THIS WONDERFUL UNIVERSE

by

Agnes Giberne

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FORWARD TO NEW EDITION

MANY years ago a small volume under this title was published by the S.P.C.K. When a letter came, asking me to revise it for re-issue in an illustrated form, I speedily found that to "revise" meant to "re-write." And re-written it has been during the past few months, with abundant omissions and still more abundant additions. Except possibly here or there in the first few pages, I doubt if a single sentence has kept its old form unaltered. And though in the main I have roughly followed the outlines of my former plan, it has been largely reconstructed, and very many of the chapters are entirely new.

I have to express my grateful thanks to Mr. W. H. Wesley, Assistant Secretary of the Royal Astronomical Society; Mr. E. Walter Maunder, F.R.A.S.; Professor H. H. Turner, F.R.S., Director of the University Observatory of Oxford; Professor E. B. Frost, Director of Yerkes Observatory, Wisconsin; Mr. Harlow Shapley, of Mount Wilson Observatory, California, and others, for most kind help given in the work of re-writing, by their ready response to inquiries on my part about difficult questions and new developments.

My thanks also are due to several poets of the present day, whose names will be found here and there, as well as to their publishers, for leave kindly granted for the use of their poems both in this and in a companion-volume on the subject of Plant-life, which is to appear a little later. So while the latter will be about flowers on our Earth, this one is about more flaming blossoms in the Garden of the Skies. As wrote Erasmus Wilson, long ago—

> *"Flowers of the sky; ye too to age must yield,*
> *Frail as your silken sisters of the field."*

In both books I have given quotations, not only from modern poets, but from many of bygone generations. It is always interesting to note the manner in which great scientific truths are received by widely differing minds, gifted with poetic insight. Perhaps not least so with writers of a past age, when that which was known, alike of life on our small world and of conditions in the great Universe, could hardly be compared with what is known to us now.

Agnes Giberne

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Part I

Our Outlook from Earth

I

A RAPID WHIRL

Once upon a time a man is reported to have said: "Don't tell *me* that the world goes round. I know better. 'Cause why? When I get up in the morning I see the very same view all round as when I went to bed."

That man, at all events, thought for himself, which is better than not thinking at all, even though his thinking led to a mistaken conclusion. And the reasoning was not out of place. Nay, he had hold of an important truth; only he used that truth wrongly.

He grasped the fact that a man, going from one spot to another, must from time to time have different things about him. If he walks the changes come slowly; if he travels by train they arrive more quickly. In any case he cannot pass onward, hour after hour, moving among objects which do not move, and still see the same houses, the same trees, the same fields, the same hills. As he advances, he leaves the old surroundings behind, and finds himself amid new surroundings.

The man, of course, knew this. Though not learned in scientific matters, he had his share of common sense.

When somebody told him that our solid old world was not, as he supposed, quietly at rest, but was incessantly twirling like a teetotum, he began to use his common sense.

He knew that when he went to bed at night he could see certain objects in the country around; and he knew that when he woke up in the morning he would find those same objects, each in exactly the same position. Then he put two and two together, and decided that the notion of the Earth spinning must be a mistake. "Don't tell *me*," he said. "I know better!"

And all the time he was himself making a curious mistake. Up to a certain point his reasoning was not incorrect; but he looked in the wrong direction for the changes of scene which he rightly considered ought to come about. And rather oddly, while taking it for granted that *he* would move with the moving Earth, he does not seem to have faced the probability that other objects on Earth's surface would do the same.

It never occurred to him that not only his own little house and garden, and everything in them, but other houses with all that they contained, and trees and fields, hedges and ponds, hills and valleys—one and all must be carried onward just as fast as the surface of the Earth was moving. Otherwise, if everything were left behind by that rushing surface, it would mean a complete and terrific jumble of destruction.

Naturally, therefore, the view before his eyes each morning had to be the same as his view of the evening before.

When a man in a railway carriage is borne along at the rate of fifty miles an hour, all that is inside that carriage travels at the same pace. The cushions, the seats, the people, the luggage, the fly on a window-pane, the air which fills the compartment, are journeying at fifty miles an hour. And when a traveller wishes to find a changing scene, he must not fix his gaze on the floor, or the seats, or on a fellow-traveller. He must look *outside* at the fields, the trees, the houses, the villages, seen through the windows.

This is just what one on Earth must do, if he would discover the movements of our globe from changes in the scenery. He must look right *outside*, away from Earth altogether; not at the things on our world, which move with the Earth as he does himself. And that is exactly what the man did not do. He looked only at the things around, all journeying with himself; and he forgot to gaze away outside, away from the hurrying surface of the solid globe on which he stood.

"Ah, yes," perhaps you may say. "He ought to have looked right off from everything on the ground. He ought to have watched the clouds. Then he would have understood."

No; not even then. That would have meant a second mistake on his part.

It is true that he would not, usually, find precisely the same clouds as the evening before; because clouds are perpetually altering their shapes, melting away, re-forming, taking new outlines. But these changes in them would be real. They would not be *seeming*

changes, brought about by his own movements.

The clouds would have travelled onward, as he did himself, with the Earth's surface. They might be blown hither and thither by currents of air; but *as a whole* they would have been carried from west to east by the steady whirl of the entire atmosphere, which moves with the surface of the Earth.

So if the man wished to get a really outside view, he would have to look beyond the clouds, beyond the great deep ocean of air, which really is a part of our Earth. He would have to lift his gaze into the sky, where float the Moon and Sun, the planets and the stars. Then at last he would find scenery which seems to change, like the objects noticed out of a rushing train, objects which often cannot but seem to move, if this world really does move, because they are not a part of the Earth, as air and clouds, hills and towns, fields and rivers and oceans are.

"Now glowed the firmament
With living sapphires; Hesperus, that led
The starry host, rode brightest, till the Moon,
Rising in clouded majesty, at length
Apparent queen unveiled her peerless light,
And o'er the dark her silver mantle threw."

