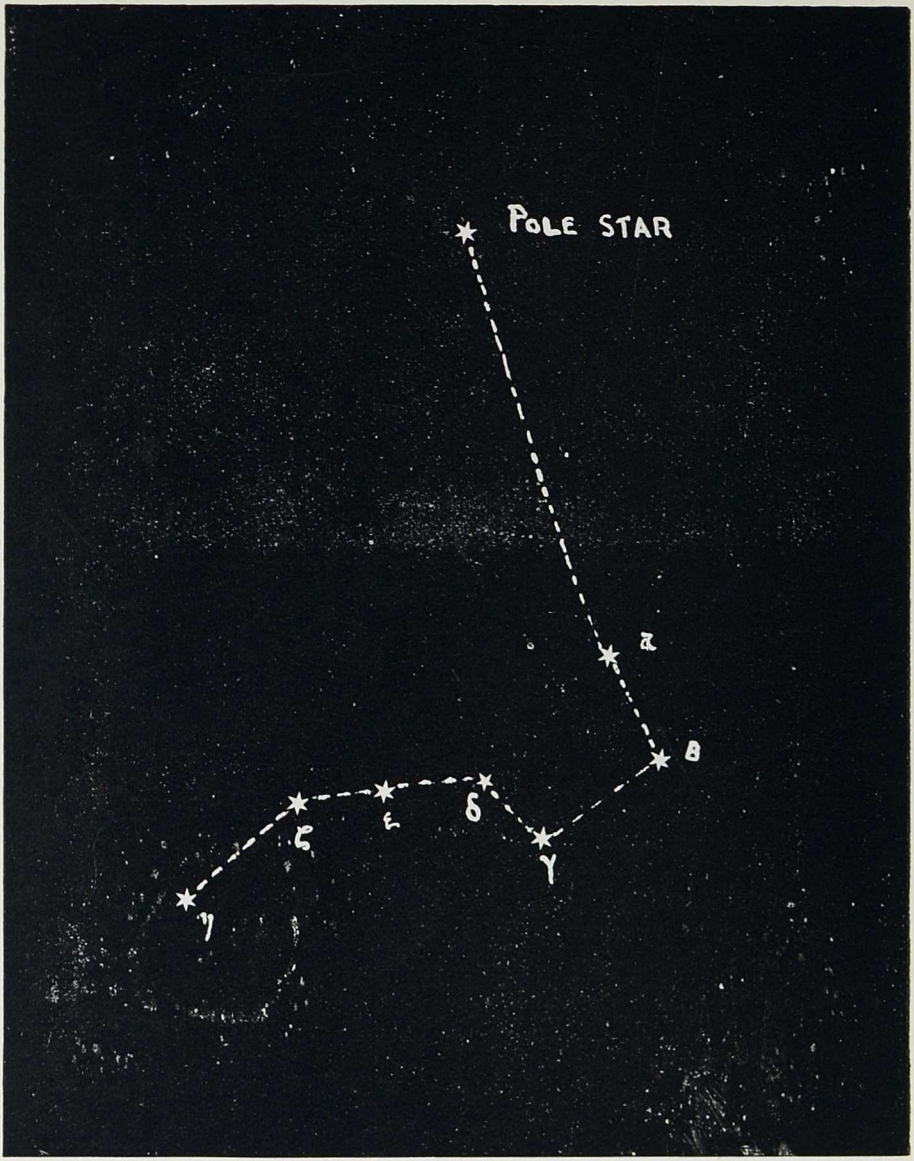
The stars of the Great Bear have been known for a long time as a constellation, and they have been found in a catalogue of the stars which was made over two thousand years ago. It has been found possible to work out the position of these stars from this ancient catalogue, and, it is said, the stars of the Great Bear have scarcely altered their places with regard to one another during the ages which have elapsed since the catalogue was made.

CHAPTER XXI

STARS NEAR THE GREAT BEAR

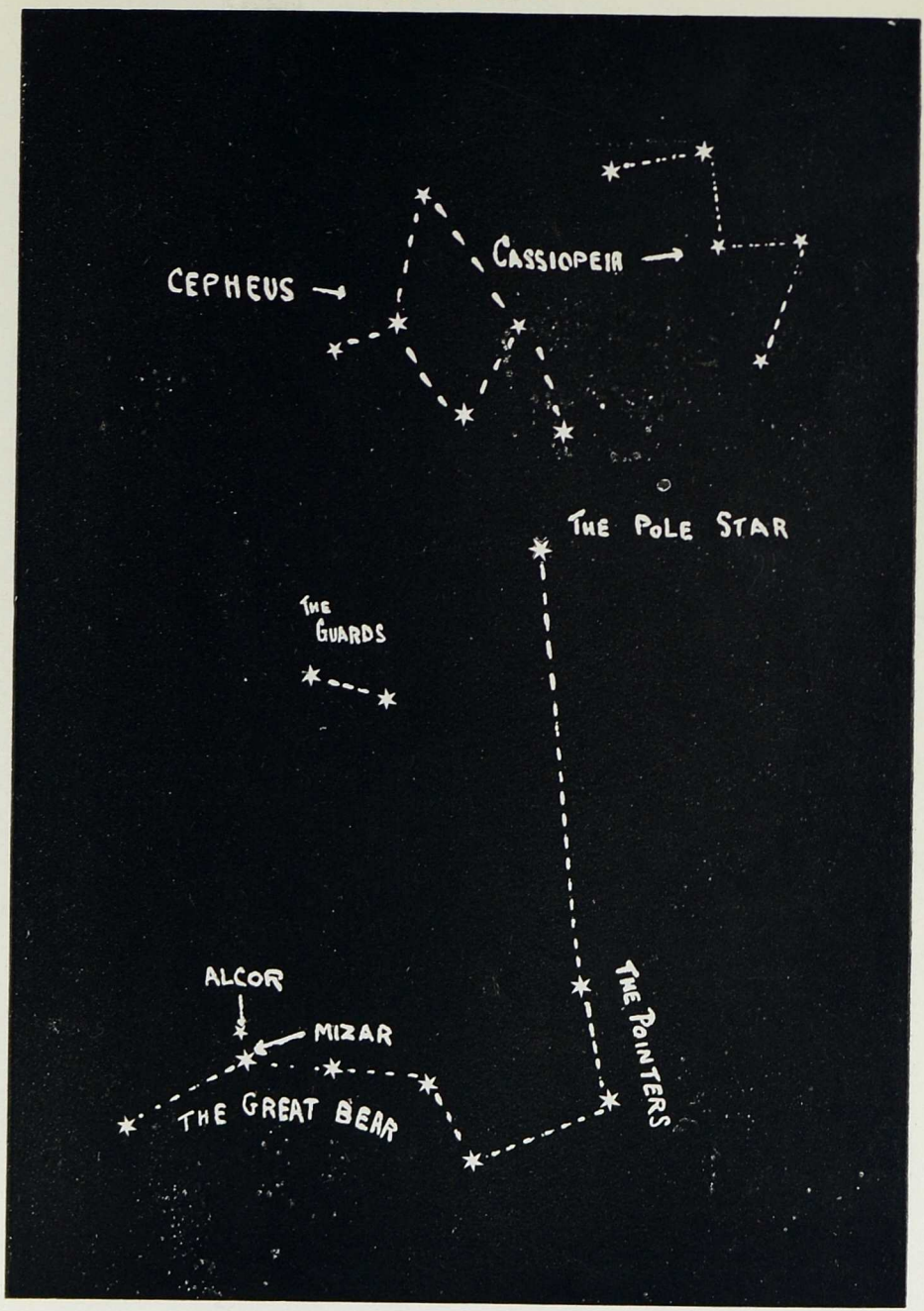
HAVING found the position of the Great Bear, we may now go on to learn another group of stars, called Cassiopeia, or the Lady in the Chair. These will be found almost on the opposite side of the Pole Star to the Great Bear, and if you look at Plate XXXI. you will see that they look like a large letter "W." They are very easy to find on a clear night, and we shall find them useful later on, like the Great Bear stars, in serving as guides to other constellations. Between the Pole Star and the Great Bear you will see two small stars, at no great distance from each other, and these are called "The Guards." As I have mentioned, the stars all seem to circle round the Pole Star, and if you make a diagram like the Plate, and stick a pin through the Pole Star, you will be able to turn the picture around, and thus gain an idea of how the stars in this part of the sky move. You will find, in observing the stars, that no matter what part of the sky the stars may be in, whether it be during the summer or during the winter, the Guards will always be in a position between the Great Bear and the Pole Star. It is for this reason that they are called the Guards, for they seem to guard the Pole Star from the Great Bear. The people of old thought that the Great Bear wanted to get at the Pole Star, so that he might add it to his stars, and so, they said, the gods had put the Guards in between the Great Bear and his prey, to prevent

PLATE XXX



The Great Bear and the Pole Star

PLATE XXXI



Cassiopeia, Cepheus, and the Guards

him from reaching the Pole Star. The Guards, therefore, will be found always carrying out their duty, remaining between the Great Bear and the Pole Star.

You will notice that by the side of the second star from the left hand of the Great Bear stars shown in Plate XXXI., there is a companion or smaller star. Unless you have fairly sharp eyesight you will not be able to see this little star, but a pair of opera-glasses will show it quite distinctly. I want you to specially look for it, because it is a most interesting object; the bright star, which it is near to, is called Mizar, while the small star itself is known as Alcor. There is a legend that in the olden times the Arabs used these two stars as a test for eyesight, and any Arab who could not see Mizar and Alcor distinctly with his naked eye was not allowed to serve as a soldier. Of course telescopes and opera-glasses were unknown in those days, and it would have been quite an easy thing for the keen-sighted Arabs to see these two stars distinctly, so that it seems as though the Arabian army would have no lack of soldiers, if the story be true!

Astronomers have had to ask themselves several things with regard to Mizar and Alcor, and one of these, which they have had to find out, was whether these two stars are really close companions, or whether they are not near to each other at all, only looking so from the earth, just as we may see two street lamps, one behind the other, which look as though they are side by side. There are many of these companion stars, or double stars as they are called, and there are also some cases where there are three or even four stars all close together. It has been found that in some cases these stars are not really near to

each other, but are, like the street lamps, one behind the other. To this class belong Mizar and Alcor, for they are not really close companions. There are numbers of double stars, however, which really are connected with each other, and many of them are of most beautiful colours.

If you will look towards the north-east, in July or August, you will see there a group of stars, which have a shape similar to those shown in Plate XXXII. The Pole Star and Cassiopeia will help you to identify the new group, which is called the Great Square of Pegasus. Its shape resembles, to a certain extent, a frying-pan; the four stars of the Square forming the "pan" itself, while the three trailing stars make the handle. This constellation of Pegasus was supposed by the people of old to represent a winged horse, but no matter how vivid an imagination we may have, it is impossible for us to find any such resemblance in the star-picture. Either the Chaldeans had very differently shaped horses from those we know, or else they were able to imagine things that did not exist. As you will see, Pegasus is to be found at about the same distance on the other side of Cassiopeia as this constellation (Cassiopeia) is from the Pole Star, and the stars of the Great Square are so bright and clear that you will have no difficulty in finding them rising in the east, during the months previously mentioned. The stars which may be supposed to form the handle of the frying-pan are members of another constellation called Andromeda, and the three stars which you will see at the end of the handle are the stars of Perseus. All these groups are named on Plate XXXII., so that you will have no difficulty in knowing exactly which is the one and which is the other.

CHAPTER XXII

THE LEGEND OF ANDROMEDA AND PERSEUS

THE constellations of Perseus, Andromeda, and Cassiopeia have each a legend which is to be found recorded in Greek mythology. This mythology is most interesting to read, for it consists of many tales and legends, resembling, to a certain degree, the fairy-tales with which you are all familiar. Some of the stories are based upon a certain amount of substantial foundation, while others are purely imaginary ones. The story of Andromeda and Perseus runs as follows:—

Once upon a time there lived a certain Ethiopian king, whose name was Cepheus. His wife was called Cassiopeia, and their daughter was remarkable for her great beauty. The daughter's name was Andromeda, and Cassiopeia, her mother, boasted far and wide of her beauty, as a proud mother often does. Now there were a number of nymphs, called the Nereids, who lived in the depths of the Inner Sea, or the Mediterranean, as it is called to-day. Cassiopeia's boastings reached their ears, and they were terribly enraged to hear that any one dare put in a claim to being beautiful while they were alive, and they brought the matter to the notice of their father Nereid. Of course Nereid cordially agreed with his daughters, and decided to avenge their wrongs by sending a great flood to the

country of King Cepheus. The flood came and devastated the king's territory, not only damaging the land and the crops, but bringing with it a terrible sea monster resembling a dragon. So terrible were these pestilences that King Cepheus consulted the oracle of Ammon as to what could be done to get rid of this great flood, and also the fearful sea monster, of which, you may be sure, the people were greatly afraid. The oracle declared to Cepheus that the only way to get out of the trouble was to sacrifice the beautiful Andromeda to the sea monster. In order to save the land and the people, King Cepheus decided to carry out the advice of the oracle, and he ordered that Andromeda should be chained to a rock, there to await the coming of the sea monster. A strong and noble youth, Perseus by name, happened to be returning victorious from a battle he had just fought with Medusa, and his path lay past the rock to which Andromeda was chained. He saw her, and was so struck by her great beauty that he determined to rescue her and to make her his wife. At this moment, so the story goes, the great sea monster appeared from the ocean, and, after a severe battle, was slain by the noble Perseus. The conqueror then broke Andromeda's chains and released her, and as a reward for his gallant deed King Cepheus gave him Andromeda for a wife. Some time after, one of the Greek gods, Athena by name, gave Andromeda and Perseus a place in the skies, where you may see them to this day. Cassiopeia is there too, as we have already seen, and not far away from her is Cepheus, as shown in Plate XXXI. The terrible dragon is also to be seen, its shape resembling the diagram on Plate XXXVII.

