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The Children's Book of Stars

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Содержание

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PREFACE

It was the intention of the late Agnes Clerke to write the preface to this 'Children's Book of Stars.' Miss Clerke took a warm and sympathetic interest in the authoress and her work, but her lamented death occurred before this kindly intention could be fulfilled.

I cannot pretend to write adequately as her substitute, but I could not resist the appeal made to me by the author, in the name and for the sake of her dear friend and mine, to write a few words of introduction.

I am in no way responsible either for the plan or for any portion of this work, but I can commend it as a book, written in a simple and pleasant style, calculated to awaken the interest of intelligent children, and to enable parents otherwise ignorant or astronomy to answer many of those puzzling questions which such children often put.

DAVID GILL.

AUTHOR'S NOTE

This little work is the outcome of many suggestions on the part of friends who were anxious to teach their small children something of the marvels of the heavens, but found it exceedingly difficult to get hold of a book wherein the intense fascination of the subject was not lost in conventional phraseology – a book in which the stupendous facts were stated in language simple enough to be read aloud to a child without paraphrase.

Whatever merit there may be in the present work is due entirely to my friend Agnes Clerke, the well-known writer on astronomy; the faults are all my own. She gave me the impetus to begin by her warm encouragement, and she helped me to continue by hearing every chapter read as it was written, and by discussing its successor and making suggestions for it. Thus she heard the whole book in MS. A week after the last chapter had been read to her I started on a journey lasting many months, and while I was in the Far East the news reached me of her death, by which the world is the poorer. For her sake, as he has stated, her friend Sir David Gill, K.C.B., kindly undertook to supply the missing preface.

G. E. MITTON.

CHAPTER I
THE EARTH

It is a curious fact that when we are used to things, we often do not notice them, and things which we do every day cease to attract our attention. We find an instance of this in the curious change that comes over objects the further they are removed from us. They grow smaller and smaller, so that at a distance a grown-up person looks no larger than a doll; and a short stick planted in the ground only a few feet away appears as long as a much longer one at ten times the distance. This process is going on all round us every minute: houses, trees, buildings, animals, all seem larger or smaller in proportion to their distance from us. Sometimes I have seen a row of raindrops hanging on a bar by the window. When the sun catches one of them, it shines so brilliantly that it is as dazzling as a star; but my sense tells me it is a raindrop, and not a star at all. It is only because it is so near it seems as bright and important as a mighty star very, very far away.

We are so much accustomed to this fact that we get into a habit of judging the distance of things by their size. If we see two lights shining on a dark night, and one is much larger than the other, we think that the bright one must be nearer to us; yet it need not necessarily be so, for the two lights might possibly be at the same distance from us, and one be large and the other small. There is no way in which we can tell the truth by just looking at them. Now, if we go out on any fine moonlight night and look up at the sky, we shall see one object there apparently much larger than any other, and that is the moon, so the question that occurs to us at once is, Is the moon really very much larger than any of the stars, or does it only seem so because it is very much nearer to us? As a matter of fact, the moon is one of the smallest objects in view, only, as it is our nearest neighbour, it appears very conspicuous. Having learned this, we shall probably look about to see what else there is to attract attention, and we may notice one star shining very brilliantly, almost like a little lamp, rather low down in the sky, in that part of it where the sun has lately set. It is so beautifully bright that it makes all the others look insignificant in comparison, yet it is not really large compared with the others, only, as it comes nearer to us than anything else in the sky except the moon, it looks larger than it has any right to do in comparison with the others.

After this we might jump to the conclusion that all the bright large stars are really small and near to us, and all the faintly shining ones large and far away. But that would not be true at all, for some bright ones are very far away and some faint ones comparatively near, so that all we can do is to learn about them from the people who have studied them and found out about them, and then we shall know of our own knowledge which of them seem bright only because they are nearer than the others, and which are really very, very brilliant, and so still shine brightly, though set in space at an almost infinite distance from us.

The sun, as we all know, appears to cross the sky every day; he gets up in the east and drops down in the west, and the moon does the same, only the moon is unlike the sun in this, that it changes its shape continually. We see a crescent moon growing every night larger and larger, until it becomes full and fat and round, and then it grows thinner and thinner, until it dies away; and after a little while it begins again, and goes through all the same changes once more. I will tell you why this is so further on, when we have a chapter all about the moon.

If you watch the stars quietly for at least five minutes, you will see that they too are moving steadily on in the same way as the sun and moon. Watch one bright star coming out from behind a chimney-pot, and after about five minutes you will see that it has changed its place. Yet this is not true of all, for if we watch carefully we shall find that some, fairly high up in the sky, do not appear to move at all. The few which are moving so slowly that they seem to us to stand still are at a part of the sky close to the Pole Star, so called because it is always above the North Pole of the earth. I will explain to you how to find it in the sky for yourselves later on, but now you can ask anyone to point it out. Watch it. It appears to be fixed in one place, while the other stars are swinging round it in circles. In fact, it is as if we on the earth were inside a great hollow globe or ball, which continually turned round, with the Pole Star near the top of the globe; and you know that if you put your finger on the spot at the top of a spinning globe or ball, you can hold it there while all the rest of the ball runs round. Now, if you had to explain things to yourself, you would naturally think: 'Here is the great solid earth standing still, and the sun and moon go round it; the stars are all turning round it too, just as if they were fixed on to the inside of a hollow globe; we on the earth are in the middle looking up at them; and this great globe is slowly wheeling round us night by night.'