MILTON, *Paradise Lost*

II

HEAVENLY BODIES

The first and simplest idea which a child generally has of Earth and sky is of a wide, flat plain, and of a fixed sky above, with clouds and a sun in it by day, and a moon and stars in it by night. Stars always at night, when the sky is clear; and a sun always by day, unless hidden by clouds; but a moon not always after dark.

So much as this an intelligent child might be expected to find out for himself, even if not told. And the first men who inhabited this Earth must have seen such things very much as an untaught child now would see them. Probably this was the idea in the mind of the man who could not believe that the Earth revolved.

But suppose that, instead of making up his mind in such a hurry, he had taken time to watch and to think. Suppose he had glanced away from Earth to the heavens, far beyond cloudland; had looked, not once or twice only, and not carelessly, but day after day with attentive and earnest eyes. Suppose he had kept this up, week after week, month after month, even year after year, trying to find out what changes in that heavenly scenery might mean.

He would see what already he knew—that the Sun each morning comes up from below the easterly horizon, crosses the sky, higher up or lower down at different seasons, and goes down below the westerly horizon.

He would notice that the Moon by night, when visible, does much the same; rising somewhere in the east, crossing part of the sky, and setting somewhere in the west.

He would find the stars also to be on the move; many of them, like the Sun and Moon, rising in an easterly direction, crossing the sky, and setting in a westerly direction, while a certain number towards the north are never seen from our part of the Earth to set, but keep circling round and round a certain point.

Then, if left to himself, with no books or teachers, and no help from the thousands of years during which other men before him have watched and waited and studied and found explanations, he would doubtless fall into the same mistakes that men of ancient days fell into long ago.

He would feel sure that this flat Earth on which he had a footing, which feels so firm and solid, must certainly be at rest. Therefore, he would feel no less sure that the whole sky, with Sun and Moon and hosts of stars, must be whirling round and round our Earth, once in every twenty-four hours.

That would indeed be a tremendous feat for the heavens to perform! Wonderful things are done in the

sky; but nothing quite so utterly and hopelessly beyond all human imagination as this!

Only, in far-back days it was not beyond imagination, because men then knew so very little of the real size of our marvellous Universe, or of the enormous numbers of stars contained in it, or of the stupendous distances which divide its stars one from another. To the mind of a man in those times it was much more difficult to imagine that our world could spin day and night like a huge top, than that the entire heavens should perpetually whirl round and round us.

Of the two explanations one had to be true; and it was just a question which was the more easy to accept. Men believed that which seemed to them the simpler.

Now that we know better what would be meant by such a whirl, we realise how very much more simple and easy is the explanation founded on the idea of our small Earth's daily turning on her own axis.

Astronomers gradually discovered that many other bodies in the sky—the Sun, for instance, and the planets—are steadily spinning or revolving, each on its own axis, some more quickly, some more slowly. Examined through a telescope, they are clearly seen to do so. And if other bodies, many of them far larger than this world, are known to behave thus, why not the Earth also? The idea, far from looking impossible, has become an every-day fact.

When once we grant that our world is ever spinning round and round, carrying with her everything on and near her surface, then the daily movements of the

Sun, the nightly movements of Moon and stars, are explained. We see them *seem* to move, merely because we ourselves are moving. We see them *seem* to come up from the east and go down in the west, because we on Earth are being carried from west to east. It is much the same as when a man, journeying in a train from north to south, sees trees and fields and villages appear to travel from south to north.

Not that this particular movement, this daily whirl of our Earth is her only movement! And not that the Sun and Moon, the planets and stars, have not real movements of their own! But just now all we have to do with is the fact that the daily and nightly whirl of the skies round us is *not* real. It is only an appearance, brought about by the ceaseless spin of our small Earth. Other movements may be left alone for a while.

"Mysterious Night; when our first parent knew
Thee from report Divine, and heard thy name,
Did he not tremble for this lovely frame,
This glorious canopy of light and dew?

"Yet 'neath a curtain of translucent dew,
Bathed in the rays of the great setting flame,
Hesperus with the host of heaven came,
And lo, Creation widened in man's view.

"Who could have thought such darkness lay concealed
Within thy beams, O Sun? or who could find,
Whilst fly and leaf and insect stood revealed,
That to such countless orbs thou mad'st us blind?
Why do we then shun Death with anxious strife?
If Light can thus deceive, wherefore not Life?

— Blanco White

III

THE SHAPE OF OUR EARTH

A MAN standing on the equator is carried, in the course of twenty-four hours, right round under the entire heavens. If he were gazing through all those hours steadily up into the sky he might view the whole landscape of stars visible from this world—but for one hindrance. That hindrance is the radiance of sunlight, which in day-time shuts off the dim flicker of starlight. Could he cover up the sun, and so secure twenty-four hours of darkness, he might survey all at a single stretch.

Not that the heavens would journey round him, while he stood on a fixed and motionless world, but that he, on the whirling surface of our revolving globe, would be carried round swiftly under each part of the sky in turn, travelling always from west to east.

But a man standing farther north or farther south, and not on the equator, would not gain so full a view. Portions of the heavens would be hidden from him by the intervening solid body of the Earth.

There are many stars over the region of the south pole, which we in Britain and in other northern parts of Europe and North America can never see. And

there are many stars over the region of the north pole, which people in southern Australia and South Africa can never see. It is only from the equator that a man might obtain a complete view.

Since the Earth is not, as was once supposed, a flat plain, reaching to endless distances, but a round globe or sphere, its surface curves away from us, wherever we happen to be, till it passes out of sight at the horizon-line. The curve is very gentle; but it is found in all parts of the world alike.

A very interesting proof of the round shape of our Earth is given in an eclipse of the Moon.

Sometimes in our yearly journeying round the Sun—this is another of the Earth's movements—we pass exactly between the Sun and the Moon, so that the three bodies are in a direct line. More often it happens that either the Sun or the Moon is just a little higher or a little lower; and then the three are not in a line. But when it does so come about, the Sun casts a shadow of the Earth upon the Moon. And since the latter shines only by reflected sunlight, she at once becomes dim.