In Plate XXXIII. you will see some more stars, which are near to Perseus, and which you will easily be able to find,

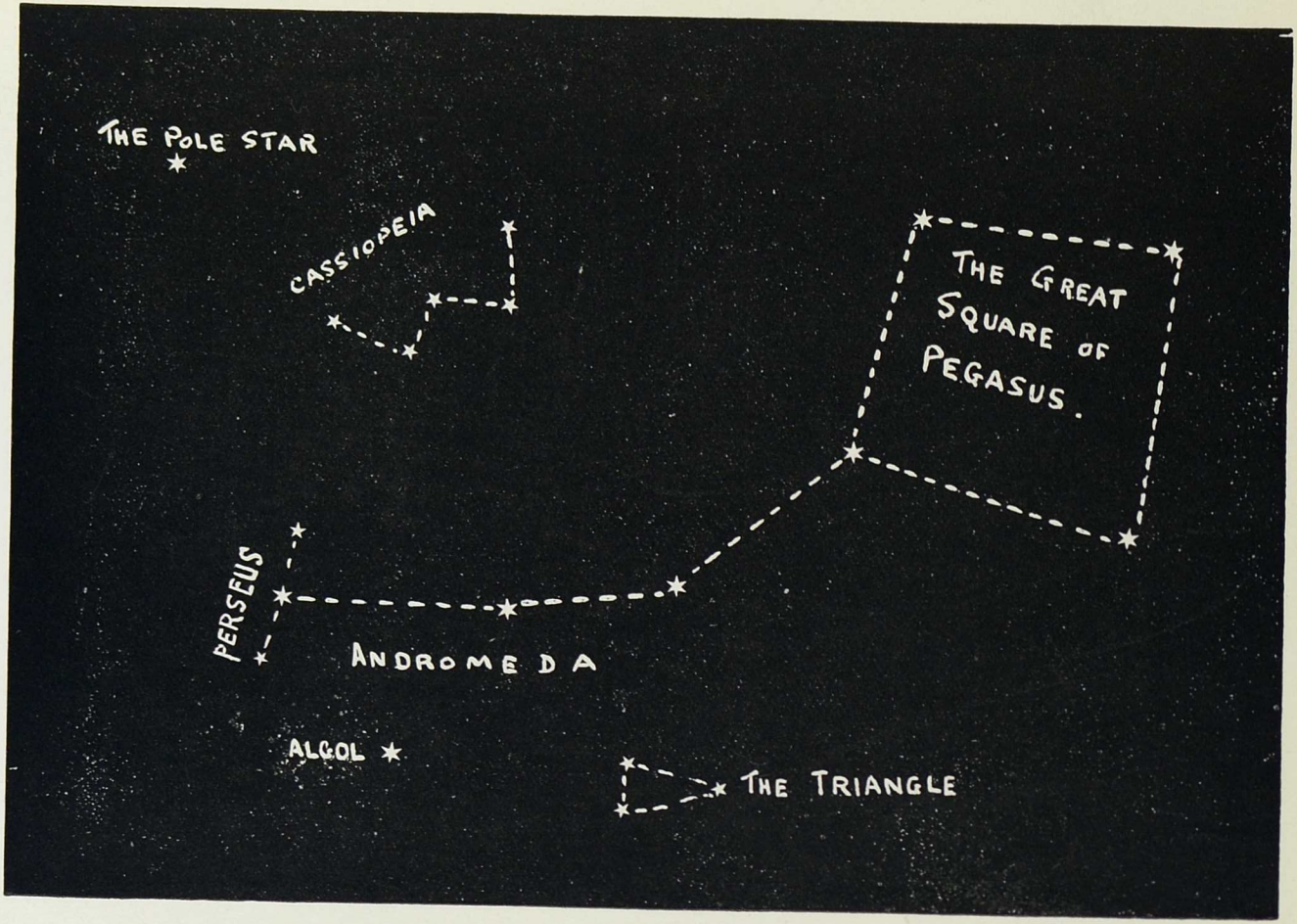
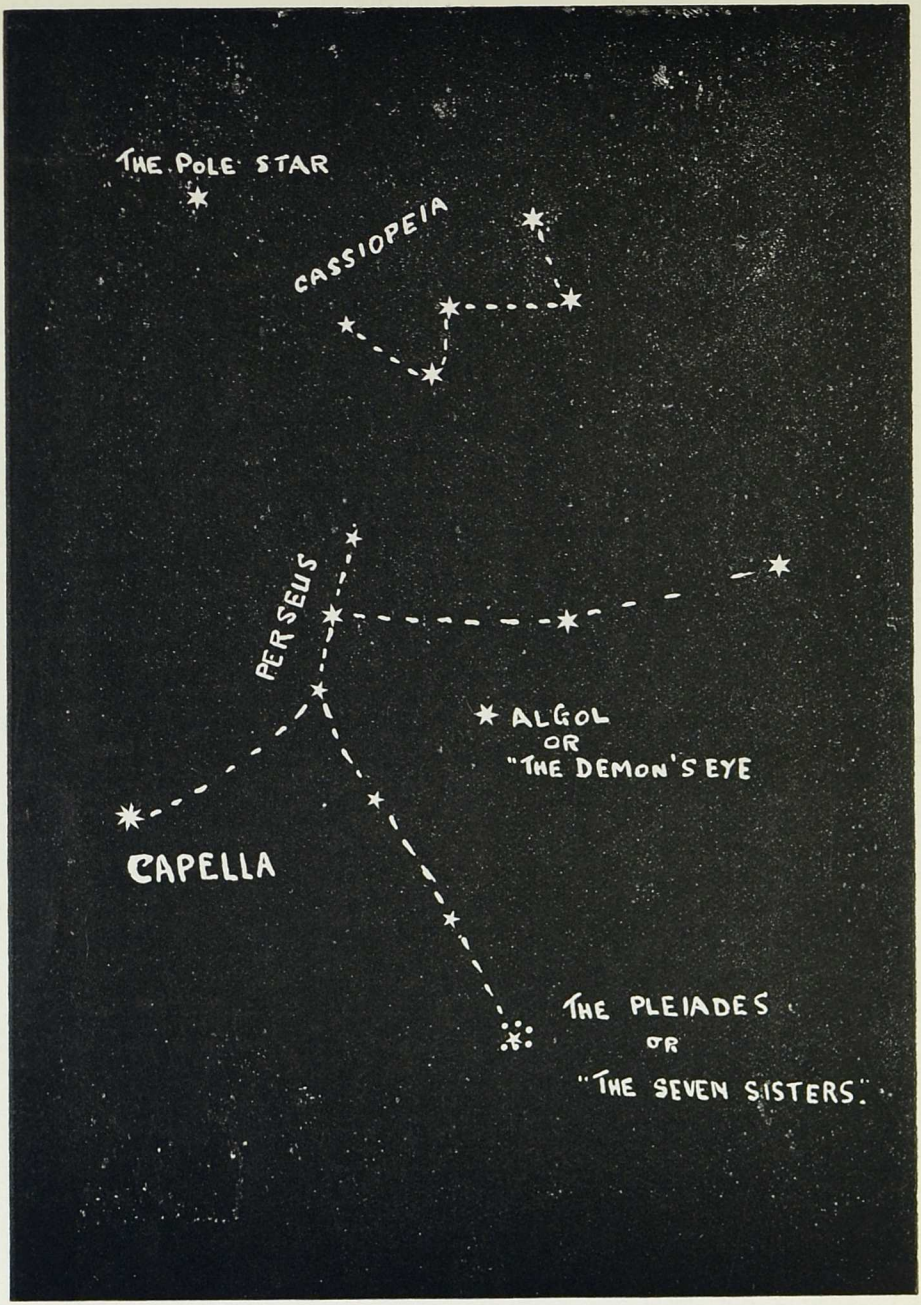


PLATE XXXII

Perseus, Andromeda, and Pegasus

PLATE XXXIII



Perseus and the Pleiades

once you know where Perseus is. The three bright stars of Perseus, just below Cassiopeia in the picture, will enable you to recognise Capella, which is one of the most beautiful stars which adorn our skies. Capella is situated at the end of a curved line, which we can imagine to extend somewhat towards the left hand, from the stars of Perseus. Near Capella again are three smaller stars known as the Kids, but here I think you will require the aid of a pair of opera-glasses, for these last-named stars will be rather difficult for you to see, unless you have sharp eyesight. If we imagine another curve, similar to Capella's curve, but travelling in the opposite direction—that is, to the right instead of to the left—we shall see a little bunch of stars called the Pleiades, or known sometimes as the "Seven Sisters." Some people also call them the "Hen and Chickens," and they form one of the most interesting star groups in the whole sky. Just see how many stars you are able to count in this group, on a clear night. Most people can see six, but those who have exceptionally keen eyesight are able to count nine, or sometimes even twelve. The Pleiades are not only wonderful for the number of stars which the group contains, but it is a peculiar fact that, though they have been called the Seven Sisters, a person with only ordinary eyesight can only see *six* stars in this group. What is more interesting still, perhaps, is the fact that not only is the number of the Pleiades spoken of as seven throughout Europe, but travellers tell us that the Red Indians of North America, the Ashantis of Western Africa, and the Chinese, as well as many other nations, all speak of these stars as being seven, instead of six, the number seen by an ordinary person. Each of the nations have stories telling how the seventh star got lost, but I am sorry to say that the old English tale of the

mysterious seventh star's disappearance has been forgotten, like many other legends of the constellations. These facts show us that there were at one time seven stars visible in the Pleiades, and that one of them has disappeared. Why so many widely separated nations should know of this, when the event must have happened ages ago, is quite a mystery.

There is another interesting object in the sky, not very far from Perseus. This is the wonderful star called Algol, and you will find this clearly shown on Plate XXXIII. The Arabs called Algol the "Demon's Eye," for it shines very brightly for a number of days, and then suddenly fades away, and almost seems to "go out," as it were. These changes in the brightness of Algol do not take place at all times, or every now and then, but are so regular that they can be predicted by astronomers for years beforehand. Every two or three days, these changes take place, and during the space of three or four hours the star will fade away or become brighter, as the case may be. You may find the exact times of these fadings set forth in Whitaker's Almanack or any astronomical paper. The alternate fading and brightening up of Algol was the reason why the Arabs called it the "Demon's Eye," for they thought, no doubt, that it was the eye of some great god, which slowly winked at them!

There are many of these "winking" stars, or Variable stars, as they are called, but Algol is by far the easiest to observe, some of the others taking months, perhaps, to fade away, and then to such a slight extent that the change is only perceptible to the trained eye of an experienced observer.

CHAPTER XXIII

THE CONSTELLATION OF ORION

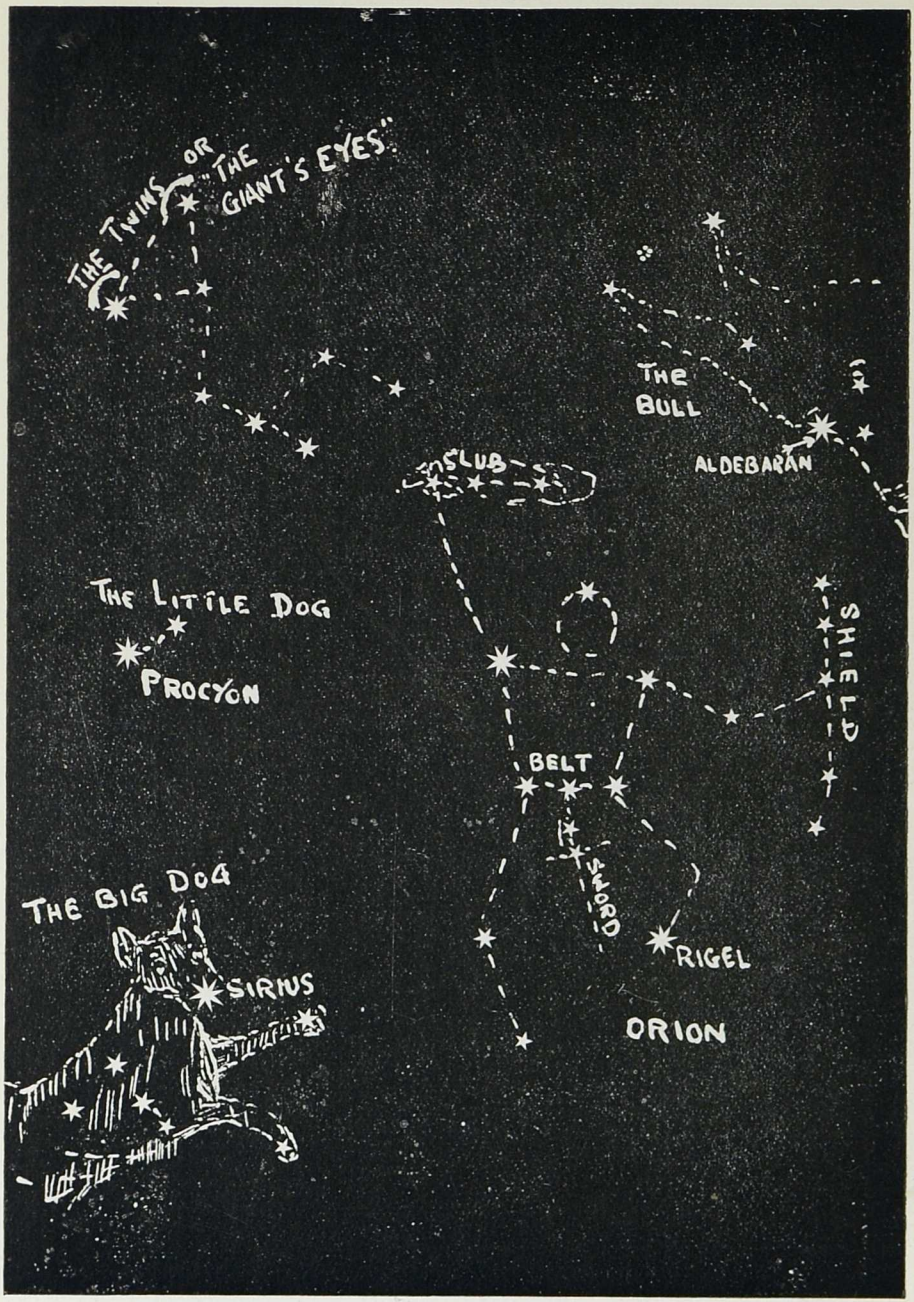
OF all the star-figures, perhaps the most interesting and beautiful is that called Orion, the Huntsman. This is the largest of all the constellations, and can only be seen during the months of late autumn, winter, and of early spring. If you look towards the south on a clear winter's night, you will see Orion, made up of stars as shown in Plate XXXIV. Of course you will know which is the south, for the Pole Star is always due north, and south must therefore be in the opposite direction to the Pole Star. The word Orion is a Greek name, but the old English people used to call him "Orwandle," and he was also known as "Grow's Husband." The brightest star of the constellation they called "Orwandle's Toe," but we now know it as Rigel. If you look carefully at the stars forming this constellation, you can make out, as it were, the shape of a man marked by the stars. The two bright stars at the top show the place of Orion's shoulders, while two other stars, lower down, mark his knees. Three smaller stars in a line mark the place of his belt, below which are some more stars representing the jewelled handle of his hunting-knife. Orion is swinging a great club in his right hand, while with his left he holds up a shield. Of the

star-pictures, I think Orion is one in which we can imagine the figure of what it was intended to represent when the people of old gave it the name. Orion was supposed to be a mighty hunter, but he did some wicked deed, and the gods put him in the sky to be a warning to men for all time. They also put his two dogs near him, and if you look a little to the left, and lower down than Orion, you will see the Big Dog, or *Canis Major*, as it is called by astronomers. Sirius, the brightest star in the whole of our skies, is to be seen in this constellation, and because it is the chief star in the Big Dog it is often referred to as "The Dog Star."