In the childhood of the world men believed that this was really true – that the earth was the centre of the universe, that the sun and moon and all the hosts of heaven were there solely to light and benefit us; but as the world grew wiser the wonders of creation were fathomed little by little. Some men devoted their whole lives to watching the heavens, and the real state of things was gradually revealed to them. The first great discovery was that of the daily movement of the earth, its rotation on its own axis, which makes it appear as if all these shining things went round it. It is indeed a very difficult matter to judge which of two objects is moving unless we can compare them both with something outside. You must have noticed this when you are sitting in a train at a station, and there is another train on the other side of yours. For if one of the trains moves gently, either yours or the other, you cannot tell which one it is unless you look at the station platform; and if your position remains the same in regard to that, you know that your train is still standing, while the other one beside it has begun to move. And I am quite sure that there is no one of us who has not, at one time or another, stood on a bridge and watched the water running away underneath until we felt quite dizzy, and it seemed as if the water were standing still and the bridge, with ourselves on it, was flying swiftly away backwards. It is only when we turn to the banks and find them standing still, that we realize the bridge is not moving, and that it is the running water that makes it seem to do so. These everyday instances show us how difficult it is to judge whether we are moving or an outside object unless we have something else to compare with it. And the marvellous truth is that, instead of the sun and moon and stars rolling round the earth, it is the earth that is spinning round day by day, while the sun and the stars are comparatively still; and, though the moon does move, yet when we see her get up in the east and go down in the west that is due to our own movement and not to hers.

The earth turns completely round once in a day and night. If you take an orange and stick a knitting-needle through it, and hold it so that the needle is not quite straight up but a little slanting, and then twirl it round, you will get quite a good idea of the earth, though of course there is no great pole like a gigantic needle stuck through it, that is only to make it easy for you to hold it by. In spinning the orange you are turning it as the earth turns day by day, or, as astronomers express it, as it rotates on its axis.

There is a story of a cruel Eastern King who told a prisoner that he must die if he did not answer three questions correctly, and the questions were very difficult; this is one of them:

'How long would it take a man to go round the earth if he never stopped to eat or drink on the way?'

And the prisoner answered promptly: 'If he rose with the sun and kept pace with it all day, and never stopped for a moment to eat or drink, he would take just twenty-four hours, Your Royal Highness.' For in those days it was supposed that the sun went round the earth.

Everyone is so remarkably clever nowadays that I am sure there will be someone clever enough to object that, if what I have said is true, there would be a great draught, for the air would be rushing past us. But, as a matter of fact, the air goes with us too. If you are inside a railway carriage with the windows shut you do not feel the rush of air, because the air in the carriage travels with you; and it is the same thing on the earth. The air which surrounds the earth clings to it and goes round with it, so there is no continuous breeze from this cause.

But the spinning round on its own axis is not the earth's only movement, for all the time it is also moving on round the sun, and once in a whole year it completes its journey and comes back to the place from whence it started. Thus the turning round like a top or rotating on its axis makes the day and night, and the going in a great ring or revolving round the sun makes the years.

Our time is divided into other sections besides days and years. We have, for instance, weeks and months. The weeks have nothing to do with the earth's movements; they are only made by man to break up the months; but the months are really decided by something over which we have no control. They are due to the moon, and, as I have said already, the moon must have a chapter to herself, so we won't say any more about the months here.

If any friend of ours goes to India or New Zealand or America, we look upon him as a great traveller; yet every baby who has lived one year on the earth has travelled millions of miles without the slightest effort. Every day of our lives we are all flung through space without knowing it or thinking of it. It is as if we were all shut up in a comfortable travelling car, and were provided with so many books and pictures and companions that we never cared to look out of the windows, so that hour by hour as we were carried along over miles of space we never gave them a thought. Even the most wonderful car ever made by man rumbles and creaks and shakes, so that we cannot help knowing it is moving; but this beautiful travelling carriage of ours called the earth makes never a creak or groan as she spins in her age-long journey. It is always astonishing to me that so few people care to look out of the window as we fly along; most of them are far too much absorbed in their little petty daily concerns ever to lift their eyes from them. It is true that sometimes the blinds are down, for the sky is thickly covered with clouds, and we cannot see anything even if we want to. It is true also that we cannot see much of the scenery in the daytime, for the sun shining on the air makes a veil of blue glory, which hides the stars; but on clear nights we can see on every side numbers of stars quite as interesting and beautiful as any landscape; and yet millions of people never look up, never give a thought to the wonderful scenery through which their car is rushing.

By reason of the onward rush of the earth in space we are carried over a distance of at least eighteen miles every second. Think of it: as we draw a breath we are eighteen miles away in space from the point we were at before, and this goes on unceasingly day and night. These astonishing facts make us feel how small and feeble we are, but we can take comfort in the thought that though our bodies are insignificant, the brain of man, which has discovered these startling facts, must in itself be regarded as one of the most marvellous of all the mysteries amid which we live.

Well, we have arrived at some idea of our earth's position; we know that the earth is turning round day by day, and progressing round the sun year by year, and that all around lie the sentinel stars, scattered on a background of infinite space. If you take an older boy or girl and let him or her stand in the middle to represent the sun, then a smaller one would be the earth, and the smallest of all the moon; only in truth we could never get anyone large enough to represent the sun fairly, for the biggest giant that ever lived would be much too small in proportion. The one representing the sun must stand in the middle, and turn slowly round and round. Then let the earth-child turn too, and all the time she is spinning like a top she must be also hastening on in a big ring round the sun; but she must not go too fast, for the little moon-child must keep on running round her all the time. And the moon-child must keep her face turned always to the earth, so that the earth never sees her back. That is an odd thing, isn't it? We have never seen the other side of the moon, which goes round us, always presenting the same face to us.