And—note this!—the shadow thrown by our Earth is a *round* shadow. As the grey shade creeps slowly over the bright Moon-face, it is always a *rounded edge* which moves onward. No matter which part of the Earth has its shadow cast, the result is the same. England, India, Australia, America—these or other countries may face the Moon; but invariably the creeping shadow is round in shape, and the back-edge following is round also.

If you hold up an orange between a lighted lamp and the wall—rather near the wall, and not too near the lamp—you will see that the shadow thrown by it is a round shadow. Turn it about as you will, offer one side after another to the lamp, and still the shadow will be round.

Then hold up a flat plate to the lamp; and you will find that the shape of the shadow depends on how you place it. In one position, and one only, it will cast a round shadow. In others the shadow will be more or less oval; while, if you hold the plate *edgeways* towards the lamp, the shadow becomes only a straight, broadish line.

Do you see how strong a proof is given here as to the shape of the Earth? And it is one that comes again and again, every time we have an eclipse of the Moon.

And now about the size of the little world on which we live.

If a road could be made straight through its centre, from one side to the other, perhaps on the equator, such a road would be nearly eight thousand miles long. A carriage drawn by quick horses, going at the rate of ten miles an hour, never lessening speed by day or night, might accomplish that distance in thirty-three days, or just over a calendar month. A train, or a motor-car, travelling fifty miles an hour, without a single break, might do the same in less than a week.

But with horses and engines, not to speak of passengers, halts are needed. And when we romance about going down into the Earth and out on the further

side, in any such fashion, we are talking about an unknown region. The outside surface of our globe is more or less familiar; but not the inside.

A recent statement gives as the greatest depth of a mine ever yet sunk: "the No. 3 shaft of the Tamarack mine in the county Michigan," which "reached a vertical depth of about 5200 feet;" that is, slightly under one mile. A mere scratching of Earth's crust! Even if we suggest a larger margin, and say that no mine has reached a depth beyond two miles—what are two miles compared with eight thousand? True, parts of our ocean-bottoms lie six or even seven miles below the ocean-surface; but those depths are far beyond our reach.

Imagine what it would mean to delve four thousand miles below the surface of our Earth; four thousand miles away from light and air; nearly four thousand miles beneath our oceans. And to complicate matters, the inside of our world is believed to be intensely heated; so much so, according to one authority, that about thirty miles down the heat must be great enough to melt all solid rocks. If they are not there in an actually molten state, it is only because the immense pressure tends to keep them solid.

Such a road would indeed utterly dwarf the grandest engineering works of man.

Though a road of this kind is impossible, and though we cannot hope ever to dig or blast our way downwards until the opposite side is reached, yet the actual size of our Earth has been again and again reckoned. The size of any globe, both through the middle and round

the outside, may always be found out from careful measurements of parts of its surface. The work of surveyors comes in here; and such measurements have been made times without number, and calculations worked out therefrom.

We now know, as a matter of certainty, that the Earth is about eight thousand miles through from pole to pole or from side to side straight through the centre, and about twenty-five thousand miles round at the equator.

By the "equator" we mean an imaginary line round the Earth, half-way between the north and south poles. And when we speak of the north pole or the south pole *in the heavens*, we mean always that point in the sky which lies just over our Earth's north pole or our Earth's south pole.

With regard to the shape of our Earth, it is, as already stated, a globe or ball; more strictly, it is like an orange, since it has slightly flattened poles. In scientific language the Earth is an "oblate spheroid;" and in connection with this term a little scene of past days comes to mind.

My father one day was showing cube-shapes to two little girls, aged about nine and seven, explaining their names and uses. In a corner of the room their small sister, only three and a half or possibly as much as four years old, was seated on the floor, playing happily with her toys.

Presently, to see how far his explanations had been

understood, my father asked a question or two, and among them: "What is the shape of our Earth?"

Seven-years-old and nine-years-old tried to remember. But the baby in the corner, busied with her dolls, had listened to some purpose, and the pause was broken by a sweet little treble voice piping out—

"An *oblate spheroid*, uncle!"

My father's surprise and amusement may well be imagined.

And perhaps I cannot do better than mention here how deep is my debt to that dear father for his early lessons in science; lessons which familiarised me as a child with scientific modes of thought and expression; laying a firm foundation, upon which a super-structure of further study could so easily be reared. It was he who first awoke my interest in such subjects; he who made Astronomy a living force in my imagination.

The teaching must have begun very early, for I well remember standing by his side, one wintry day, when I was certainly not more than seven or eight years old, asking why and how it could be that we were nearer to the Sun in winter than in summer, and yet were more cold. A fire was burning, and he sat not far off. I can see now his fine, stately figure, the short-frocked child standing by his side, and the gesture with which he pointed to a fly on his knee. "See—if that fly were *one inch* nearer to the fire, would it feel any hotter?"

No; it would not. I understood that instantly; and though the real cause of summer and winter in the

slant of Earth's axis did not become evident till long after, I did see then, with daylight clearness, that the difference of three millions of miles, compared with the Sun's whole distance, was no more than that one inch in the fly's distance from the fire. There was no need to ask more.

"Heaven's ebon vault,
Studded with stars unutterably bright,
Thro' which the moon's unclouded grandeur rolls,
Seems like a canopy which love has spread
To curtain her sleeping world."

— Percy Bysshe Shelley

Part II

Studying the Heavens

I

GROUPS OF STARS

LIKE every study, that of Astronomy has to be from small beginnings. To start with a difficult text-book, or with hard calculations, would in most cases have no good result.

It is a study which ought to be followed on two lines at the same time. Much can be learnt from books; much also from actual observation of the sky. A beginner may choose the one plan or the other; but the better mode is to use both plans.