Near by, but higher up, is *Canis Minor*, or the Little Dog; the chief star in this group, though not so bright as Sirius, is a beautiful object, and is called Procyon. There is another star-picture connected with Orion besides the Dogs, and this is *Taurus*, the Bull, and it is this animal that Orion is supposed to be hunting through the heavens. There is not the full figure of a Bull in the sky, but only its head; it is charging down on Orion, and he is holding up his shield with his left hand to protect himself, while with his right he is about to bring down his great club upon the head of the oncoming Bull. Higher up than the Little Dog we can see two bright stars known to astronomers as *Gemini*, the Twins, but called by the old English people the "Giant's Eyes."

Ages ago, so the story goes, there lived a giant called Daze, and he was so clever that he was able to take the shape of any bird or beast that he wished. He generally took the shape of an eagle, however, and in this guise he would fly about the land, seeing what he could pick up

PLATE XXXIV



The Twins, Orion, the Bull, and the two Dogs

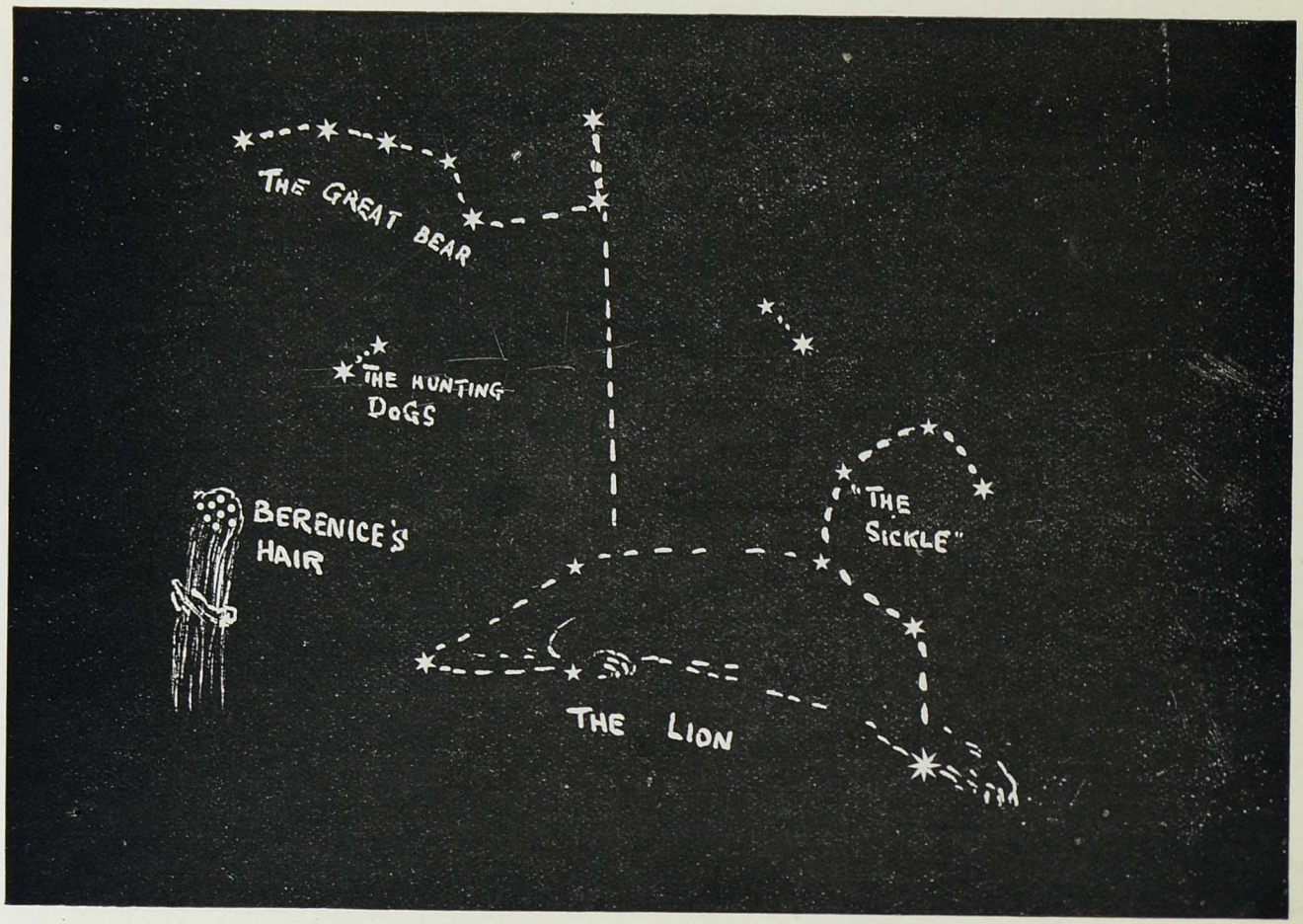


PLATE XXXV

Berenice's Hair and the Lion

from men. On one of his journeys he came across three gods, encamped under a tree. They had just killed an ox, and had lighted a huge fire with which they intended to cook it, for they were hungry with travelling far.

Giant Daze, in the form of an eagle, perched himself on a tree, and as he was well versed in witchcraft, he cast a spell over the pot, commanding that the meat should not be cooked until he pleased. The gods built up the fire, which burnt brightly beneath the pot, and the water soon began to boil. The meat, however, would not cook, and the gods began to get angry. The more wood they piled upon the fire, the hotter did it become, and even yet the meat would not cook. As the gods were by this time exceedingly hungry, they began to think that they were never going to get their meal, when giant Daze cried out from the tree above: "What will you give me if I make the meat cook?" "We will give you a share of the meat," answered the gods. With that the pot began to bubble and boil as it had never done before, and ere long the meat was cooked to a nicety. One of the gods, who was known by the name of Loke, took off the lid and was about to lift out the meat, when giant Daze swooped down from the tree and caught up the best part of the meat in his claws, leaving only the bones for the hungry gods to pick. Upon this Loke jumped up, and catching up a pole which lay near at hand, dealt Daze a great blow. Daze, however, was ready for this, and he cast a spell upon the pole so that it stuck fast to his back, and Loke's hands stuck fast to the pole! Away flew Daze, with the meat in his claws and with Loke hanging on to the pole; but the weight of both was so great that the giant could

only fly near to the ground. In consequence of this, Loke's feet were bumped against the rocks and stones, while his body was badly scratched by thorns and bushes. Daze then made Loke promise to bring him the Apples of Youth, and on his consenting to do this, released him from his hold on the pole.

After many adventures, Loke managed to bring Daze the Apples which he wanted to ensure everlasting youth, but the gods were so angry with Loke for having stolen the Apples of Youth, that they bade him get them back from Daze, and even threatened to kill him should he fail to do so. So Loke impersonated a bird and flew away to giant Daze's house. The giant was out fishing, and Loke, seeing the Apples of Youth upon a table, caught them up and flew homeward with them. Shortly after his departure, however, Daze returned, and finding the Apples gone, he changed into his eagle's shape and flew after Loke at top speed. Having more powerful wings than Loke, the giant overtook him, just as he drew near to the gods' city. All the gods were on the city walls, watching the race, and seeing that Loke was being closely pursued by Daze, they obtained a great quantity of dry shavings and set them along the top of the wall. As soon as Loke, with the Apples of Youth in his grasp, had flown over the wall, the gods set fire to the shavings, and Daze, being so close behind, and flying so fast, could not stop himself, but flew right into the centre of the blaze. The flames burnt all his feathers, and down he fell to the ground, and there the gods slew him. The chief of the gods, however, put the giant's eyes into the sky, and they may be seen there to this day, being now called the Twins.

CHAPTER XXIV

OTHER CONSTELLATIONS

YOU will remember the two stars, in the constellation of the Great Bear, which are called The Pointers, for the reason that they always point to the Pole Star. If we imagine a line through the Pointers, but in the opposite direction to the Pole Star, during the months of winter, spring, and summer, we shall see the constellation of *Leo*, or the Lion, as shown in Plate XXXV. In this star-picture one can easily imagine a lion in a sitting position, resembling one of the lions which are round Nelson's monument in Trafalgar Square. There are six stars which form the Lion's head and chest, and these resemble a question mark which has been turned from left to right, thus: ʔ The bottom star, which is called Regulus, marks the place of one of the lion's paws. Sometimes these six stars are called "The Sickle," for they resemble the sickle of a reaper. Shooting stars appear to come from this "sickle," on or about the 13th November each year, and if you watch this part of the sky, late at night on the above-mentioned date, you will be almost certain to see a few of these shooting stars, which are called Leonids, because they seem to come from that part of the sky where Leo is situated. Away to the left of Leo are several smaller

stars close together, and these are called *Coma Berenice*, or the Hair of Berenice. It is said that Berenice, the wife of one of the kings of Egypt, was a very beautiful woman, and her hair was known over the wide world for its loveliness. She offered to give it to the goddess Venus, if her husband should be victorious over the enemies against whom he was about to fight. The King went away to the wars, and by the aid of Venus he conquered all his foes. On his return, however, he was grieved to find that Queen Berenice had given her hair to Venus, as she had arranged, and that this was the price of his victories. The priests and the astronomers were sent for, and to comfort him they told him that they would place Berenice's Hair among the stars, which they did. Between the Hair of Berenice and the Great Bear there are a few faint stars to be seen, which go by the name of *Canes Venatici*, or the Hunting Dogs. Of these I shall speak again in a later chapter, for in this region of the sky there is a most beautiful object called the Whirlpool Nebula.

If we again use the stars of the Great Bear as a guide, in the manner shown in Plate XXXVI., we can find a beautiful star called Arcturus, which is in a line with the last two stars of the Great Bear's seven. Arcturus is of a decidedly golden colour, and is one of the most beautiful stars we have in our skies. Above Arcturus are to be seen five stars, looking somewhat like a kite, with Arcturus for the tail. These form the constellation of Boötes, which is a Greek word meaning Ox-Driver. Boötes was robbed of all his goods by his brother, so the story says, and after many hardships and wanderings, he invented a plough, which was drawn by two oxen. With this he tilled the land, and made his

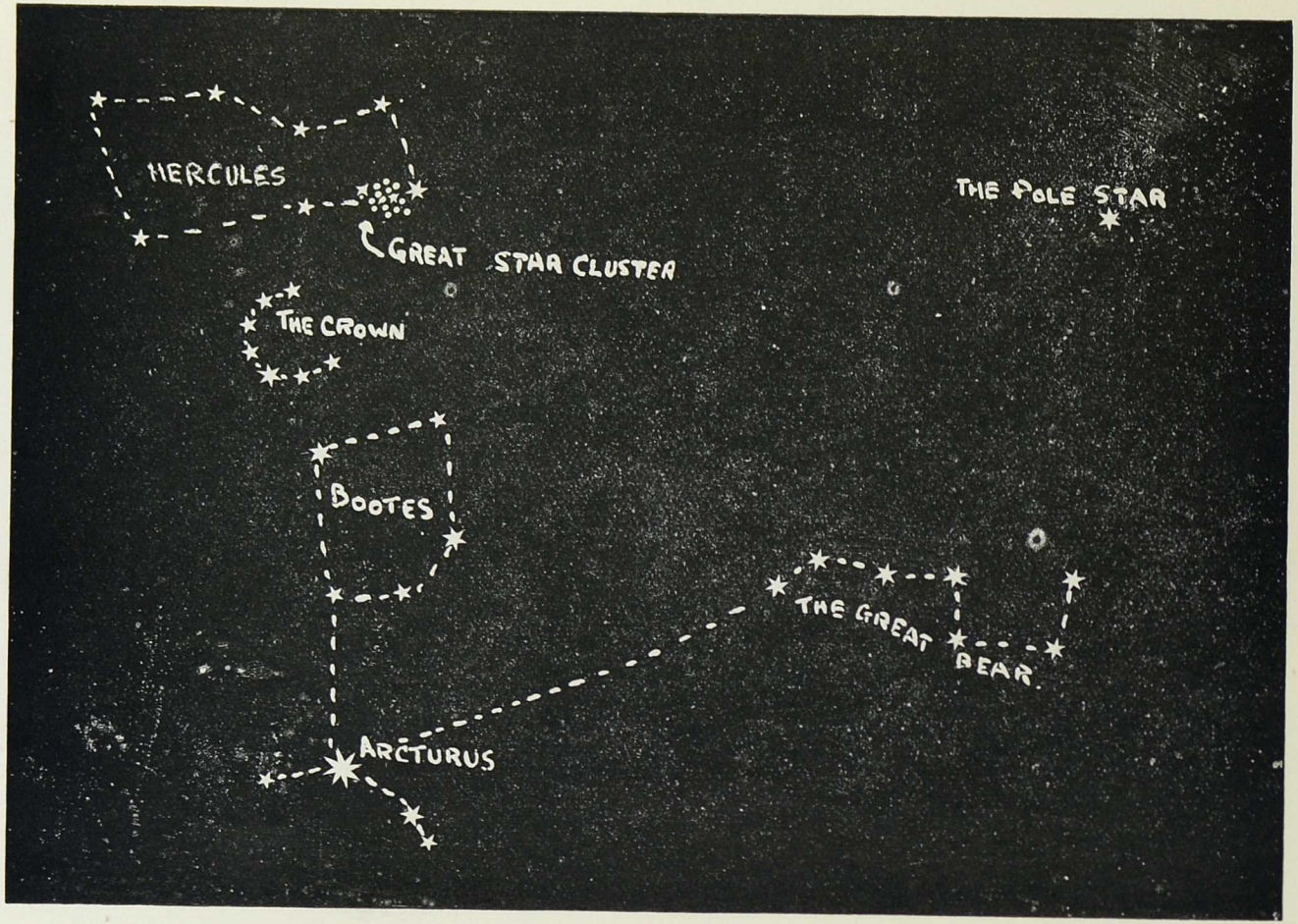


PLATE XXXVI

Boötes, the Crown, and Hercules

living by following this occupation. His mother was so pleased with him for inventing this plough and for working the land, that she placed him in the sky, together with the Plough, and when you look on the stars of Boötes in the heavens you may see the Plough near by. To the east of Boötes is to be seen a semicircle of seven stars called *Corona Borealis*, or the Northern Crown; and this star-figure does indeed look like a beautiful crown of sparkling diamonds. Still further to the east is the constellation of Hercules, and you will thus see that the Crown lies between Hercules and Boötes. In Hercules there is situated the Great Star Cluster, as it is called, where many thousands of stars seem to be gathered together, and to this beautiful object I shall refer again, in a later chapter.