The earth is not the only world going round the sun; she has many brothers and a sister; some are nearer to the sun than she is, and some are further away, but all circle round the great central light-giver in rings lying one outside the other. These worlds are called planets, and the earth is one of them, and one of the smaller ones, too, nothing so great and important as we might have imagined.

CHAPTER II
HANGING IN SPACE

If you are holding something in your hand and you let it go, what happens? It falls to the ground, of course. Now, why should it do so? You will say: 'How could it do anything else?' But that is only because you are hampered by custom. Try to shake yourself free, and think, Why should it go down instead of up or any other way? The first man who was clever enough to find some sort of an answer to this question was the great philosopher Sir Isaac Newton, though he was not quite the first to be puzzled by it. After years of study he discovered that every thing attracts every other thing in proportion to their masses (which is what you know as weight) and their distance from each other. In more scientific language, we should say every *body* instead of every *thing*, for the word body does not only mean a living body, but every lump or mass of matter in the universe. The earth is a body in this sense, and so is the table or anything else you could name. Now as the earth is immeasurably heavier than anything that is on it, it pulls everything toward itself with such force that the little pulls of other things upon each other are not noticed. The earth draws us all toward it. It is holding us down to it every minute of the day. If we want to move we have to exert another force in order to overcome this attraction of the earth, so we exert our own muscles and lift first one foot and then the other away from the earth, and the effort we make in doing this tires us. All the while you are walking or running you are exercising force to lift your feet away from the ground. The pull of the earth is called gravitation. Just remember that, while we go on to something else which is almost as astonishing.

We know that nothing here on earth continues to move for ever; everything has to be kept going. Anything left to itself has a tendency to stop. Why is this? This is because here in the world there is something that fights against the moving thing and tries to stop it, whether it be sent along the ground or thrown up in the air. You know what friction is, of course. If you rub your hands along any rough substance you will quickly feel it, but on a smooth substance you feel it less. That is why if you send a stone spinning along a carpet or a rough road it stops comparatively soon, whereas if you use the same amount of force and send it along a sheet of ice it goes on moving much longer. This kind of resistance, which we call friction, is one of the causes which is at work to bring things to a standstill; and another cause is the resistance of the air, which is friction in another form. It may be a perfectly still day, yet if you are bicycling you are breaking through the air all the time, just as you would be through water in swimming, only the resistance of the air is less than that of water. As the friction or the resistance of the air, or both combined, gradually lessens the pace of the stone you sent off with such force, the gravitation of the earth begins to be felt. When the stone first started the force you gave to it was enough to overcome the gravitation force, but as the stone moves more slowly the earth-pull asserts itself, and the stone drops down to the ground and lies still upon the surface. Now, if there were no friction, and therefore no resistance, there would be no reason why anything once set moving should not go on moving for ever. The force you give to any object you throw is enough to overcome gravitation; and it is only when the first force has been diminished by friction that the earth asserts its authority and pulls the moving object toward it. If it were possible to get outside the air and out of reach of the pull of the earth, we might fling a ball off into space, and it would go on in a straight line until something pulled it to itself by the force of gravity.

Gravitation affects everything connected with the earth; even our air is held to the earth by gravitation. It grows thinner and thinner as we get further away from the earth. At the top of a high mountain the air is so thin that men have difficulty in breathing, and at a certain height they could not breathe at all. As they cannot breathe in very fine air, it is impossible for them to tell by personal experiment exactly where the air ends; but they have tried to find out in other ways, and though different men have come to different conclusions on the subject, it is safe to say that at about two hundred miles above the earth there is nothing that could be called air. Thus we can now picture our spinning earth clothed in a garment of air that clings closely about her, and grows thinner and thinner until it melts away altogether, for there is no air in space.

Now in the beginning God made the world, and set it off by a first impulse. We know nothing about the details, though further on you shall hear what is generally supposed to have taken place; we only know that, at some remote age, this world, probably very different from what it is now, together with the other planets, was sent spinning off into space on its age-long journey. These planets were not sent off at random, but must have had some particular connection with each other and with the sun, for they all belong to one system or family, and act and react on each other. Now, if they had been at rest and not in movement, they would have fallen right into the sun, drawn by the force of gravitation; then they would have been burned up, and there would have been an end of them. But the first force had imparted to them the impulse to go on in a straight line, so when the sun pulled the result was a movement between the two: the planets did not continue to move in a straight line, neither did they fall on to the sun, but they went on a course between the two – that is, a circle – for the sun never let them get right away from him, but compelled them to move in circles round him. There is a very common instance of this kind of thing which we can see, or perhaps feel, every day. If you try to sit still on a bicycle you tumble off, because the earth pulls you down to itself; but if, by using the force of your own muscles, you give the bicycle a forward movement this resists the earth-pull, and the result is the bicycle runs along the ground. It does not get right away from the earth, not even two or three feet above ground; it is held to the earth, but still it goes forward and does not fall over, for the movement is made up of the earth-pull, which holds it to the ground, and the forward movement, which propels it along. Then again, as another instance, if you tie a ball to a string and whirl it round you, so long as you keep on whirling it will not fall to the ground, but the moment you stop down it drops, for there is nothing to fight against the pull of gravitation. Thus we can picture the earth and all the planets as if they were swinging round the sun, held by invisible strings. It is the combination of two forces that keeps them in their places – the first force and the sun's pull. It is very wonderful to think of. Here we are swinging in space on a ball that seems only large to us because we are so much smaller ourselves; there is nothing above or below it but space, yet it travels on day by day and year by year, held by invisible forces that the brain of man has discovered and measured.