Without books, a student of the skies stands in much the same position as an ancient astronomer of Chaldean days. He has to find out for himself those things which have taxed the minds of men through centuries. And without some amount of watching of the heavens, the known facts which may be learnt from books can never be quite so real to him, if he does not use his own eyes to verify them, to the small extent which lies in his power.

Some teachers of Astronomy prefer to start with the distant stars, and to work their way back to such

heavenly bodies as lie nearer to Earth. Others think it wise to tackle first the nearer bodies, and gradually to wander farther afield. For instance, we may begin with our closest neighbour of all, the Moon; and with our brother and sister worlds, the planets; and with the great head and centre of our system, the Sun; afterwards passing on to the stars.

But even from the first we cannot ignore the stars. Night by night, unless hidden by clouds, they shine forth; and from childhood those tiny glimmers are a part of our lives.

With them the earliest stage should be just to grow used to their ordinary look, as seen from our Earth; to learn something of the various groups or "constellations;" to become acquainted with the shapes and names of such constellations, and their places in the heavens; also to understand a little about their seeming nightly and yearly movements, due to our own daily and yearly revolvings. What they really are, and how far they truly and actually move, must come later.

Earth's daily whirl on her own axis has been explained as making all the sky seem to travel round us by day and by night. And her yearly journey round the Sun also causes a slow shifting—apparent, not real—of the various constellations through summer and winter.

Certain constellations, far north, such as the Great Bear and the Little Bear, are always visible to us in Great Britain and in the northern parts of Europe and North America. Certain constellations, such as the Southern Cross, are never visible to us in those regions. But other

constellations, not so far north and not so far south, are sometimes to be seen, and sometimes not. Many stars, high up in the southern sky—for instance, those in the constellation of Orion—visible to us in winter nights, are hidden in summer nights.

We can at any time see only those groups which lie in a direction *away from* the Sun; not those which lie on the same side of the heavens with the Sun. Those stars, if seen at all, would have to be seen by daylight; that is, at the same time as the Sun. And this, under ordinary conditions, is out of the question, because they are veiled from our eyes by the glare of sunlight.

So it is not till the Earth, in her twelve-months' voyage, gets round to the other side of the Sun, and sees him against the opposite heavens, that the stars which were hidden months before become visible. While, from the same cause, many stars which have been visible take their turn to disappear.

One fact should from the first be absolutely clear. This is—*that the stars are always there*. They do not come and go. They are always overhead, high in the heavens, round the whole Earth, whether we do or do not see them.

I do not mean that the same stars are always over one particular part of the world; but that *some* stars are there always, which of them depending on which part of the heavens our part of the Earth happens to be under at any particular hour. The whole vast company of stars, each in its own constellation, to which it has

belonged through thousands if not millions of years, is always in the skies.

If you had a good telescope, with a friend able to use it, you might get a glimpse of certain stars, even in the brightest noonday.

Picture to yourself a small toy balloon floating in the air of a vast hall, with walls and ceiling and floor, pictures and furniture, surrounding it above and below and on all sides. So our Earth floats in the measureless expanse of space, with countless stars above and below and on all sides.

Think of a small spider clinging to that little balloon. He would be able to see only part of the hall, whichever part towards which his side of the balloon happened to face. If he were looking at the right wall, he could not see the left, because the balloon between would hide it. And just so we on Earth can, at any particular time, see only that part of the heavens towards which our side of this floating globe is turned.

Longfellow wrote on the subject—

> *"And as the evening twilight fades away,*
> *The sky is filled with stars, invisible by day."*

And Wordsworth—

> *"Look for the stars, you'll say that there are none;*
> *Look up a second time, and one by one*
> *You mark them twinkling out with silvery light,*
> *And wonder how they could elude the sight."*

The above illustration of balloon and hall is, of course, defective, as such illustrations are bound to be.

On Earth we know no true "up" or "down," except in the sense of towards and away from our Earth's centre. This is just as true in Australia as in Britain, even though the feet of our fellow-subjects there do point towards the feet of men walking on British soil here.

Picture once again to yourself the small globe floating in the great hall, about half-way between floor and ceiling. But now think of it as obeying rule, as floating round and round a centre which is occupied by another and much larger ball. Picture also that a slender needle is thrust through the little balloon's centre, one end coming out at its north pole, the other at its south pole. And as it moves that needle is *slanting*, not upright, and the slant is always in the same direction. The needle does not wobble about, pointing this way and that way. It points always steadily towards the same wall.

So does the axis of our Earth keep always the same slant; and our north pole points always towards one part of the heavens. There lies the celestial north pole, carried straight on from the north pole of our little world.

In this slant of our Earth's axis lies the explanation of our seasons.

For in one part of our yearly journey round the Sun our north pole points *towards* the Sun, and our south pole is turned *away* from him. This means the northern summer and the southern winter. Six months later it is the south pole which points towards the Sun, and the north pole which is turned away from him. And though, during that northern winter, we are really nearer to the

Sun than in our summer, the trifling difference of three million miles is of little account. The main fact is that we have so much less of actual direct sunshine, and that it comes to us from a Sun far lower down in the sky. Spring and autumn lie between these two extremes, when the Earth is in a half-way position.

II

HOW TO KNOW THE STARS

It is a good plan to cultivate the habit of looking from some particular window at certain stated hours after dusk each evening. Much may be learnt thus.

The brighter stars should first be picked out and carefully watched. It may be noted how they are placed with respect to neighbour-stars not quite so bright: whether they twinkle or shine steadily; whether they keep, night after night, at the same distance from those other stars, or whether they slowly alter their positions; and if they do move, how they move.

This is one of the first questions of interest, because thereby one may distinguish between stars and planets. A star twinkles; a planet generally does not. A star keeps always the same position among other stars; a planet wanders about from one place to another among the stars.

Many years ago a working-man wrote to my father, begging for help in his efforts to learn about the heavenly bodies. In his letter he made this remark: *"If I can once get hold of Venus, I will not let her go."*

No better plan could be suggested. Try to "get hold" of a planet here, of a star there, and do not let them go, do not lose them, but follow their movements day by day.