If you look at Plate XXXVII. you will see there the constellations we have just learned, and in addition there are some more of these interesting star-figures. Boötes, the Crown, and Hercules are there, and to the left of this last constellation you will see *Cygnus*, or the Swan; this figure is sometimes called the Northern Cross, because, as you will see, it somewhat resembles a cross in shape. The chief constellation in the southern hemisphere, at the other side of the world, as it were, is the Southern Cross, and you will often hear travellers speak of this well-known star-figure. The Southern Cross, however, is not nearly so much like a cross as what we call the Northern Cross, or, to give it its Latin name, *Cygnus*.

Between the Great Bear and the Pole Star you will see a long, straggling figure, and this is *Draco*, the Dragon. This is the great sea monster referred to in the legend of

Andromeda and Perseus, which has been told in Chapter XXII. There is also shown on the Plate, Cepheus, the King, of whom you would read in the same chapter. Near the Pole Star are a few faint stars, to be seen on a clear night, and these have been given the name of *Ursa minor*, or the Little Bear. Between *Cygnus* and Hercules is the constellation of *Lyra*, the Harp, and this is marked by a beautiful steel-blue star Vega, which, with Arcturus near by, forms a most beautiful spectacle. To the south of *Cygnus* is the star-figure called *Aquila*, or the Eagle, and this is made conspicuous by three stars, the middle one of which is more brilliant than the side ones, and yet not so bright as Vega.

We have now seen something of the constellations, and the pictures which the people of old thought they could see in the sky. Although many of the star-figures do not bear much resemblance to the shapes they are supposed to represent, we are able by their help to learn the constellations, and to name the brightest stars. You will be surprised to find how interesting it becomes to be able to point to a bright star and to name it, or to tell to which constellation it belongs. Perhaps, too, a friend may wonder how the stars came to get their names, and you will then be able to tell him of the shepherds on the hills in far-off days, and of the stories they made up about the constellations.

I have dealt only with the most conspicuous star-figures, for there are a number of others which are not so distinct, but which you may, nevertheless, some day learn.

CHAPTER XXV

WHAT ARE THE STARS?

IF we could take a long journey into space, upon a voyage which lasted thousands of years, and if we looked back at our sun, as we travelled, we should see it gradually growing smaller and smaller, until there would come a time when it looked only like a bright star. If we journeyed still further, we should see it grow fainter and fainter, and at last it would disappear altogether from our sight. All the stars are great suns, just like our sun, and it is because they are so far away that they look only like tiny points of light, just as our sun would look at the same distance. Perhaps it may be that these stars have planets revolving around them, just as our sun has. How grand it is to look up at the stars, remembering that each one is a great sun, and some of them, perhaps, many times larger than our sun.

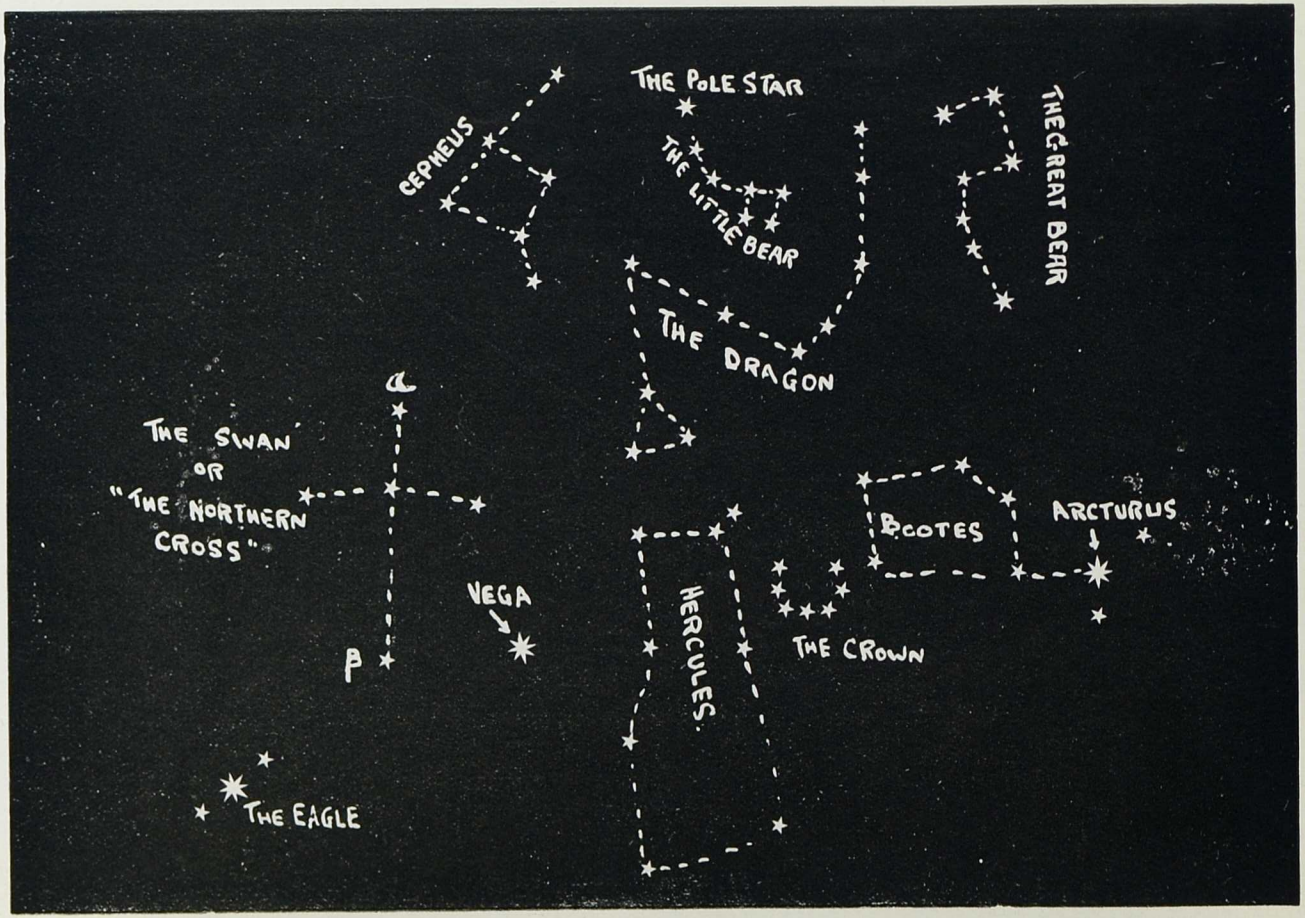
One wonders how many stars there are in the sky, for on a clear night we can see what appear to be thousands upon thousands of twinkling points of light. In reality, however, no person can see more than about 3000 stars at one time with the naked eye. But of course 3000 is not the *total* number of the stars, for if we look through even a very small telescope, the number is increased many times,

while in a large instrument they are quite uncountable. The latest photographs, taken with a moderate-sized telescope, show so many stars that it is impossible to count them, and we have had to resort to estimates. These estimates have been very carefully made, and it has been found that there must be over one hundred millions of stars visible in this particular size of telescope. We can, perhaps, gain some slight idea of this tremendous number when we remember that it would take a man a fortnight, without stopping day or night for either rest or food, to count one million

I have mentioned the Great Star Cluster in Hercules, and this is shown in the accompanying photograph, Plate XXXVIII. What a beautiful picture it is, for it seems as though great numbers of stars had gathered together at this spot, forming a universe of their own. There are more than 3000 stars in this cluster alone, which is about the same number that can be seen by the naked eye, in the whole sky, on a clear night. The Hercules star cluster is not the only one in the heavens; there are many other such clusters, and one near the Lion, called the Bee Hive, is so thick with stars as to remind one of bees swarming round a hive, and hence its name.

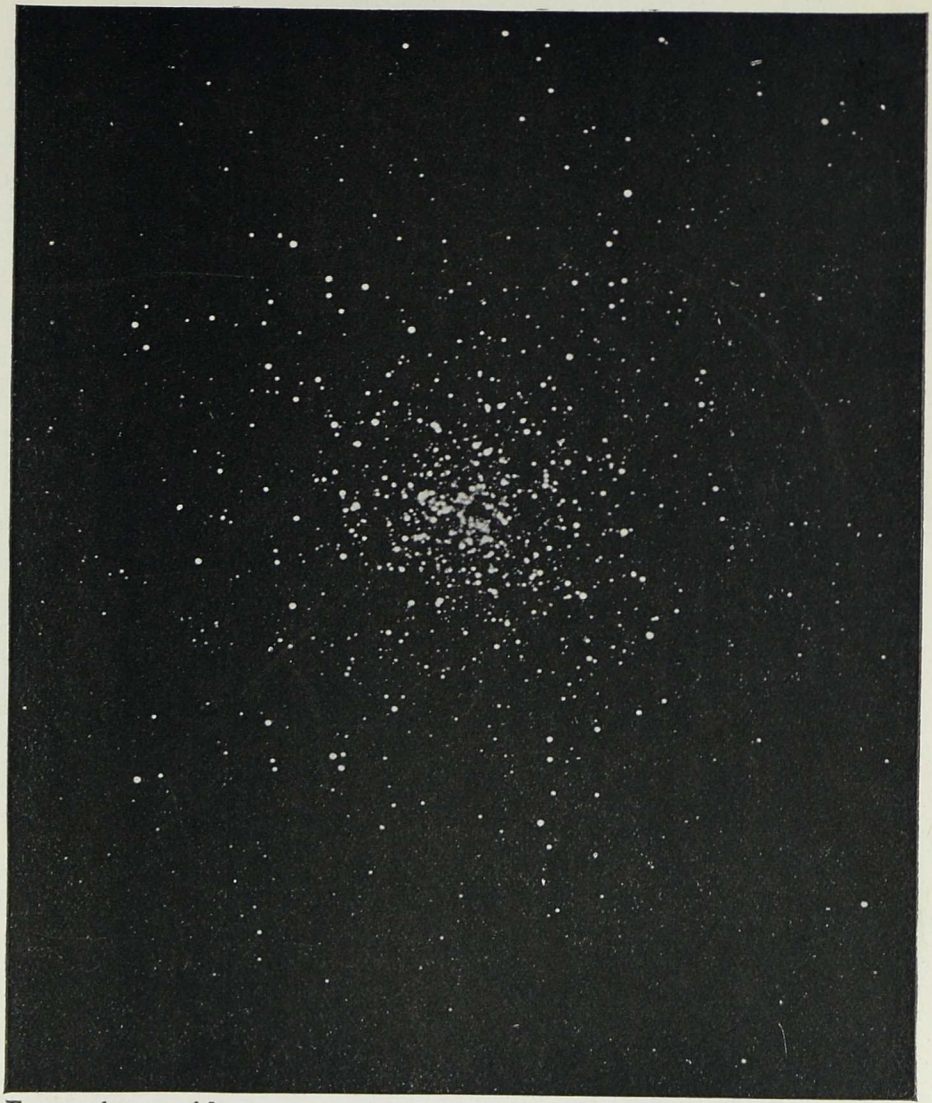
For the most part all the star clusters are invisible to the naked eye, but on a very clear night the Cluster of Hercules can just be seen, looking like a faint misty speck.

Not only do the stars differ in brightness, but they also differ in colour, a fact which you will have already noticed, no doubt. Look, for instance, at Vega, which is of a decided blue colour, and compare it with the golden-yellow star Arcturus, not far away. Sirius is blue-white, and



The Swan, the Dragon, and the Little Bear

PLATE XXXVIII



From a photograph] [taken at the Yerkes Observatory

A Star cluster in Hercules

Capella almost pure white, but Aldebaran, chief of the constellation of the Bull, is of a decidedly red colour. We have heard that the stars are suns, some of them more beautiful and many times greater than our sun, and it is supposed that the older a sun gets, the redder it becomes in colour. You will have noticed the electric arc lights in the principal streets of our cities. These lamps, when they are new, burn with a blue-white light, but as they are used night after night, their light changes first to yellow-white, then to yellow, and finally, when they are almost burnt out, their light is of a red colour. It is the same way with the stars, for when the star is "young" it is blue-white, and as it grows older it changes first to yellow, and when almost burnt out it assumes a red colour. You will know that, in order to tell the age of a horse, a dealer looks at its teeth, but when the astronomer wishes to gain some idea of the age of a star he looks at its colour, and by this means he can roughly ascertain its age as a sun. The age of a star cannot be measured in "years," for many millions of years may pass away before the slightest change takes place in a star's colour.

In an earlier chapter of this book we read that the planets are worlds belonging to the sun's family. There is a wide difference between a planet and a star, although they may sometimes look very like each other in the sky. A planet is a mere world, circling round a central sun, but a star is itself a sun. One may distinguish the difference between a planet and a star by the fact that a star is always "twinkling," while a planet seldom "twinkles," except when very low down, and near the horizon. The name "planet," which means "a wanderer," was given to these

objects because they wander, or move, as we should say, about the sky. Just in the same way as the moon appears to travel through the constellations, so too do the planets move among the stars. If you will watch a planet for a few weeks' time, you will see that it slowly shifts its position with regard to the neighbouring stars; and this is another way in which you can distinguish a planet from a star, for the stars do not move among themselves, but are fixed in the sky, as it were, and it is only the planets, or "wanderers," which move.