Of course, every planet gives a pull at every other planet too, but these pulls are so small compared with that of the sun that we need not at present notice them. Then we come to another point. We said that every body pulled every other body in proportion to their weights and their distance. Now, gravity acts much more strongly when things are near together than when they are far away from each other; so that if a smaller body is near to another somewhat larger than itself, it is pulled by it much more strongly than by a very much larger one at a considerably greater distance.

We have an instance of this in the case of the earth and moon: as the earth responds to the pull of the sun, so the moon responds to the pull of the earth. The moon is so comparatively near to the earth that the earth-pull forces her to keep on going round and round, instead of leaving her free to circle round the sun by herself; and yet if you think of it the moon does go round the sun too. Recall that game we had when the sun was in the middle, and the two smaller girls, representing the earth and moon, went round it. The moon-child turned round the earth-child, but all the while the earth-child was going round the sun, so that in a year's time the moon had been all round the sun too, only not in a straight line. The moon is something like a dog who keeps on dancing round and round you when you go for a walk. He does go for the walk too, but he does much more than that in the same time. Thus we have further completed our idea of our world. We see it now hanging in space, with no visible support, held in its place by two mighty forces; spinning on year after year, attended by its satellite the moon, while we run, and walk, and cry, and laugh, and play about on its surface – little atoms who, except for the brain that God has given them, would never even have known that they are continually moving on through endless space.

CHAPTER III
THE SHINING MOON

'Once upon a time,' long, long ago, the earth was not a compact, round, hard body such as she is now, but much larger and softer, and as she rotated a fragment broke off from her; it did not go right away from her, but still went on circling round with the motion it had inherited from her. As the ages passed on both the earth and this fragment, which had been very hot, cooled down, and in cooling became smaller, so that the distance between them was greater than it had been before they shrank. And there were other causes also that tended to thrust the two further from each other. Yet, compared with the other heavenly bodies, they are still near, and by looking up into the sky at night you can generally see this mighty fragment, which is a quarter the diameter of the earth – that is to say, a quarter the width of the earth measured from side to side through the middle. It is – as, of course, you have guessed – the moon. The moon is the nearest body to us in all space, and so vast is the distance that separates us from the stars that we speak as if she were not very far off, yet compared with the size of the earth the space lying between us and her is very great. If you went right round the world at the thickest part – that is to say, in the region of the Equator – and when you arrived at your starting-point went off once again, and so on until you had been round ten times, you would only then have travelled about as far as from the earth to the moon!

The earth is not the only planet which has a moon, or as it is called, a satellite, in attendance. Some of the larger planets have several, but there is not one to compare with our moon. Which would you prefer if you had the choice, three or four small moons, some of them not much larger than a very big bright star, or an interesting large body like our own moon? I know which I should say.

'You say that the moon broke off from the earth, so perhaps there may be some people living on her,' I hear someone exclaim.

If there is one thing we have found out certainly about the moon, it is that no life, as we know it, could exist there, for there is neither air nor water. Whether she ever had any air or water, and if so, why they disappeared, are questions we cannot answer. We only know that now she is a dead world. Bright and beautiful as she is, shedding on us a pale, pure light, in vivid contrast with the fiery yellow rays of the sun, yet she is dead and lifeless and still. We can examine her surface with the telescope, and see it all very plainly. Even with a large opera-glass those markings which, to the naked eye, seem to be like a queer distorted face are changed, and show up as the shadows of great mountains. We can only see one side of the moon, because as I have said, she keeps always the same face turned to the earth; but as she sways slightly in her orbit, we catch a glimpse of sometimes a little more on one side and sometimes a little more on the other, and so we can judge that the unseen part is very much the same as that turned toward us.

At first it is difficult to realize what it means to have no air. Besides supporting life in every breath that is drawn by living creatures, the air does numerous other kind offices for us – for instance, it carries sound. Supposing the most terrific volcano exploded in an airless world, it could not be heard. The air serves as a screen by day to keep off the burning heat of the sun's rays, and as a blanket by night to keep in the heat and not let it escape too quickly. If there were no air there could be no water, for all water would evaporate and vanish at once. Imagine the world deprived of air; then the sun's rays would fall with such fierceness that even the strongest tropical sun we know would be as nothing in comparison with it, and every green thing would shrivel up and die; this scorching sun would shine out of a black sky in which the stars would all be visible in the daytime, not hidden by the soft blue veil of air, as they are now. At night the instant the sun disappeared below the horizon black darkness would set in, for our lingering twilight is due to the reflection of the sun in the upper layers of air, and a bitterness of deathly cold would fall upon the earth – cold fiercer than that of the Arctic regions – and everything would be frozen solid. It would need but a short time to reduce the earth to the condition of the moon, where there is nothing to shrivel up, nothing to freeze. Her surface is made up of barren, arid rocks, and her scenery consists of icy black shadows and scorching white plains.