Bad weather may interrupt and confuse such attempts, and for a while your new friends may slip out of sight, but they can be found again. They never really take their departure; they only change their positions. The stars only change theirs in appearance, though in more ways than one. The planets change theirs, not only in appearance, but also in reality, yet they always move by rule, and astronomers know at all times where to look for them.

Such watching as this means the giving of time and trouble, but it is worth while. Even while we must all depend largely on what others can tell us, since there is an enormous amount which we could never discover for ourselves, yet the little that we can do well repays for the trouble.

In a sense stars are more easily "followed" than planets, because through centuries they do not visibly alter their positions, one with regard to another. The different groups or constellations still look the same to us as they did in the days of the patriarchs. The soft shining of the Pleiades and the armour of Orion we see just as Job saw them. The Great Bear has not appreciably altered in shape since the time of Julius Cæsar.

Even before learning the names of the constellations, you might become familiar with some of their shapes;

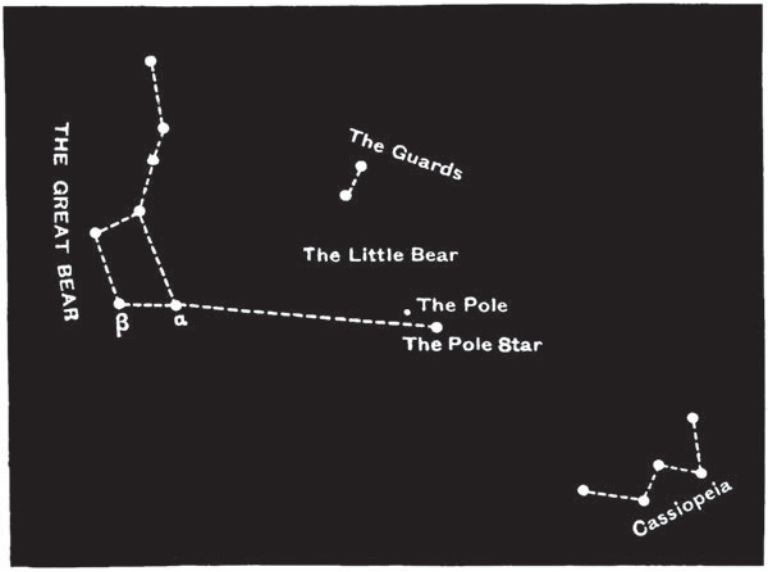
and then, with the help of a star-map, you could discover what they are called.

Or again, the map may be studied first, and afterward you can try to find out the constellations and the chief stars belonging to them.

Though we speak of star-*magnitudes*, which means star-*sizes*, no true star in the sky can show to us any difference of size. The only real difference lies in degrees of brightness. A star of the first magnitude does not mean a star which looks bigger, but only a star which looks brighter. The light of each star comes in a single slender ray of light, and the star itself is to us only a *point*—even in the most powerful of telescopes, still only a point! No telescope yet made has ever been able to show a *disc*—that is, a surface with any breadth—of any single star. The planets show discs, or a surface which can be measured, which has breadth—but the stars, never! They are too far distant.

One of the first to have pointed out to you should be the Pole-star, at the tip of the Little Bear's tail. The two pointers of the Great Bear point towards the Pole-star. And in the daily seeming whirl of the heavens that faint Pole-star, lying over our north pole, scarcely stirs, while the constellations near keep circling round and round the Pole-star, as seen by us in the northern hemisphere. But this circling is not real. It is due to Earth's own daily spinning on her axis.

So Cæsar claimed—



THE GREAT BEAR, POINTERS AND POLE-STAR

"But I am constant as the Northern Star,
Of whose true-fixed and resting quality
There is no fellow in the firmament."

SHAKESPEARE, *Julius Cæsar*

Among those northern circling groups may be found the beautiful star Capella, in the constellation of Auriga, one of the brightest in our sky. Another glorious star, farther off, is Arcturus in Boötes. Others among the brightest are Vega and Aldebaran.

But the most radiant in the whole heavens is Sirius; and this distant sun can only be seen by us in winter months. When once you have found the magnificent constellation of Orion—also a winter constellation to us

in the north—you will find Sirius with ease, because the two feet-stars of Orion point in almost a straight line to that brilliant star, with his gleaming diamond sparkle.

On the other side of Sirius may be seen the soft shimmer of the Pleiades, many dim stars which look as if they were close together, and of which not many people, at least in our English climate, can often make out more than six or seven. Not far off is another bright star, Aldebaran.[1]

The word "constellation" is from two Latin words which mean "star" and "together," or "connection." So the strict sense seems to be "a group of stars connected together." How far such stars really are connected is another question. Sometimes undoubtedly they are, but not always, and not necessarily.

This grouping of stars into definite constellations, with names, belongs to a very early period in the world's history.

"Down steps Orion to the west,
High-headed, starry-eyed,
Watchful beneath his warrior-crest,
His sword upon his side.

"Amid the unnumbered stars of night
He fills his measured space,
And covers under points of light
The fashion of his face.

[1]In such studies of the heavens, great help may be obtained from a volume of star-maps, *Half-Hours with the Stars*, by R.A. Proctor. Their positions at different times and different hours are clearly given, with directions how to use the maps.

STUDYING THE HEAVENS

"He makes no gesture, gives no sign;
Yon form is all we know.
So belt and scabbard used to shine
Millions of years ago.

"Upon his brow endures no frown,
No tumult stirs his breast;
In martial stride he still goes down
With all his stars at rest.

"When Earth was young and Night was old,
That harness he put on,
And girt for war, with nails of gold,
The belted warrior shone."