CHAPTER XXVI

THE NEBULÆ

I WISH now to tell you something of the Nebulæ, a class of objects which are most beautiful and also wonderful. *Nebula* is a Latin word meaning "a mist," and the name is really most suitable, because the nebulæ look very like clouds of fiery mist. There are many thousands of these wonderful objects scattered about the sky, but unfortunately they cannot be seen in all their beauty without the aid of a telescope. You may be able to see one or two of them on a very clear night, looking just like tiny fleecy specks, against the dark background of the sky. The nebulæ have been called the "Workshops of the Creator," and for this reason. You will know that everything has to have a beginning, and that the material from which things are made is often totally unlike the finished object. For instance, there is not the least resemblance between a great mass of steel and the railway engine, into which it is made by the engineers. Just in the same way, the world and the planets have not always been as they are at the present time; they have been gradually formed, or evolved as it is called, from rough material of quite a different appearance, but in their case the work has not been done by human hands. We believe that the nebulæ we see in the heavens

are the beginnings of countless suns and planets. How grand it is to be able to look at these wonderful objects, and to think that we are looking right into the "Workshops of the Creator," and seeing in the process of formation suns like our sun, which will, perhaps, in the course of time, have planets circling around them, as our sun has at the present time. The stars are a long way off, but we believe the nebulæ are even further away than most of the stars. You will remember that, when speaking of the earth's distance from the sun, I used an illustration of a railway train. Were I to attempt to illustrate the distance of even the nearest star in the same manner, I could not give you any conception of the vast gulf of space which separates it from us, for the distance is so great that the figures would have no meaning to you. Perhaps by another method I may be able to give you a slight idea of the distance of the nearest star. You will know that when a cannon is fired, say, a mile away, we first see the flash, and a short time afterwards we hear the "Bang!" Now the reason we do not see the flash and hear the report both together, is that sound travels much slower than light. It is the same with thunder and lightning, for although the roar of the thunder takes place at exactly the same time as the flash of the lightning, yet we see the flash some seconds before the noise of the thunder reaches us, for the reason that sound takes time to travel. Sound travels at the rate of about 1000 feet a second, but light, which is infinitely swifter, travels about 186,000 *miles* every second. At this rate, light from the moon would reach the earth in a second and a quarter, and from the sun in eight minutes, but to reach us from the nearest star light takes over four years

PLATE XXXIX

From a photograph by] [E. Hawks

The Orion nebula

and four months. Many stars are much further away even than this, and their distances are so great that astronomers do not speak of them in miles, but refer to them as "light years," saying, for instance, in the case of the nearest star: "It is over four light years away from us." Sirius is over $8\frac{1}{2}$ light years away, while Vega, that beautiful blue star near Cygnus, is at a distance of 27 light years. The distances of other stars are: Aldebaran, the chief star of the Bull, 32 light years; Capella, near Perseus, 32 light years also; the Pole Star, 47 light years; and Arcturus, 160 light years. It is interesting to remember, when looking at these stars, that we are not seeing them as they are now, but as they were so many years ago. For instance, suppose that Arcturus were to be extinguished to-day, it would still continue to shine in our skies, with undimmed brilliance, for another 160 years.

There are about 20,000 nebulæ in the heavens, but they are for the most part small, and only visible with powerful telescopes. By far the best known of them all is the Great Nebula in Orion, which is situated in the sword-handle under Orion's belt. With a good pair of field-glasses you will be able to see that one of the stars, which form the sword-handle, is surrounded by what looks like a patch of misty light, which is really the Great Nebula, and in large telescopes is a most beautiful object. You will see a photograph of it on Plate XXXIX., and this will give you a good idea of what the nebulæ are like.

Another famous object is shown in the next picture, Plate XL., and this is called the Spiral Nebula, and is situated in the constellation of *Canes Venatici*, the Hunting Dogs. This nebula seems to be whirling round, like the

whirlpools one sees in a river; we cannot actually see the spiral nebula moving round, for its distance from us is too great. If we are at the seaside and looking out to sea, we may notice a large steamer far away, perhaps nearly on the horizon. If we look again in a few minutes' time, the steamer will still seem to be in the same place, not appearing to have moved at all, though we know it may be travelling through the ocean at the rate of many miles per hour. Because we are so far away from the boat, it does not seem to move in so short a time as a few minutes, and it is the same with the nebulæ, for a man's lifetime is just like a glance at the steamer. We may look at a nebula when we are quite young, and again when we are old, after the passing of many years, yet the nebula may still appear the same, and may not seem to have moved, although it is probably actually whirling round at a great speed.

CHAPTER XXVII

THE MILKY WAY

ON a fine clear night, a band of misty light may be seen stretching across the sky, and this is called the Milky Way; it was known to the old English people as "the Fairies' Path." This Milky Way stretches in a narrow band right across the heavens, and one of the best parts in which it may be seen is near the constellation of *Cygnus*, the Swan. Although the Milky Way only appears to the naked eye as a faint band of light, there is quite a revelation made to us when we turn a powerful telescope to it. No longer is it faint and misty, but we find that it is composed of countless numbers of small stars, so far away that the eye cannot see them separately. Only their combined light reaches the earth, and, to our naked eye, looks like a faint band across the sky. Look at the beautiful photograph shown in Plate XLI., and you will perhaps obtain some slight idea of the beauty of the sight. Countless numbers of stars are here seen, some divided from each other by dark spaces, others heaped up one on top of the other, as it were, so that we cannot separate them. It is indeed a sight which we are unable to understand, and it is all the more wonderful when we remember that each of these tiny stars is a sun, some of them, perhaps, many

times greater and more powerful than our sun. Even in this particular photograph it would be impossible for us to count the stars shown, and if you have any doubts upon the point, just try. This picture is not the only one which has been taken of the Milky Way, but hundreds of others have been made, of different parts of this most wonderful structure. Each of the photographs shows countless numbers of stars, just as this picture does, so you will see that it is quite out of the question for us to say how many stars the Milky Way contains.

Not the least wonderful things shown in these photographs are the great dark spaces, where it seems as though some one might have been with a spade and shovelled the stars to one side, in the same way that men shovel the snow from our streets. There are numbers of these dark gaps, the best known of which is perhaps that shown in Plate XLI., which is part of the Milky Way in a constellation called Ophiuchus. The dark gap shown in this picture is near the star called by the Greek letter "theta," and it is well known to all astronomers. There are many other dark rifts in the Milky Way, and some familiar ones are to be found in the constellation of *Cygnus*, the Swan. These have been called "the Northern Coal Sacks," for they are as black as sacks of coal. No doubt you will ask what there is through these great gaps; it seems as though we are here looking right out into the depths of space, which perhaps has no end.

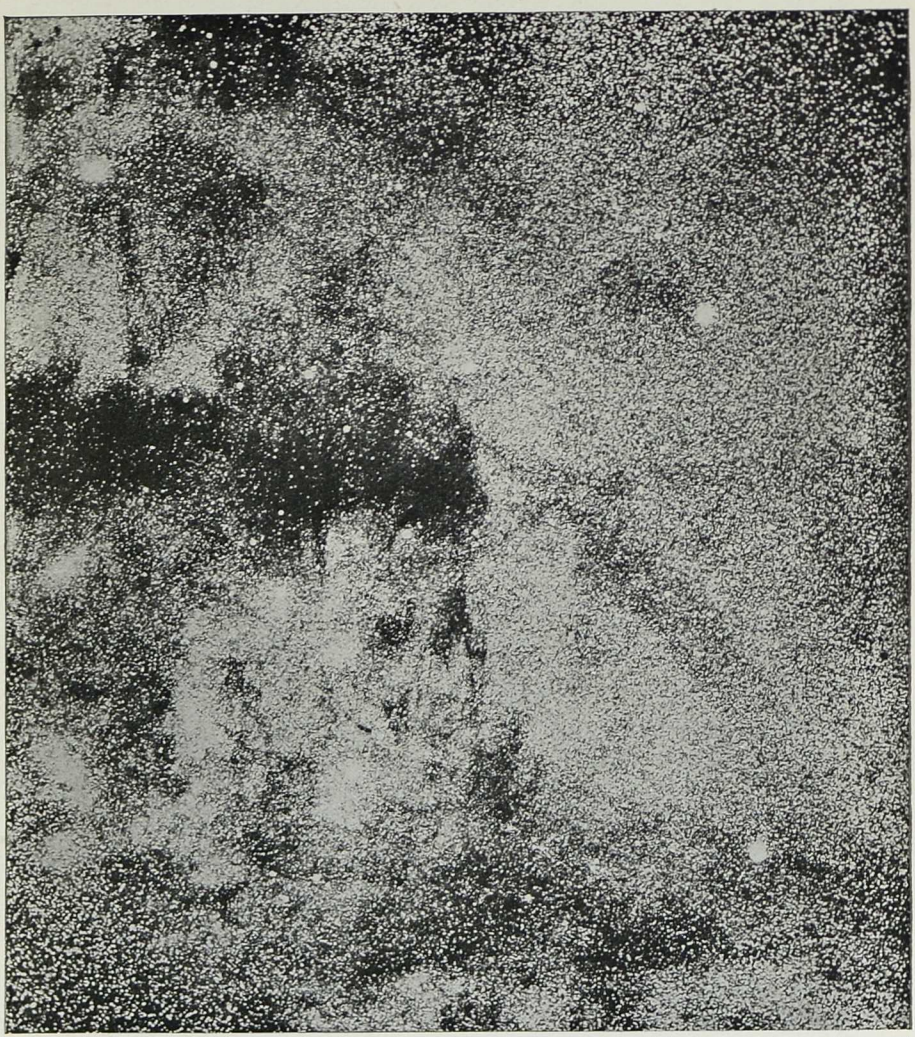
It has been said that our sun really belongs to the Milky Way, and that the Milky Way, and all the stars we know, make up one great star cluster, but of this we cannot speak with certainty.

PLATE XI.

From a photograph by] [Dr. Max Wolf

The Spiral Nebula in "Canes venatici"

PLATE XLI



From a photograph by] [Professor E. E. Barnard

Part of the Milky Way, showing the great rift near the star Theta Ophiuchi

One of the most wonderful things that we know about the stars has recently been discovered, and this is that most of the stars are moving slowly through the heavens. They are travelling stars, as we might say, and our sun is one of this class, although we on the earth are unable to feel his motion day by day. The sun, with all the planets, comets, and meteors, is travelling towards a part of the sky which is not very far distant from the beautiful star Vega, in the constellation of *Lyra*, the Harp. Other stars are moving also, but not all towards Vega, like the sun, nor are they all moving at the same rate of travel. The sun and planets are travelling towards Vega at a rate which is greater even than the swiftest rifle-bullet, for every half-hour sees us about 10,000 miles nearer that part of the heavens. But the star with the swiftest movement of all is that called by astronomers "1830 Groombridge," because this is its number in a catalogue of the stars made by an astronomer of that name. Some people know it as the "Runaway Star," for it is estimated to be travelling at no less a speed than 138 miles per second. Just imagine, if you can, this terrific rate of motion! We consider an express train, which travels sixty miles an hour, to be going at a tremendous speed, but the "Runaway Star" travels in one second more than twice as far as the express train does in one hour!

Perhaps you would be interested to know how astronomers have discovered that the sun is moving towards Vega. As you walk along a street at night time, you will have noticed that the lamps in front of you seem to open out as you travel along. If you look behind, you will find that the lamps at the back of you seem to be closing in as

you leave them. Now, astronomers found that the stars in a certain part of the sky, not very far distant from Vega, were opening out, and when they came to think the matter over, they decided to look behind, as it were, at the stars in the opposite part of the heavens, just as you might look behind at the lamps as you walk down the street. As the astronomers looked, and made their observations, they found that it was as they had supposed, for the stars in that part of the sky were actually closing in! Here was a great discovery, for these observations undoubtedly showed that the sun and the solar system, of which the earth is, of course, a member, are travelling towards Vega. What new stars will be seen, as the earth journeys through space, we cannot say, but many ages must pass before even a slight change takes place in the position of the stars in our skies.

Not only has this fact of the motions of the stars been found out, but it has recently been discovered that the stars are not moving this way and that, or indiscriminately, as we should say. They are travelling in streams, just as certain kinds of birds fly away from England to warmer countries when the cold weather comes, and which we call "Migrating Birds." As many of the stars seem to be travelling in the same direction, in something the same way as the birds, they have been called "Migrating Stars." For instance, five of the stars of the Great Bear are travelling along in apparently the same direction, and it has just been discovered that Sirius, the Dog Star, is also moving in the same direction as they are. The Pleiades are another instance of this, for nearly all the stars in this beautiful group are travelling in the same direction, and

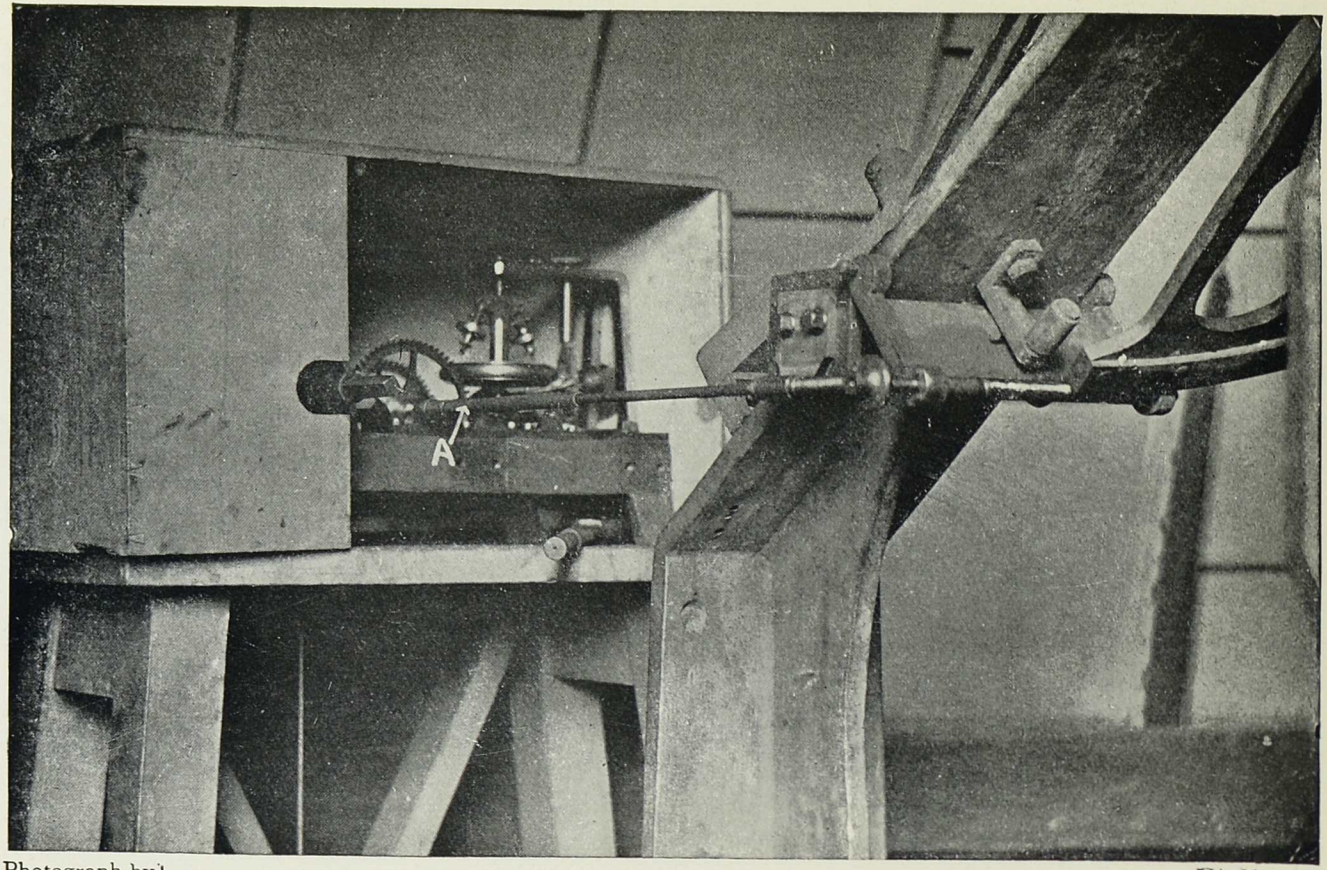
with a large telescope there are something like 1500 stars to be seen in this particular cluster. The Pleiades, however, are not travelling towards the same part of the sky as are the five stars of the Great Bear and Sirius; nor are these stars travelling towards Vega, in the direction in which our star—the sun—seems to be moving. There may be, and probably are, many other "flocks" of stars travelling in other directions, but as the discovery of the Migrating Stars has only been made quite recently, it is impossible for us to say at the present time. Astronomers are carefully going into the question, and we may hope for some further information on this interesting subject in the course of a short time.