The black shadows define the mountains, and tremendous mountains they are. Most of them have craters. A crater is like a cup, and generally has a little peak in the middle of it. This is the summit of a volcano, and when the volcano has burst up and vomited out floods of lava and débris, this has fallen down in a ring a little distance away from it, leaving a clear space next to the peak, so that, as the mountain ceases vomiting and the lava cools down, the ring hardens and forms a circular ridge. The craters on the moon are immense, not only in proportion to her size, but immense even according to our ideas on the earth. One of the largest craters in our own world is in Japan, and this measures seven miles across, while in the moon craters of fifty, sixty, and even a hundred miles are by no means uncommon, though there are also hundreds and thousands of smaller ones. We can see the surface of the moon very plainly with the magnificent telescopes that have now been made, and with the best of these anything the size of a large town would be plainly visible. Needless to say, no town ever has been or ever will be seen upon the moon!

All these mountains and craters show that at one time the moon must have been convulsed with terrific disturbances, far worse than anything that we have any knowledge of on our earth; but this must have been ages ago, while the moon still probably had an atmosphere of its own. Now it has long been quiet. Nothing changes there; even the forces that are always at work on the earth – namely, damp and mould and water – altering the surface and breaking up the rocks, do not act there, where there is no moisture of any sort. So far as we can see, the purpose of the moon is to be the servant of the earth, to give her light by night and to raise the tides. Beautiful light it is, soft and mysterious – light that children do not often have a chance of seeing, for they are generally in bed before the moon rises when she is at the full.

We know that the moon has no heat of her own – she parted with all that long ago; she cannot give us glowing light from brilliant flames, as the sun does; she shines only by the reflection of the sun on her surface, and this is the reason why she appears to change her shape so constantly. She does not really change; the whole round moon is always there, only part of it is in shadow. Sometimes you can see the dark part as well as the bright. When there is a crescent moon it looks as if it were encircling the rest; some people call it, 'seeing the old moon in the new moon's arms.' I don't know if you would guess why it is we can see the dark part then, or how it is lighted up. It is by reason of our own shining, for we give light to the moon, as she does to us. The sun's rays strike on the earth, and are reflected on to the moon, so that the moon is lighted by earthshine as we are lighted by moonshine, and it is these reflected earth-rays that light up the dark part of the moon and enable us to see it. What a journey these rays have had! They travel from the sun to the earth, and the earth to the moon, and then back to the earth again! From the moon the earth must appear a much bigger and more glorious spectacle than she does to us – four times wider across and probably brighter –

for the sun's light strikes often on our clouds, which shine more brilliantly than her surface.

Once again we must use an illustration to explain the subject. Set a lamp in the middle of a dark room, and let that be the sun, then take a small ball to represent the earth and a smaller one for the moon. Place the moon-ball between the lamp and the earth-ball. You will see that the side turned to the earth-ball is dark, but if you move the moon to one side of the earth, then from the earth half of it appears light and half dark; if you put it right away from the lamp, on the outer side of the earth, it is all gloriously lit up, unless it happens to be exactly behind the earth, when the earth's shadow will darken it. This is the full explanation of all the changes of the moon.

Does it ever fall within the earth's shadow? Yes, it does; for as it passes round the earth it is not always at the same level, but sometimes a little higher and sometimes a little lower, and when it chances to pass exactly behind it enters the shadow and disappears. That is what we call an eclipse of the moon. It is nothing more than the earth's shadow thrown on to the moon, and as the shadow is round that is one of the proofs that the earth is round too. But there is another kind of eclipse – the eclipse of the sun; and this is caused by the moon herself. For when she is nearest to the sun, at new moon – that is to say, when her dark side is toward us, and she happens to get exactly between us and the sun – she shuts out the face of the sun from us; for though she is tiny compared with him, she is so much nearer to us that she appears almost the same size, and can blot him right out. Thus the eclipses of both sun and moon are not difficult to understand: that of the moon can only happen at full moon, when she is furthest from the sun, and it is caused by the earth's shadow falling upon the moon; and that of the sun at new moon, when she is nearest to him, and it is caused by the solid body of the moon coming between us and the sun.

Besides giving us light by night, the moon serves other important purposes, and the most important of all is the raising of the tides. Without the rising of the sea twice in every day and night our coasts would become foul and unwholesome, for all the dead fish and rotting stuff lying on the beach would poison the air. The sea tides scour our coasts day by day with never-ceasing energy, and they send a great breath of freshness up our large rivers to delight many people far inland. The moon does most of this work, though she is a little helped by the sun. The reason of this is that the moon is so near to the earth that, though her pull is a comparatively small one, it is very strongly felt. She cannot displace the actual surface to any great extent, as it is so solid; but when it comes to the water she can and does displace that, so that the water rises up in answer to her pull, and as the earth turns round the raised-up water lags behind, reaching backward toward the moon, and is drawn up on the beach, and makes high tide. But it is stopped there, and meantime, by reason of the earth's movement, the moon is left far behind, and pulls the water to itself further on, when the first high tide relapses and falls down again. At length the moon gets round to quite the opposite side of the earth to that where she began, and there she makes a high tide too; but as she draws the water to herself she draws also the solid earth beneath the water to her in some degree, and so pulls it away from the place where the first high tide occurred, leaving the water there deeper than before, and so causing a secondary high tide.

The sun has some influence on the tides too, and when moon and sun are in the same line, as at full and new moon, then the tides are highest, and are called spring tides; but when they pull in different directions, as when it is half-moon, then the tides are lowest and are called neap tides.