Laurence Housman,
The Heart of Peace and Other Poems

III

SOME OTHER WORLDS

The planets which belong to our Solar System—that is, to the Family of our Sun—are far nearer to us than any of the stars. So much so, that they can easily be seen to move onward in the course of weeks and months. Really to move, I mean; not merely to seem as if they moved because we ourselves move. They journey round and round the Sun, just as our Earth journeys round and round him. And as they travel, they appear to us to wander in and out, to and fro, among the so-called "fixed stars."

Actually, they do nothing of the kind. What happens is that, in their onward movements, we see them *against* one star-group after another in the sky. It is much the same as if you stood on the beach, watching a small boat some little distance out. You would see it against one far-off ship after another, as it passed along; and this would not mean that the boat ever went near those ships, but only that you happen to see the two in the same "line of sight," though they might be separated by many miles of water.

Again, no stars are truly "fixed," though by reason

of their enormous distance they seem to us to be so, keeping their constellation-shapes unchanged through centuries.

Most easily found and most easily "kept" of all the planets is Venus, the lovely "Evening Star" of some months in the year, and quite as truly the "Morning Star" of other months. Venus is not a star at all, but a planet or world, much the same in size as this world on which we live. No other planet and no star in all the sky shines with such a lustre as Venus at her best; not because she is larger or brighter than all other heavenly bodies, but because she is better placed for our powers of sight.

Once get this beautiful orb pointed out to you, and you may enjoy her soft resplendence evening after evening, or morning after morning, weather permitting. She is never very far away from the Sun, being nearer to him than we are ourselves. You will always find her, when she is visible, either in the western sky soon after sunset, or else in the eastern sky a little while before sunrise.

Mercury may be seen in the same manner; but as this small world is still closer to the Sun than Venus, he is much oftener lost in the Sun's radiance. At the best of times he is less easy to find, because he is so small, and also because he rises such a short time before the Sun, and sets such a short time after him.

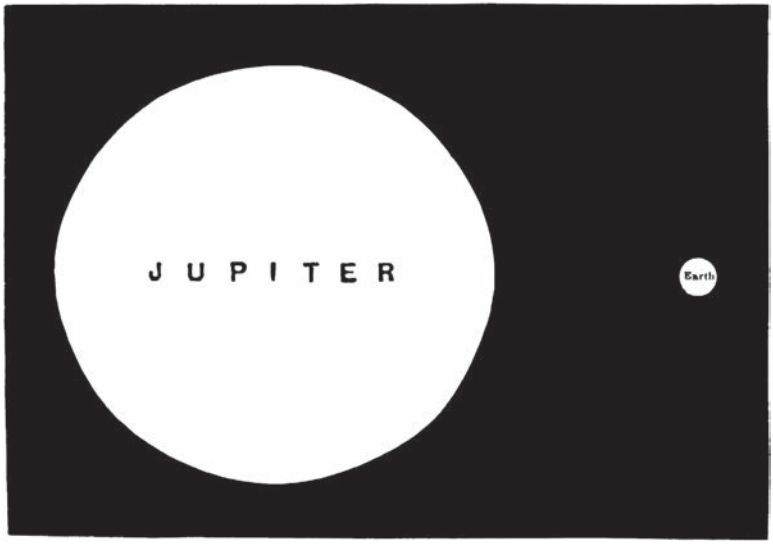
Next to Venus in brightness, as seen by us, comes Jupiter, often a most beautiful sight. When you notice a particularly bright body, not twinkling like a star, but shining with a strong and steadfast light, in a part of

the sky where Venus cannot be because it is too distant from the rising or setting sun, you may feel pretty sure that you are gazing on Jupiter.

The pathway of Jupiter round the sun, unlike that of Venus, is a great deal farther away than our own. You should go to an almanac for news as to his whereabouts in any special month, since he can be seen in many parts of the sky, though, as said above, he may often be recognised simply by his brilliance. And when you have found him, you may follow his movements too by night, for a good while if the weather permits.

Mars also may be seen in various parts of the sky; for the pathway of Mars, like that of Jupiter, lies outside the pathway of Earth.

Quite a small world is this interesting little globe, much smaller than Earth, though not so small as



COMPARATIVE SIZES OF JUPITER AND EARTH

Mercury. He is one of our nearest celestial friends, while Jupiter—decisively the biggest member of the Sun's family—lies far away.

Saturn, the next in size after Jupiter, a most lovely and marvellous world, is so very distant, and in consequence is often so very dim, that he may be less easily found by a beginner. The two outer planets, Uranus and Neptune, can only be seen with the help of a telescope.

Of all these brother and sister worlds, none perhaps has awakened keener interest with people generally than Mars. At one time much popular talk went on about the possibilities of intercourse with Martian people—supposing that any such people exist. "Flag-wagging" had even been suggested as a mode of interchanging ideas—till one authority stated that a flag, to be seen there, would have to be about the size of Ireland!

Part III

The Silver Moon

I

OUR PLACID COMPANION

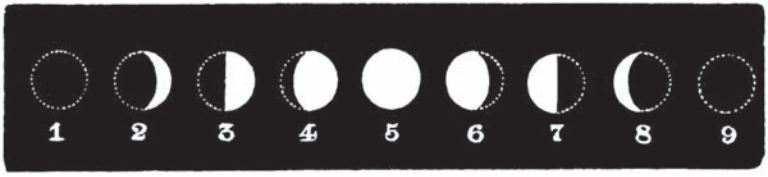
All the world knows her, round-faced and calm, serene and distant, yet faithful in comradeship. She never wanders very far away. She never seeks another fellow-traveller.

We may count securely upon her, for she is regular in her habits, and is sure to be in those parts of our sky where she is expected by those who understand her ways. If at such times we fail to see her, that is the result of earthly mists which rise between; not *her* fault.

To be sure, she does not shine at one and the same hour upon all parts of this round globe. Manifestly, it would be impossible. When she is on one side of the solid Earth, she cannot be on the other side also. And when she happens to be in the same part of the sky as the Sun, her light is smothered by his greater radiance. But still she goes on, travelling around and with her big companion, keeping always over a certain belt of Earth's surface, within a definite distance north or south of the equator.