CHAPTER XXVIII

PHOTOGRAPHING THE STARS, &c.

THROUGHOUT this book you will see photographs of the sun, moon, stars, and nebulæ, and perhaps you will be wondering how these are obtained. You will know that in an ordinary camera there is a lens, which may be called the "eye of the camera," for it is through this opening that the camera is able to "see" the picture which it is required to register on the photographic plate. The size of the photograph depends, for one thing, on the size of the camera lens, and the larger the lens, the more light it passes through to the sensitive plate behind it. Now a telescope is really a very big lens, and if we place a photographic plate behind the telescope lens, we should be able to take a picture of a star, or whatever we wish. This is indeed the way in which photographs of celestial objects are obtained.

Before ordinary photography was thought of, astronomers had to make all their pictures by drawings, using the pen or pencil, as the case might be. You will know how easy it is to make a mistake when drawing a picture, and it is easier still when drawing such a delicate object as some part of the moon. Now that we can photograph these objects, we can be sure of obtaining a perfectly correct picture, which can be obtained a great deal quicker than under the old method.



Photograph by] [E. Hawks

The machinery used for turning a telescope

A certain astronomer in France made a beautiful drawing of the moon which took him about twenty years to finish. Nowadays we can get just a similar picture, by exposing a photographic plate in the telescope, in about three seconds; so you will see that the introduction of photography to astronomy means a great saving of time, among other things.

Perhaps the most marvellous thing of all about the photographic plate is that it is able to "see" objects which, owing perhaps to their extreme faintness, are invisible to the human eye, even though assisted by the largest of the world's telescopes. For instance, Jupiter's eighth satellite is so tiny, and so far away, that no one has ever yet seen it! We know it is there, because it has been photographed many times. When we look at the nebulæ through a telescope, they seem like faint patches of misty light, but photographs show them to be great bodies of fiery gas, with all manner of peculiar whirlings; parts which are quite invisible to us are shown quite clearly on the photographs. The reason why the photographic plate is so much better in this respect than the human eye is because the eye only gets a glance at an object, and very soon becomes tired with the strain of looking. The photographic plate, however, can never get tired, no matter how long it is exposed on an object, so we are able to direct a plate to a nebula for perhaps six or eight hours, or even longer. During the whole time of the exposure, the rays of light from the nebula have been falling on the sensitive plate, and so in the finished photograph, instead of just a glance, we get a sort of condensed view of the nebula. You will thus see that photography has been of the greatest service to the astronomer, since by its aid he has been able to find out things which were previously unknown.

There is one difficulty that has to be overcome, however, before the astronomer can take photographs of the stars or the nebulæ, and this is caused by the earth turning on its axis, as has been described in an earlier chapter. You know that the sun seems to rise and to set, and it is just the same with the stars, for they rise and set too. You can prove this for yourself, by going out of doors some clear evening as soon as it is dark. Note the position of some bright star, say Vega or Sirius, with some object in the landscape, such as a chimney or a church steeple. Then go out again in a couple of hours' time, and you will find that the star has moved considerably in the sky. If you were to take a picture of the stars with an ordinary camera, you would not get a photograph of round dots, as you might expect, but you would find on the plate many long trails of lines, for the stars will have moved across the sky during the exposure. Therefore, when the astronomer wants to make a long exposure of the stars, which he wishes to show themselves as round dots, he has to fit some mechanism to the telescope, to turn it in the same direction as that in which the stars are moving, and by this means the rotation of the earth, and the consequent moving of the stars through the sky, is overcome. So you will find that all large telescopes are fitted with a clockwork device, which turns the instrument for the purpose I have mentioned. In Plate XLII. is shown the machinery that turns a telescope which I use; before photographing the stars the clockwork has to be first wound up, and regulated. It then turns the rod, marked "A," and on the end of this there is a screw which fits into a groove, and this turns the telescope itself.

CHAPTER XXIX

ASTRONOMERS AND THEIR WORK

NOW that we have seen something of the wonders that are to be found in the heavens by those who seek them, it will perhaps be of interest to you to hear a little about the astronomers and their work. Many times people have said to me: "What is the use of spending hours and hours gazing through a telescope on a cold night?" I am sure, after what you have just read, you will know that there is something more to be done than simply "gazing through a telescope." On fine, clear nights we make our observations at the instrument, and carefully note anything that is worth recording in an Observation Book. Those who have the ability make drawings or take photographs, as the case may be; and when the nights are cloudy, and no stars to be seen, we work out our observations, and in this way no time is lost.

By far the greatest astronomical undertaking that has ever been thought of is now in progress; this consists of making a complete set of photographic pictures of all the stars above a certain brightness. For the carrying out of this great task, observatories in all parts of the world are working together. In order that the photographs may all be on a uniform scale, each observatory taking part in the

great scheme uses a certain size of telescope for taking the photographs. The sky has been divided into sections, or divisions, and each observatory has a certain number of these divisions to photograph, and a share of the great responsibility to undertake. Clear nights are none too frequent, and the undertaking is so great that, although the work has been going on for many years with all speed, it is, even yet, far from being completed. Some of the observatories, however, have finished their share of the work, and amongst these are Greenwich and Oxford. In the rooms of these institutions are hundreds upon hundreds of photographs of different parts of the sky, which are catalogued, carefully indexed, and each in its proper place. Other countries have not yet been able to finish their share of the work, as, for instance, a certain republic in South America. Here they are always having revolutions, and have been so busy fighting, first with one party and then the other, that the poor astronomers have been unable to get on with their work at all. A traveller tells me that he was recently passing through the principal city of another country which had promised to take part in the photographing of the stars, and being interested in astronomy, my friend asked to be shown over the observatory. He expected to see piles upon piles of the star-photographs, arranged and indexed like those which are at Greenwich and Oxford. Instead of this, however, he found the observatory closed up, and in the charge of an old caretaker, who took him to see the telescope which was, as he said, "to picture all and every star in creation." But the traveller found that some one had fired a cannon-ball through the telescope, which was shattered and of no use at all. The caretaker said that the astronomer

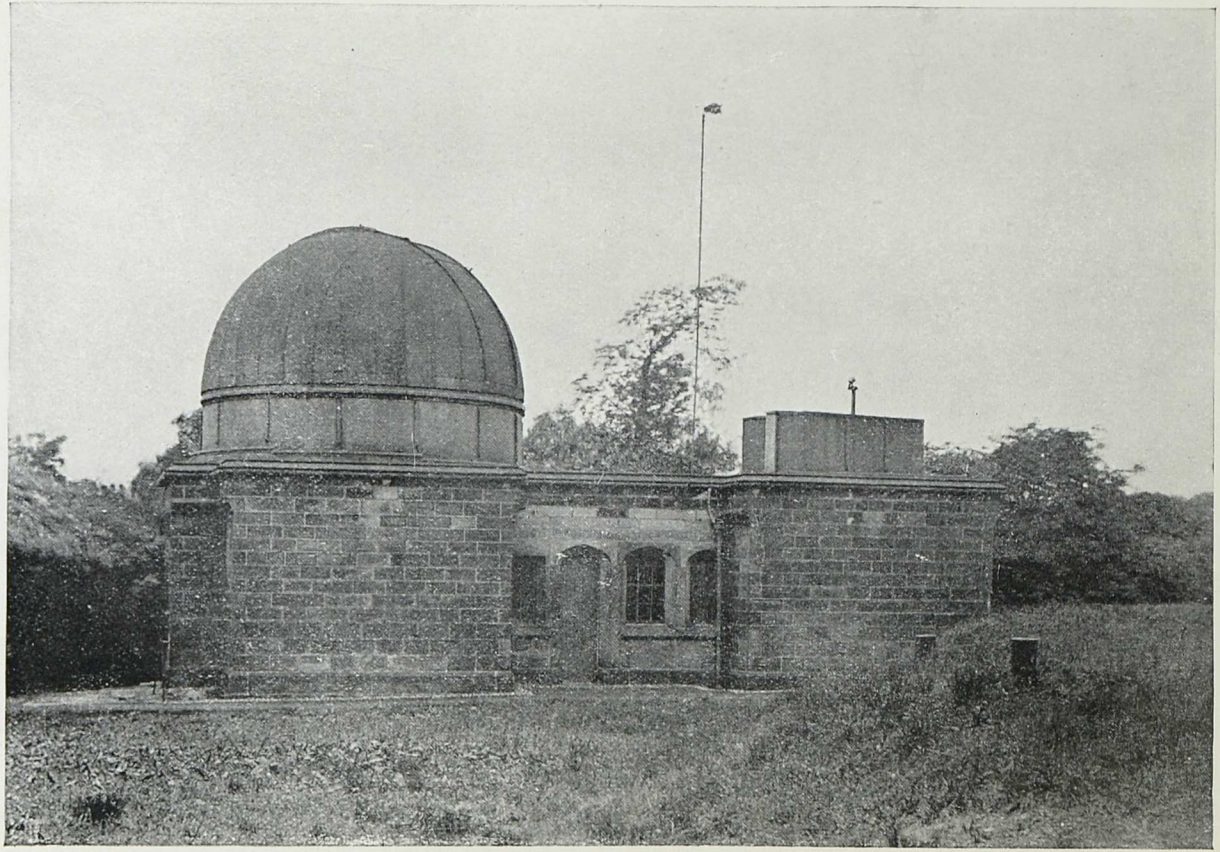
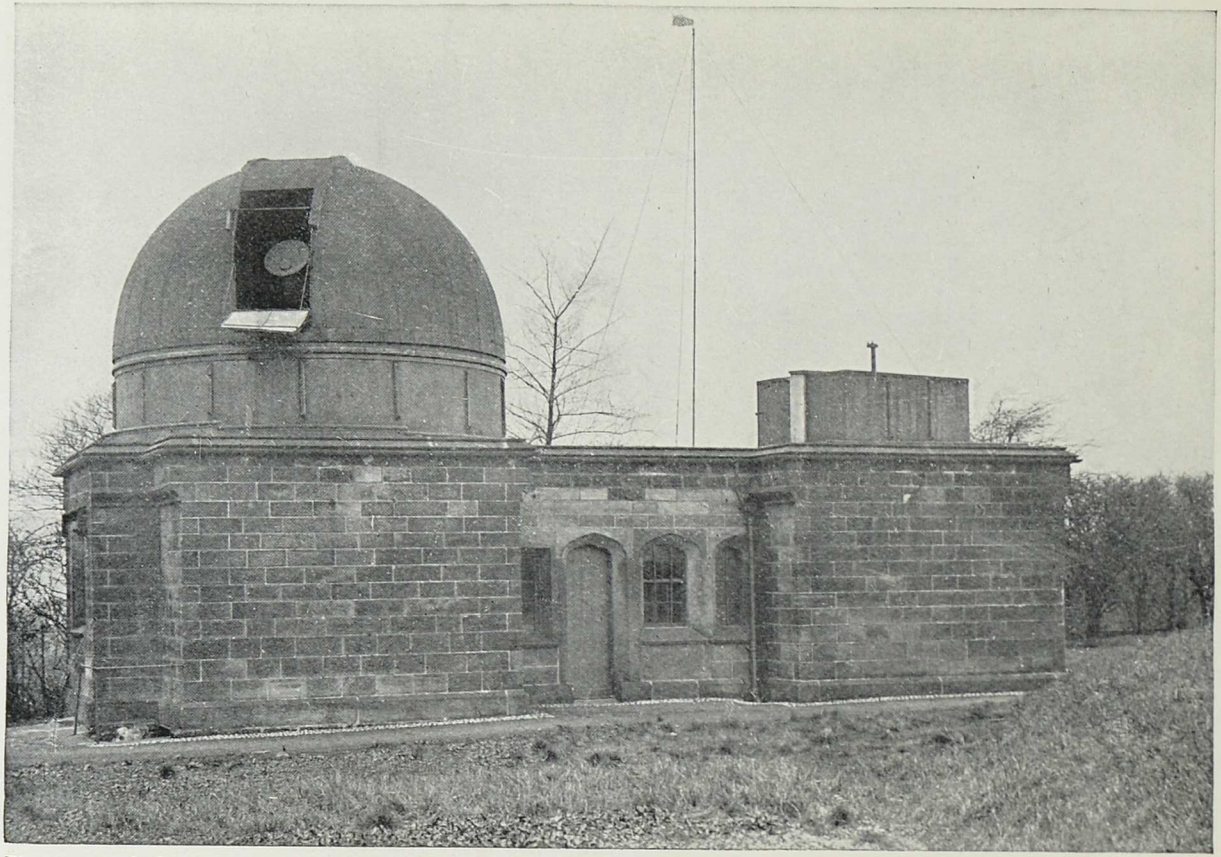


PLATE XLIII

From a photograph by] [E. Hawks

An observatory with dome closed



Photograph by] [E. Hawks

An observatory with the dome open. The telescope can be seen inside the dome

who had charge of the observatory had been sent to prison, because he was not liked by the new president of the republic, and so you will see that the paths of the astronomers are not always as smooth as they are sometimes said to be.

Another great work which has been undertaken, within comparatively recent years, is the photographing of all the nebulæ in the sky. A very clever astronomer, Professor Keeler by name, had just commenced this great task, and was getting well on with it, when he was taken seriously ill and died. He was quite a young man, and had he lived he would no doubt have accomplished a most valuable work, for he was one of the finest celestial photographers that have ever been known. As it happened, certain people decided to make a monument to his memory, but they did not put up a marble statue, as some might have done. Instead, they had copies taken of all Professor Keeler's nebulæ photographs, and these they bound together and issued in the form of a book. I am sure you will agree with me that a monument of this sort is far more useful than any marble statue, no matter how beautiful it may be.