CHAPTER IV
THE EARTH'S BROTHERS AND SISTER

The earth is not the only world that, poised in space, swings around the sun. It is one of a family called the Solar System, which means the system controlled and governed by the sun. When we look up at the glorious sky, star-studded night by night, it might seem to us that the stars move only by reason of the earth's rotation; but when men first began to study the heavens attentively – and this is so long ago that the record of it is not to be found – they noticed that, while every shining object in the sky was apparently moving round us, there were a few which also had another movement, a proper motion of their own, like the moon. These curious stars, which appeared to wander about among the other stars, they called planets, or wanderers. And the reason, which was presently discovered, of our being able to see these movements was that these planets are very much nearer to us than any of the real stars, and in fact form part of our own solar system, while the stars are at immeasurable distances away. Of all the objects in the heavens the planets are the most intensely interesting to us; for though removed from us by millions of miles, the far-reaching telescope brings some of them within such range that we can see their surfaces and discover their movements in a way quite impossible with the stars. And here, if anywhere, might we expect to find traces of other living beings like ourselves; for, after all the earth is but a planet, not a very large nor a very small one, and in no very striking position compared with the other planets; and thus, arguing by what seems common-sense, we say, If this one planet has living beings on its surface, may not the other planets prove to be homes for living beings also? Counting our own earth, there are eight of these worlds in our solar system, and also a number of tiny planets, called asteroids; these likewise go round the sun, but are very much smaller than any of the first eight, and stand in a class by themselves, so that when the planets are mentioned it is generally the eight large well-known planets which are referred to.

If we go back for a moment to the illustration of the large lamp representing our sun, we shall now be able to fill in the picture with much more detail. The orbits of the planets, as their paths round the sun are called, lie like great circles one outside another at various distances, and do not touch or cut each other. Where do you suppose our own place to be? Will it be the nearest to the sun or the furthest away from him? As a matter of fact, it is neither, we come third in order from the sun, for two smaller planets, one very small and the other nearly as large as the earth, circle round and round the sun in orbits lying inside ours. Now if we want to place objects around our lamp-sun which will represent these planets in size, and to put them in places corresponding to their real positions, we should find no room large enough to give us the space we ought to have. We must take the lamp out into a great open field, where we shall not be limited by walls. Then the smallest planet, named Mercury, which lies nearest of all to the sun, would have to be represented by a pea comparatively close to the sun; Venus, the next, would be a greengage plum, and would be about twice as far away; then would come the earth, a slightly larger plum, about half as far again as Venus. After this there would be a lesser planet, called Mars, like a marble. These are the first four, all comparatively small; beyond them there is a vast gap, in which we find the asteroids, and after this we come to four larger planets, mighty indeed as regards ourselves, for if our earth were a greengage plum, the first of these, Jupiter, would have to be the size of a football at least, and the next, Saturn, a smaller football, while Uranus and Neptune, the two furthest out, would be about the size of the toy balloons children play with. The outermost one, Neptune, would be thirty times as far from the sun as we are.

This is the solar system, and in it the only thing that shines by its own light is the sun; all the rest, the planets and their moons, shine only because the rays of light from the sun strike on their surfaces and are reflected off again. Our earth shines like that, and from the nearer planets must appear as a brilliant star. The little solar system is separated by distances beyond the realm of thought from the rest of the universe. Vast as are the intervals between ourselves and our planetary neighbours, they are as nothing to the space that separates us from the nearest of the steady shining fixed stars. Why, removed as far from us as the stars, the sun himself would have sunk to a point of light; and as for the planets, the largest of them, Jupiter, could not possibly be seen. Thus, when we look at those stars across the great gulf of space, we know that though we see them they cannot see us, and that to them our sun must seem only a star; consequently we argue that perhaps these stars themselves are suns with families of planets attached to them; and though there are reasons for thinking that this is not the case with all, it may be with some. Now if, after learning this, we look again at the sky, we do so with very different eyes, for we realize that some of these shining bodies are like ourselves in many things, and are shining only with a light borrowed from the sun, while others are mighty glowing suns themselves, shining by their own light, some greater and brighter, some less than our sun. The next thing to do is to learn which are stars and which are planets.

Of the planets you will soon learn to pick out one or two, and will recognize them even if they do change their places – for instance, Venus is at times very conspicuous, shining as an evening star in the west soon after the sun goes down, or us a morning star before he gets up, though you are not so likely to see her then; anyway, she is never found very far from the sun. Jupiter is the only other planet that compares with her in brilliancy, and he shines most beautifully. He is, of course, much further away from us than Venus, but so much larger that he rivals her in brightness. Saturn can be quite easily seen as a conspicuous object, too, if you know where to look for him, and Mars is sometimes very bright with a reddish glow. The others you would not be able to distinguish.

It is to our earth's family of these eight large planets going steadily round the same sun that we must give our attention first, before going on to the distant stars. Many of the planets are accompanied by satellites or moons, which circle round them. We may say that the sun is our parent – father, mother, what you will – and that the planets are the family of children, and that the moons are *their* children. Our earth, you see, has only one child, but that a very fine one, of which she may well be proud.