And if she is sometimes large and bright, and

sometimes only a narrow sickle of light, that, again, is not her fault. She cannot shine except on the side which is turned towards the Sun and reflects his brightness, since she has no light whatever of her own. If that side which faces the Sun is turned partly away from Earth, we see only a portion of it—half-Moon, or quarter-Moon, or a mere slender bow, as the case may be. And when it is turned wholly away, as at New Moon, we see nothing of her.



PHASES OF THE MOON

These changes are called "phases," and perhaps you know Jean Ingelow's lines, as supposed to be spoken by a child of seven—

"O Moon, in the night I have seen you sailing
And shining, so round and low;
You were bright, ah, bright; but your light is failing—
You are nothing now but a bow.

"You Moon, have you done something wrong in Heaven,
That God has hidden your face?
I hope, if you have, you will soon be forgiven,
And shine again in your place."

For a little child now, as for a grown man of ancient days with complete ignorance of astronomy, no reasons exist, or did exist, *why* the round Moon should thus alter her shape, week after week, month after month.

Have you ever seen a piece of magnesium-wire set alight in a dark room? If so, you may have noticed two things—first, the dazzling brilliance of the burning wire; second, the lesser brightness of all around, including people's faces. That burning wire shone, as the sun shines, by its own radiant light. But the faces and walls and ceiling shone as the moon shines, by a reflection of the light given to them.

Half of the Moon shines always in the blaze of sunlight poured upon it; but not the whole of that half can always be seen by us; and this, as already said, is why we see often a mere crescent of light; not because the Moon has a less bright face than usually, but because most of that face is turned away, so that we only catch a glimpse of one edge of its brightness.

Still, we must remember that all the while the whole round Moon is *there*, a solid globe, half-bright, half-dark.

A friend[2] once sent to me a Christmas card, and wrote with it: "Two stars, actually, *in* the Moon! Times can't be improving, as we are so fond of imagining; for Coleridge only spoke of '*one* bright star' within the horned Moon's nether tip; and now, in 1884, some one was found capable of putting *two* stars in the Moon!"

The artist who designed the said card, having sketched a crescent-moon in the sky, proceeded to place a couple of stars *inside the crescent*. He utterly forgot that the crescent-shape is filled with the solid dark body of the Moon. A star might lie just in that direction, far,

[2]Lady Huggins, wife of the great spectroscopist.

far away beyond the Moon, but no one on Earth could see it, because the Moon would lie between. *And no star in all the Universe ever comes between the Moon and the Earth.*

Occasionally we can see for ourselves that the dark body is there. It only happens now and then, but it does happen. The bright Moon-face, lit up by the Sun, is chiefly turned away, so that we have no more than a sickle of light. But the dark Moon-face, which is towards us, catches a gleam from the shining of our Earth. Then we can see faintly the dark body of the Moon inside the bright crescent, and we call it "the Old Moon in the arms of the New." But the New Moon and the Old Moon are the same Moon.

Perhaps the idea of our Earth shining may be new to you. Yet she does shine. She is just as much a "heavenly body" as the Moon is, and as any planet is. Like them, she shines by borrowed light, reflected from the Sun.

If we could see our dull old Earth, as she sometimes, may be seen from Venus, for example, we should be amazed at her radiant beauty. We should not wonder then that the Moon can sometimes borrow some of our brightness.

In her night-journey, as she seems to travel across the sky, she comes between the stars and us, blotting out one star after another. At the time of full-moon very few can be visible in her near neighbourhood, because of her shining. But when she becomes a mere sickle of

light, something else can be observed, which proves the actual presence of the dark body.

Watch carefully for a bright star disappearing behind that outer shining Moon-edge. You will not see it when quite close to the rounded sickle-edge, but you may notice the Moon's drawing near, till it vanishes. Then you can watch for the reappearance of the same star on the other side—the inner side.

But you will not see it directly the sickle of light has passed. You will not detect it anywhere *within* the rim of brightness; for that rim holds the solid body of the Moon. And the star cannot appear again till the whole Moon, both the bright rim and the dark body, has passed by. Then it will once more be visible, not close to the crescent, but beyond the dark Moon-body.

Through countless ages the Moon has been *our* Moon. Not Jupiter's Moon, nor Mars' Moon, nor Saturn's Moon; but Earth's own particular possession. No world in the whole Solar System, so far as we know, gets any good out of the Moon except this Earth. She is not even the Sun's Moon, in any especial sense, beyond the fact that the Moon, like the Earth, is one of his planets, a very small one.

We often speak of Sun and Moon together, because for us the one is king of day, the other is queen of night. The Moon is to us what she can be to no other heavenly body in the Universe. But the Sun is to all his planets, in a greater or less degree, what he is to us. And though we could, so far as light and heat are concerned, manage to exist without the Moon, it is far otherwise with regard

to the Sun. Apart from him our world would speedily become one vast tomb of death.

Early in the last century a popular song was afloat offering a comparison between the two from an extremely Irish point of view. It began as follows—

"Och, long life to the Moon for a swate noble cratur,
That serves us for lamplight each night in the dark;
While the Sun only shines in the day, which by natur
Needs no light at all, as you all may remark.
But as for the Moon, sir, I will be bound, sir,
'Twould save the whole nation a great many pound, sir,
To subscribe for to light her up all the year round, sir!"

A difficult feat, this last, for even an Irishman to carry through; while if once that great luminary, the Sun, were blotted out, it would soon be seen how little brightness "day" could boast "by nature."

The Sun once gone, all warmth, all life, all growth, would be at an end, and the only light remaining would be that of the dim and twinkling stars. No Moon or planets would then be seen, no bright Venus or Jupiter could gladden our sky; for there would be no Sun to lend them of his brilliance. Even if certain of the planets have some faint power to shine of themselves, it would be too feeble a glimmer to benefit our Earth.