There is still a great deal to be learned about the sun and the sunspots, and it is quite an important thing to have records of the sun's appearance day by day. Every clear day, photographs are taken at Greenwich Observatory, which is our National Observatory. Many days are cloudy, and it is of course quite impossible to obtain photographs of the sun at these times. The Astronomer Royal then writes to another observatory, situated in Mauritius, where the skies are more often clear than in England. The astronomers of that far-away island observatory then send a

copy of their photograph for the day that it was cloudy in England, and in this way we are able to have a complete record of the sun's surface all the year round. There is no doubt that in time to come these records will become most valuable. There are many other branches of astronomy which I could mention, where equally important work is going on, but I must now tell you a little about the observatories themselves.

CHAPTER XXX

THE OBSERVATORY AND ITS INSTRUMENTS

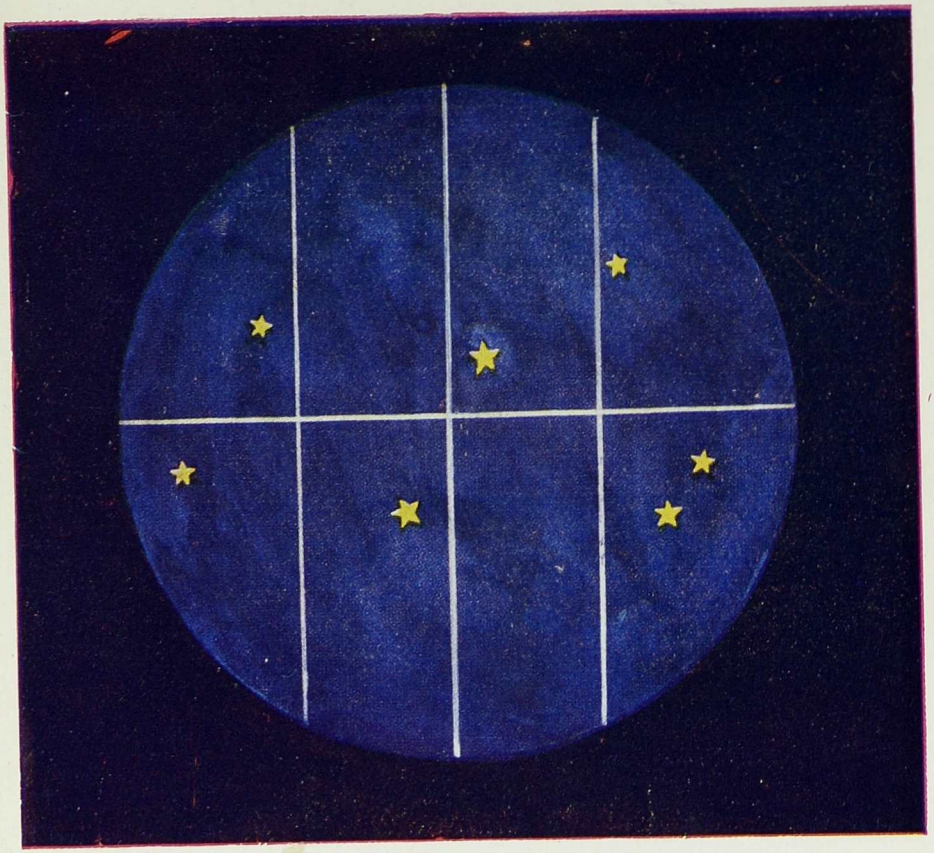
ONE of the chief things that an observatory is built for is to provide a house for the telescope, and of course all astronomical observatories have their telescopes, which differ in size and make. When telescopes were first invented, some three hundred years ago, their users were very much puzzled as to how they should house them, for the telescopes in those days were of a very great length. The old astronomers racked their brains over the matter, and at last they decided upon a very simple plan: they left the telescopes out in the open air, without any covering at all. The consequence of this was that the instruments soon became covered with dirt and dust, and they also became very badly rusted. As time went on, and telescopes became more numerous, a method of protecting the great instruments from the weather had to be found, and so it is to-day that observatories are generally provided with a dome, which serves as a covering for the telescope. Such a one is shown in Plate XLIII. The object of this dome is to enable the instrument to be pointed to any part of the sky, either high or low, according to the position of the object which is being observed. If an ordinary

roof had been placed on the observatory, the astronomer would have had to lift off the whole roof every time he wanted to observe, and this would have entailed a loss of time as well as a great deal of trouble. The difficulty is overcome by having a circular-shaped roof, made of metal, which revolves on wheels. In the side of the dome, at a certain point, a long slit is made, extending from the bottom to the top. This is covered with a sliding panel of metal, so that all the astronomer has to do is to open the slit by pulling the sliding panel to one side, and then he can easily turn the slit to any part of the sky he wishes, by revolving the dome on its wheels. The telescope is then pointed through the slit and all is ready for observing, and in Plate XLIV. you will see this slit in the dome and the telescope pointed through it.

No doubt you will be wondering how an astronomer is able to find any particular star that he wishes to look at, from among the great number of stars in the sky; or, if he is looking at a star, how he can tell whether or not the star has been seen before.

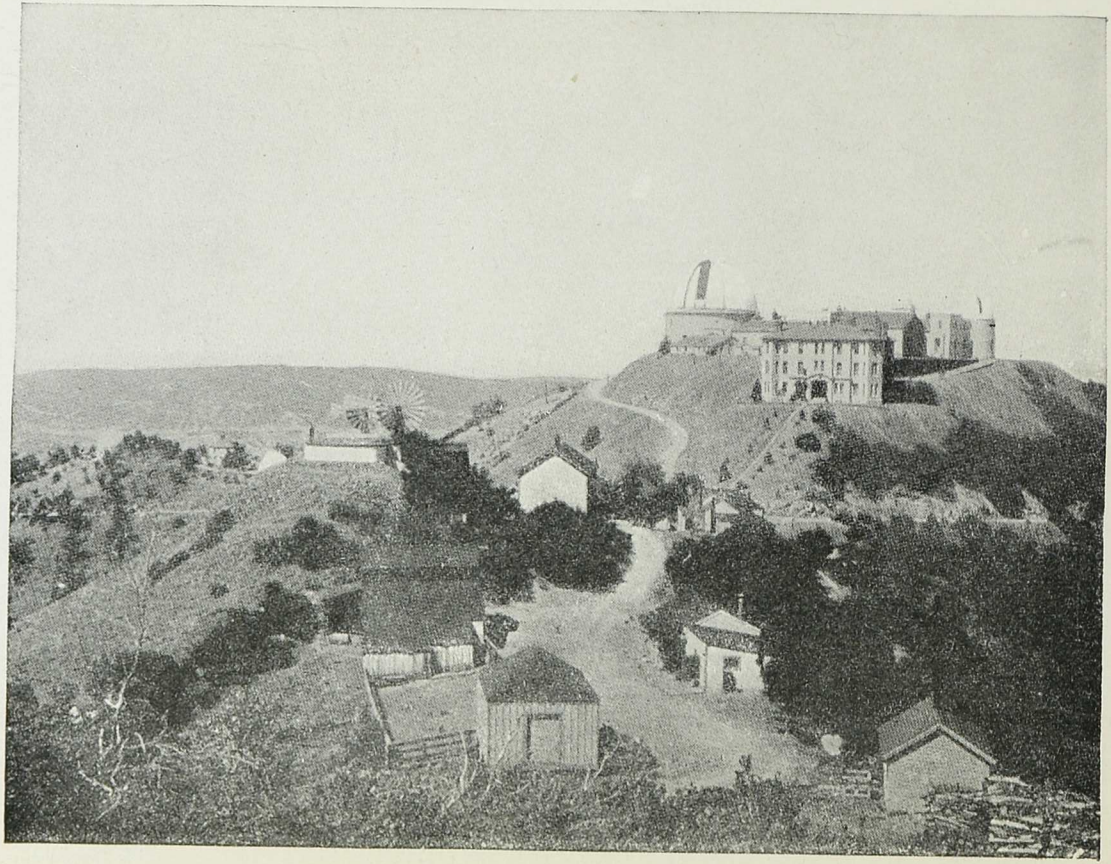
There is a story told of a young lady, who, after having been shown round an observatory, said to the astronomer, "I can quite understand how you discover new stars, but I cannot, for the life of me, imagine how you find out their names"! Astronomers cannot find out the names of the stars, but they can at least give them names, and, as you will already have learned, all the bright stars have names of their own, or else they are known by a letter of the Greek alphabet.

The smaller stars have not names, but are generally referred to by a number, which is taken from a catalogue



From a painting] [by E. Hawks

The view through a Transit Instrument



The Lick Observatory, showing the astronomers' house

of stars. There is still another way of identifying the stars. You will know that if a captain of a ship meets with a dangerous or unknown rock, he will enter in his log-book the latitude and longitude of the dangerous object, and in this way he will be able to warn the captains of other ships of the whereabouts of the danger. In something the same way as the earth is divided up into latitude and longitude, so is the sky mapped out. The celestial measurements are called Right Ascension and Declination, and if an astronomer knows these two quantities of a star, he will have no difficulty in finding any star he wants to observe. But it is most important that the astronomer should have the correct time, in order to find a given object. All large observatories have, therefore, a very good time-keeper, called the Sidereal Clock, which is very delicately regulated and is proof against all the changes of the weather. These clocks are nearly always of beautiful workmanship, and on this account they are very expensive. You will perhaps be wondering how the astronomer manages to keep his Sidereal Clock absolutely correct, for you must remember that many observatories are situated right away from big towns, and the astronomers are not able to get the time of day, as we can, by simply looking at a town clock and regulating our watches accordingly.

You will see in the picture, Plate XLIV., towards the back of the observatory there is a sort of square-shaped object on the roof. This is the roof of the Transit room, and here is situated a small telescope which is so fixed that it points due south. That is to say, although one may move the telescope up and down, it cannot be moved

to left and right, for it is set pointing towards what astronomers term the "Meridian," or the true north and south line in the sky. In the eyepiece of this Transit instrument are some very fine lines, as shown in Plate XLV. Now the mathematicians are able to calculate, with great accuracy, the exact second that any star crosses the meridian, and as the middle wire in the eyepiece of the Transit telescope is really the Meridian, it follows that when a certain star, for instance Vega, touches this central wire, then the astronomer knows that it is exactly, say, 8 hours 5 minutes and 2 seconds. Not only are seconds taken into account, but fractions of seconds also, so that it can be stated exactly, to a hundredth part of a second, when Vega or any other star crosses the Meridian. The astronomer by these means is able to correct the clock to a very small fraction of a second. In the accompanying picture you will see a bright star just about to cross the Meridian, while some others have just passed it, and two more are yet to travel over the central wire

CHAPTER XXXI

FAMOUS OBSERVATORIES

THE largest of the world's observatories are to be found in America, for there are so many more millionaires in that country than anywhere else, that our American cousins are not only able to put up a greater number of observatories than we can, but are also able to spend more money on their equipment. Consequently they have larger telescopes and more instruments than are to be found anywhere else in the world. By far the most famous of all observatories is that called the Lick Observatory, and photographs of this well-known building are to be seen in Plates XLVI. and XLVII. A very wealthy American, called Mr. Lick, wanted to build a monument, so that after he died people would have something to remember him by. Mr. Lick also wanted to build his monument on the shores of the Pacific Ocean, where it could be seen by the sailors in their ships as well as by the people on the land. There were some very wise men at that time who heard of Mr. Lick's idea, and so they went to him asking him what use there was in building a monument such as he suggested, for if America had a war with any country, they said, the enemy's ships would fire at the monument and destroy it, and its builder would only be remembered by a heap of stones. This set Mr. Lick thinking, so he asked the wise men what could be done to overcome this difficulty, for he did so

want to leave a monument behind him. The wise men, who were really American astronomers, had their answer ready. They pointed out to Mr. Lick that in time of war churches are kept sacred by the combatants, and are not touched by their cannon-shot or pillaged by the soldiers. Observatories are also kept sacred in the same way, and so the American astronomers suggested to Mr. Lick that if he wanted to leave behind him an everlasting monument, it would not be a bad idea for him to build a big observatory, which would not be destroyed if America happened to have a war with any other nation. Mr. Lick thought this a capital idea, and gave instructions for an observatory to be built. In this story there is a very good moral, which perhaps you will already have seen. After a good deal of prospecting to find a suitable place for the observatory that was to be, the astronomers came to the conclusion that the best site was on the top of Mount Hamilton, in California. So it came about that the great observatory was built on the top of this beautiful mountain, and for many years it has given to the scientific world a great amount of knowledge, and discoveries have been plentiful. One of the conditions that Mr. Lick made, when giving the money for the building and equipping of the observatory, was that the building should be thrown open to the public every Saturday, and that the citizens of the neighbouring town, or visitors, should be able to come and look through the great telescope at the wonders of the heavens. When we hear that the observatory is situated on the top of a mountain which is over 4000 feet in height, and that the nearest railway is thirty miles away, we should hardly suppose that many people take advan-