When I say that the planets go round the sun in circles I am only speaking generally; as a matter of fact, the orbits of the planets are not perfect circles, though some are more circular than others. Instead of this they are as a circle might look if it were pressed in from two sides, and this is called an ellipse. The path of our own earth round the sun is one of the most nearly circular of them all, and yet even in her orbit she is a good deal nearer to the sun at one time than another. Would you be surprised to hear that she is nearer in our winter and further away in our summer? Yet that is the case. And for the first moment it seems absurd; for what then makes the summer hotter than the winter? That is due to an altogether different cause; it depends on the position of the earth's axis. If that axis were quite straight up and down in reference to the earth's path round the sun we should have equal days and nights all the year round, but it is not; it leans over a little, so that at one time the North Pole points towards the sun and at another time away from it, while the South Pole is pointing first away from it and then toward it in exactly the reverse way. When the North Pole points to the sun we in the Northern Hemisphere have our summer. To understand this you must look at the picture, which will make it much clearer than any words of mine can do. The dark part is the night, and the light part the day. When we are having summer any particular spot on the Northern Hemisphere has quite a long way to travel in the light, and only a very short bit in the dark, and the further north you go the longer the day and shorter the night, until right up near the North Pole, within the Arctic Circle, it is daylight all the time. You have, perhaps, heard of the 'midnight sun' that people go to see in the North, and what the expression means is that at what should be midnight the sun is still there. He seems just to circle round the horizon, never very far above, but never dipping below it.

When the sun is high overhead, his rays strike down with much more force than when he is low. It is, for instance, hotter at mid-day than in the evening. Now, when the North Pole is bowed toward the sun, the sun appears to us to be higher in the sky. In the British Isles he never climbs quite to the zenith, as we call the point straight above our heads; he always keeps on the southern side of that, so that our shadows are thrown northward at mid-day, but yet he gets nearer to it than he does in winter. Look at the picture of the earth as it is in winter. Then we have long nights and short days, and the sun never appears to climb very high, because we are turned away from him. During the short days we do not receive a great deal of heat, and during the long night the heat we have received has time to evaporate to a great extent. These two reasons – the greater or less height of the sun in the sky and the length of the days – are quite enough to account for the difference between our summer and winter. There is one rather interesting point to remember, and that is that in the Northern Hemisphere, whether it is winter or summer, the sun is south at mid-day, so that you can always find the north then, for your shadow will point northwards.

New Zealand and Australia and other countries placed in the Southern Hemisphere, as we are in the Northern, have their summer while we have winter, and winter while we have summer, and their summer is warmer than ours, because it comes when the earth in its journey is three million miles nearer to the sun than in our summer.

All this seems to refer to the earth alone, and this chapter should be about the planets; but, after all, what applies to one planet applies to another in some degree, and we can turn to the others with much more interest now to see if their axes are bowed toward the sun as ours is. It is believed that in the case of Mercury, in regard to its path round the sun, the axis is straight up and down; if it is the changes of the seasons must depend on the nearness of Mercury to the sun and nothing else, and as he is a great deal nearer at one time than another, this might make a very considerable difference. Some of the planets are like the earth in regard to the position of their axes, but the two outermost ones, Uranus and Neptune, are very peculiar, for one pole is turned right toward the sun and the other right away from it, so that in one hemisphere there is continuous day all the summer, in the other there is continuous night, and then the process is reversed. But these little peculiarities we shall have to note more particularly in the account of the planets separately.

There is a curious fact in regard to the distances of the planets from the sun. Each one, after the first, is, very roughly, about double the distance from the sun of the one inside it. This holds good for all the first four, then there is a great gap where we might expect to find another planet, after which follow the four large planets. Now, this gap puzzled astronomers greatly; for though there seemed to be no reason why the planets should be at regular distances one outside the other, yet there the fact was, and that the series should be broken by a missing planet was annoying. So very careful search was made, and a thrill of excitement went all through the scientific world when it was known that a tiny planet had been discovered in the right place. But this was not the end of it, for within a few years three or four more tiny planets were observed not far from the first one, and, as years rolled on, one after another was discovered until now the number amounts to over six hundred and others are perpetually being added to the list! Here was a new feature in the solar system, a band of tiny planets not one of which was to be compared in size with the least of those already known. The largest may be about as large as Europe, and others perhaps about the size of Wales, while there may be many that have only a few square miles of surface altogether, and are too small for us to see. To account for this strange discovery many theories were advanced.

One was that there had been a planet – it might be about the size of Mars – which had burst up in a great explosion, and that these were the pieces – a very interesting and exciting idea, but one which proved to be impossible. The explanation now generally accepted is a little complicated, and to understand it we must go back for a bit.

When we were talking of the earth and the moon we realized that once long ago the moon must have been a part of the earth, at a time when the earth was much larger and softer than she now is; to put it in the correct way, we should say when she was less dense. There is no need to explain the word 'dense,' for in its ordinary sense we use it every day, but in an astronomical sense it does not mean exactly the same thing. Everything is made up of minute particles or atoms, and when these atoms are not very close together the body they compose is loose in texture, while if they are closer together the body is firmer. For instance, air is less dense than water, and water than earth, and earth than steel. You see at once by this that the more density a thing has the heavier it is; for as a body is attracted to another body by every atom or particle in it, so if it has more particles it will be more strongly attracted. Thus on the earth the denser things are really heavier. But 'weight' is only a word we use in connection with the earth; it means the earth's pulling power toward any particular thing at the surface, and if we were right out in space away from the earth, the pulling power of the earth would be less, and so the weight would be less; and as it would be impossible always to state just how far away a thing was from the earth, astronomers talk about density, which means the number of particles a body contains in proportion to other bodies. Thus the planet Jupiter is very much larger than the earth, but his density is less. That does not mean to say that if Jupiter were in one scale and the earth in the other he would weigh less, because he is so very much bigger he would outweigh the earth still; his total *mass* would be greater than that of the earth, but it means that a piece of Jupiter the same size as a piece of the earth would weigh less under the same conditions.