II

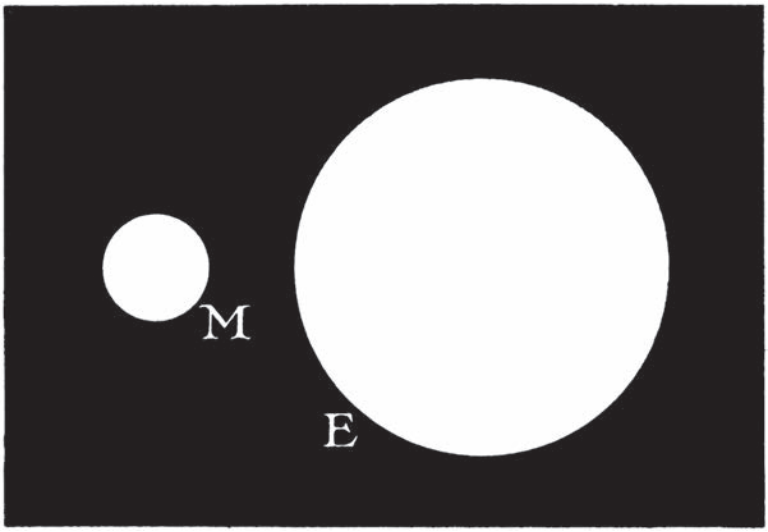
IN STRONG CONTRAST

THE Moon is a globe, in shape much like this world, but not nearly so large.

A piece of tape, just long enough to be passed straight through the Earth's centre, reaching from one side to the other, would serve to measure the Moon in two ways. One quarter of the tape might be passed in the same manner through the Moon's centre, the two ends just touching her opposite sides; and the remaining three-quarters could be folded round the Moon's equator, with the two ends meeting.

That gives some idea of the *comparative* sizes of the two. You might find a couple of balls, the *through-measure* of the one just serving for the two measurements of the other. Then you would see this comparison more clearly.

If you wanted to make out of several moons, each the size of our Moon, a single globe as large as the Earth, you would need for that purpose nearly fifty moons. But if, in the same way, you wished to make a globe as large as the Sun, you would need well over fifty millions of moons.



DIAMETER, 2163 MILES. DIAMETER, 7912 MILES.

COMPARATIVE SIZES OF EARTH AND MOON

Such a tape, just long enough to be passed through the Moon from side to side, would have to be two thousand miles long. But a tape which could be passed through the Sun, from side to side, would have to be nearly nine hundred thousand miles long! Rather a difference!

As a mere matter of guess-work, nobody would ever imagine, looking first at the one and then at the other, that the Sun is so huge compared with the Moon. And for ages in the world's history nobody did imagine it.

So long as the two were supposed to be just about the same distance away, it was impossible that their sizes could be known. Until telescopes were made, and many other astronomical instruments had been invented, until also countless improvements had come

about both in telescopes and in other instruments, the measurement of heavenly bodies was out of the question.

If the Sun really were, as used to be thought, just as near to us as the Moon, he would be an appalling object. Not alone from his colossal size, but because of the ocean of furious fiery gases which enfold his whole surface, and because of the fierce and whirling storms, the fearful heat, the scorching glare.

Could such an event come to pass, as that the Sun should approach to where the Moon now is, then at any instant vast tongues of glowing hydrogen gas—great crimson "flames" might leap from the Sun and enwrap our little Earth in their fervid embrace. Such mighty outbursts are no rare matter on the Sun, sometimes reaching to a height of more than three hundred thousand miles. And the Moon is only two hundred and forty thousand miles away from us.

But that the Earth should remain in her present position, moving still at her present speed, under such circumstances, would be impossible. So terrific would be the force of the Sun's attraction that, long before he could draw thus near, she would have leapt with lightning speed to greet him, and would have been lost in that fierce tumultuous sea of fire, as a pebble drops and is lost in the ocean.

While therefore we may be thankful for the light and heat bestowed upon us by the Sun—without which we could not live—we may also be thankful that he is placed at a safe distance. We may congratulate ourselves

that it is not the raging and storm-driven Sun, but the cold and quiet Moon which lies only a few thousands of miles away; even though the poet Tennyson did look upon her as a rather unsympathetic friend, when he wrote—

"Oh, a cold, cold glance hath the Lady Moon,
And a stately step, and slow,
As with queenly gaze, so proud and pure,
She looketh on all below.

"She pauseth not on her onward path,
To list to the mourner's sigh;
She pitieth not the throbbing pulse,
Nor the dim and sunken eye."

Still, if somewhat impassive, she is constant in her attachment. And it is better to depend on her steadfast shining than to have only the will-o'-the-wisp flash of a shooting-star, or the uncertain visits of a comet. We do at least know when we may expect her; and she never fails to arrive punctually to the minute.

It is fair, however, to add that Shakespeare did not, through the voice of one of his characters, allow her even the virtue of steadfastness—

"O swear not by the Moon, the unconstant Moon,
(That monthly changes in her circled orb)—
Lest that thy love prove likewise variable."

— Shakespeare, *Romeo and Juliet*

So though the Sun and Moon fill much the same space in our sky, this does not mean that they are the same in bulk. Far from it! The Sun is enormously the

larger of the two, and also he is immensely farther off. To the latter fact is due their seeming likeness in size. The very much greater distance lessens hugely his apparent not his real size. A man who is fifty or a hundred yards away may look to our sight much bigger than a house which is half-a-mile or a mile away, yet that does not make him as large as the house.

Our Moon's distance from us is not always exactly the same. She travels round in a pathway, or orbit, which may be described as slightly oval in shape, and the Earth is not at the precise centre of that oval.

In one part of her monthly tour she is more than twenty-six thousand miles nearer to Earth than in another part. The two hundred and forty thousand miles which—speaking roughly—separate her from Earth, though a good deal when compared with distances on Earth itself, form a very insignificant little gap when compared with the wider heavenly distances which separate star from star.