PLATE XLVII

The Lick Observatory in winter

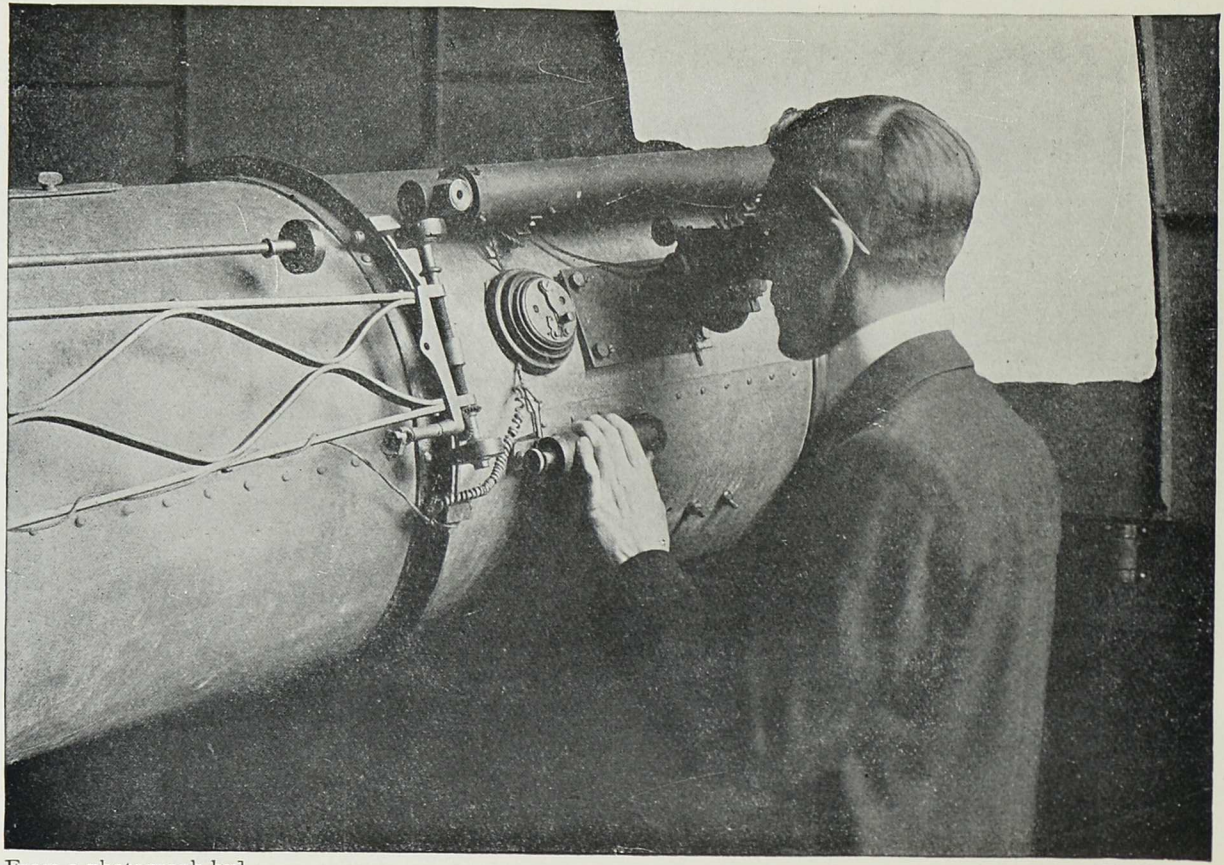


PLATE XLVIII

From a photograph by] [E. Hawks

How a reflecting telescope is used

tage of these conditions. It is to the contrary, however, for every Saturday, so the astronomers of the Lick Observatory tell us, a long string of carts and waggons of all descriptions may be seen right away down the valley, slowly winding their way up the corkscrew path to the observatory at the top of the mountain. Sometimes there are as many as 300 visitors on a Saturday night, who come to view the beautiful objects to be seen in the sky through the great Lick telescope.

Of course, the astronomers have to live at the top of Mount Hamilton, and so houses have been built for their accommodation near the observatory itself. Here they live for a certain length of time and then go "on leave," to their homes in the town of San José, thirty miles away. Very often the top of Mount Hamilton is covered with snow, as you see in the accompanying illustration, and you may be sure that it is very cold up there. The astronomers do not mind, however, for there is so much to be done, and the work is so interesting, that the cold is quite unnoticed amid their work.

Another well-known American observatory is that called the Yerkes, and here they have a telescope which is a little larger than the instrument at the Lick Observatory; but the astronomers at the Yerkes are handicapped, for their observatory is not situated in clear mountain air, like the Lick, but is near to the great city of Chicago, where there are multitudes of factory chimneys, which fill the air with soot and dust and thus make it "quivery," as we see it over a watchman's fire.

Of course, the observatory that English people are most proud of is our own National Observatory at Greenwich,

near London. Here the Astronomer Royal, appointed by the King, is in charge. The work of this observatory is firstly taken up with looking after the time, and matters pertaining to navigation, and secondly with the other departments of astronomy. At 10 o'clock and at 1 o'clock each day, Greenwich Observatory sends what is called a "Time Signal" all over England. To every post office there is an electrical connection, and at the times mentioned an instrument in the post offices gives a big "Click!" and the postmasters of England each know that it is then 10 o'clock or 1 o'clock, as the case may be. If you happen to be buying a stamp at either of these times at a post office, just listen for the Time Signal! In the windows of many watchmakers there is a sort of needle, which wags furiously at these hours, and each of these Time Signals is sent from Greenwich Observatory, the Greenwich astronomers taking their time from the stars in the way that has been explained in an earlier chapter.

Greenwich Observatory, too, is situated on the Meridian, which means that it is from this point that sailors take their measurements each day, whether far out at sea or close to land. If a sailor wishes to find his whereabouts on the wide ocean, he must, of course, have some place from which to commence his measurings, and for this point Greenwich Meridian, or "Longitude 0" as it is called, has been in use ever since the observatory was established, now some hundreds of years ago. And so we see that although our National Observatory is not so large as the American observatories, yet it is quite useful in another way.

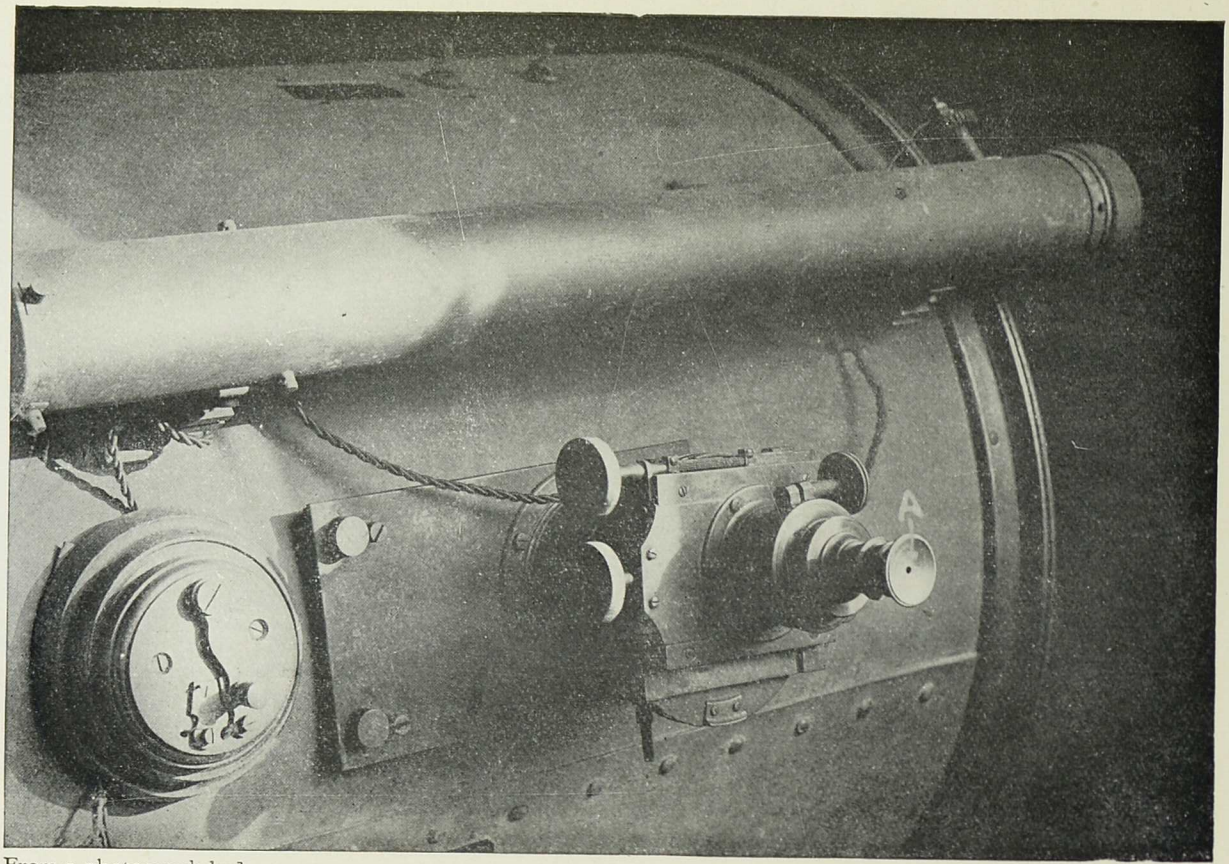
CHAPTER XXXII

THE TELESCOPE

BEFORE bringing to a close this little book, I think you might care to hear something about the telescope, the instrument by means of which astronomers have obtained most of their knowledge. Some three hundred years ago, there lived in the town of Middelburg, in Holland, a spectacle-maker called Lippershay. One day his apprentice was playing with some spectacle glasses, and suddenly he so arranged the glasses that the clock of a neighbouring church became large, and seemed quite near when viewed through the glasses. The apprentice was delighted with this, and soon told his master, who then made the first telescope. But people did not think of looking at the stars with the new instrument, which was not at all powerful as telescopes go. All they thought about was that it would be very useful in time of war, for their generals to be able to see from a distance what the soldiers of the other side were doing. The discovery soon became known over all Europe, and the principle of the invention soon reached the ears of Galileo, who set to work to make himself one of these new instruments. He soon had completed one which magnified about three times, which is not even so powerful as opera-glasses of the present time. Galileo did not care about wars or soldiers, and he applied his instrument to the heavens; the wonderful sights he saw, even with such slight optical aid, soon determined him to make a larger and more powerful instrument. This he did, and constructed a telescope that magnified thirty times, and with this instrument he dis-

covered the mountains on the moon, four satellites to Jupiter, saw more stars in the Pleiades, watched the changes of Venus, and discovered spots on the sun. He also saw Saturn "like an olive," and you will remember reading of this in an earlier chapter of this book.

After Galileo's time the telescope became quite a recognised instrument, and great improvements were made as time went on. It was left to Sir Isaac Newton, however, to invent a new form of telescope, which has been most serviceable, and with this new type of instrument most beautiful photographs of the celestial bodies have been obtained in recent years. There are two kinds of telescopes at the present day; these are Galileo's type, called the Refractor, and Sir Isaac Newton's type, called the Reflector. The first kind is just the ordinary "spyglass" sort of instrument which we look through, but the reflecting telescopes are made on a different principle. They have a large mirror mounted at the bottom of the telescope tube, and this mirror is carefully ground down to a certain curvature, so that when the rays of light from a star, or any other heavenly body, fall upon this mirror, they are reflected back to the top of the tube. Just at the correct point, near the top of the tube, there is a little prism inserted, which catches the rays from the mirror and diverts them to the side of the tube where the eyepiece is placed; so that, instead of looking through a reflecting telescope, we look into the side of the tube, and there see whatever object the telescope is directed to. This will perhaps be made clearer to you by the illustration in Plate XLVIII. You will see here the wide slit in the dome of the observatory, to which I have referred in a previous chapter, and through which the telescope is being pointed. The observer is looking into the telescope, and the rays of light from the



From a photograph by] [E. Hawks

The eyepiece of a large reflecting telescope

object which is under observation are falling on the mirror situated at the bottom of the telescope tube, which is not shown in the picture. There is a great advantage in reflecting telescopes, because they can be made larger than refractors, and also because they are somewhat cheaper. The largest reflecting telescope in the world is that of Lord Rosse, in Parsonstown, Ireland, and the mirror of this great instrument is six feet in diameter, and weighs three tons! The largest refracting telescope is that of the Yerkes Observatory, and the object-glass, upon which the power of this class of telescope depends, is forty inches in diameter. A telescope is like a funnel when placed in the neck of a bottle, and put out in the rain. You know that the bottle will very soon become filled with water if it has a funnel in its neck to collect the raindrops, and the bigger the funnel the sooner will the bottle become filled. It is similar with a telescope, for the object-glass or the mirror, as the case may be, collects the rays of light from a distant object, bringing them to a focus at the eyepiece of the instrument. It is through this eyepiece that the astronomer looks. Plate XLIX. will show you an eyepiece of a reflecting telescope, and the tiny black hole, over which I have put the letter A, shows the place that we have to look through, if we wish to observe anything. With the aid of a telescope, bright stars and planets can be seen during the daytime, in full sunlight, provided, of course, that the clouds are not in the way. This is a circumstance of which many people are in ignorance, for they think that the stars only "come out" at night-time; but you will now be able to tell your friends that there are always stars in the sky, both day and night, and it is only the glaring light of the sun that prevents us seeing them during the daytime.

CHAPTER XXXIII

CONCLUSION

I HOPE that I have now succeeded in showing you some of the things which astronomers have before them at the present time. I have told you of the storm-ridden sun, which is the centre of a family of planets, of which the earth is one. I have shown the differing appearances of the planets—some resembling the earth to a certain degree, and others totally unlike it. The comets, with all their mysterious wonders, have been touched upon; the stars themselves, those countless shining points of light —each one a sun, many of them perhaps greater and brighter than our own sun. The nebulæ, the Milky Way, and, finally, the observatories, have all been dealt with. Of course, in a little book like this, one cannot write everything about these wonders, and if you are interested in the planets, in the stars, or in the hundred and one other objects which are to be found in the heavens, I would ask you not to let your interest drop, but to read other books which deal with these subjects more fully. Perhaps some day you will come to possess a telescope, and then you will find a new world opened out to your gaze. Quite a small telescope will show many wonders among the heavenly bodies, and even a pair of opera-glasses will provide you

with many a night's enjoyment out of doors. For large comets a pair of good field-glasses are, in some respects, even better than a telescope, because the telescope will show only a little bit of a comet at a time, while a field-glass will show it in all its beauty. For those who have not even a field-glass, many interesting hours may be spent in learning the constellations thoroughly—as the Chaldean shepherds learnt them—with the unaided eye, while a watch of an hour or two on a clear night is almost certain to be rewarded by the sight of at least a few shooting stars.

And what of our earth? you will ask. Day by day it travels around the sun, in company with the moon, and in the same manner as the other planets; but it cannot go on in this manner for ever. There must come a time when the "end of the world" will come to pass, but how or when this will take place we have not the slightest idea. Floating about in space are numbers of dark bodies, or dead suns, as they are called. These are really stars which have burnt themselves out, and should our sun collide with one of these bodies, then indeed such a heat would be generated that the earth would speedily be scorched up to a cinder. There is yet another way in which the end of the world might come, and, from what we know at present, this seems to be a much more likely manner. Worlds, just like planets and animals, have a "life" of a certain length, and there must come a time when all worlds "die." The moon is a dead world at the present time, for it has neither air nor water. Mars, too, is in a dying state, although it still has some water and a certain amount of atmosphere. Slowly, very slowly, it is losing these, and a time will come when Mars, like the moon, will be

absolutely unable to support life as we know it. Perhaps that time has already come, but this we cannot tell. It is only reasonable to suppose that the earth also will lose its water and its atmosphere, and, as a matter of fact, it has been proved that it *is* actually losing them at the present time. At last there must come a time when there is neither air nor water upon the earth, and plants, animals, and men will no longer be able to live upon its surface. Such a time, however, must be so far distant that we cannot form the slightest idea of the period.

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