Now, before there were any planets at all or any sun, in the place of our solar system was a vast gaseous cloud called a nebula, which slowly rotated, and this rotation was the first impulse or force which God gave it. It was not at all dense, and as it rotated a part broke off, and inheriting the first impulse, went on rotating too. The impulse would have sent it off in a straight line, but the pull of gravity from the nebula held it in place, and it circled round; then the nebula, as it rotated, contracted a little, and occupied less space and grew denser, and presently a second piece was thrown off, to become in time another planet. The same process was repeated with Saturn, and then with the huge

Jupiter. The nebula was always rotating and always contracting. And as it behaved, so did the planets in their turn; they spun round and cooled and contracted, and the moons were flung off from them, just as they – the planets – had been flung off from the parent nebula.

Now, after the original nebula had parted with the mighty mass of Jupiter, it never again made an effort so great, and for a long time the fragments that were detached were so small as hardly to be worth calling planets; they were the asteroids, little lumps and fragments that the nebula left behind. But as it still contracted in time there came Mars; and having recovered a little, the nebula with more energy got rid of the earth, and next Venus, and lastly little Mercury, the smallest of the eight planets. Then it contracted further, and perhaps you can guess what the remainder of it is – the sun; and by spinning in a plastic state the sun, like the earth, has become a globe, round and comparatively smooth; and its density is now too great to allow of its losing any more fragments, so, as far as we can see, the solar system is complete.

This theory of the origin of the planets is called the nebula theory. We cannot prove it, but there are so many facts that can only be explained by it, we have strong reason for believing that something of the kind must have happened. When we come to speak of the starry heavens we shall see that there are many masses of glowing gas which are nebulæ of the same sort, and which form an object-lesson in our own history.

We have spoken rather lightly of the nebula rotating and throwing off planets; but we must not think of all this as having happened in a short time. It is almost as impossible for the human mind to conceive the ages required for such slow changes as to grasp the great gulfs of space that separate us from the stars. We can only do it by comparison. You know what a second is, and how the seconds race past without ceasing day and night. It makes one giddy to picture the seconds there are in a year; yet if each one of those seconds was a year in itself, what then? That seems a stupendous time, but it is nothing compared with the time needed to form a nebula into a planetary system. If we had five thousand of such years, with every second in them a year, we should then only have counted one billion real years, and billions must have passed since the sun was a gaseous nebula filling the outermost bounds of our system!

CHAPTER V
FOUR SMALL WORLDS

What must the sun appear to Mercury, who is so much nearer to him than we are? To understand that we should have to imagine our sun increased to eight or nine times his apparent size, and pouring out far greater heat and light than anything that we have here, even in the tropics. It was at first supposed that Mercury must have an extra thick covering of clouds to protect him from this tremendous glare; but recent observations tend to prove that, far from this, he is singularly free from cloud. As this is so, no life as we know it could possibly exist on Mercury.

His year – the time he takes to go round the sun and come back to the same place again – is eighty-eight days, or about one-quarter of ours. As his orbit is much more like an ellipse than a circle, it follows that he is much nearer to the sun at one time than at another – in fact, when he is nearest, the size of the sun must seem three and a half times greater than when he is furthest away from it! Even at the best Mercury is very difficult to observe, and what we can learn about him is not much; but, as we have heard, his axis is supposed to be upright. If so his seasons cannot depend on the bend toward or away from the sun, but must be influenced solely by the changes in his distance from the sun, which are much greater than in our own ease.

There is some reason to believe, too, that Mercury's day and year are the same length. This means that as the planet circles round the sun he turns once. If this is so the sun will shine on one half of the planet, producing an accumulated heat terrific to think of; while the other side is plunged in blackness. The side which faces the sun must be heated to a pitch inconceivable to us during the nearer half of the orbit – a pitch at which every substance must be at boiling-point, and which no life as we know it could possibly endure. Seen from our point of view, Mercury goes through all the phases of the moon, as he shines by the reflected light of the sun; but this point we shall consider more particularly in regard to Venus, as Venus is nearer to us and easier to study. For a long time astronomers had a fancy that there might be another planet even nearer to the sun than Mercury, perhaps hidden from us by the great glare of the sun. They even named this imaginary planet Vulcan, and some thought they had seen it, but it is tolerably certain that Vulcan existed only in imagination. Mercury is the nearest planet to the sun, and also the smallest, of course excepting the asteroids. It is about three thousand miles in diameter, and as our moon is two thousand miles, it is not so much bigger than that. So far as we are concerned, it is improbable we shall ever know very much more about this little planet.

But next we come to Venus, our beautiful bright neighbour, who approaches nearer to us than any other heavenly body except the moon. Alas! when she is nearest, she like Mercury, turns her dark side toward us, coming in between us and the sun, so that we cannot observe her at all.

Everyone must have noticed Venus, however carelessly they have looked at the sky; but it is likely that far more people have seen her as an evening than a morning star, for most people are in bed when the sun rises, and it is only before sunrise or after sunset we can see Venus well. She is at her best from our point of view when she seems to us to be furthest from the sun, for then we can study her best, and at these times she appears like a half or three-quarter moon, as we only see a part of the side from which the sunlight is reflected. She shines like a little silver lamp, excelling every other planet, even Jupiter, the largest of all. If we look at her even with the naked eye, we can see that she is elongated or drawn out, but her brilliance prevents us from seeing her shape exactly; to do this we must use a telescope.

Конец ознакомительного фрагмента.