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ASTRONOMY AS A RECREATION

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ASTRONOMY AS A RECREATION*

By Joseph Pope

"ASTRONOMY as a recreation." I think I hear someone say: "This man must be an unconscious humorist! Astronomy is, no doubt, a very elevating and noble pursuit. But is it not, at the same time, one calling for the exercise of the highest intellectual faculties? Does it not demand, in addition to long years of profound study, immense constancy, patience and perseverance, laborious days, sleepless nights and an utter abnegation of all mundane pleasures, to enable one to qualify as an astronomer? And, we are told forsooth, that this abstruse and all-engrossing study may be viewed as a pastime! Surely the title of this paper is a contradiction in terms."

Upon this point the testimony is overwhelming. Every passing allusion to astronomy in the literature of the day — or of past days, for that matter — confirms the prevalent theory that, even in its simplest phase, it is quite beyond the comprehension of the ordinary mortal. That brilliant statesman and thinker,— perhaps, more brilliant as a thinker than as a statesman — Lord Rosebery, is credited with the observation that he would not advise any one to go in for amateur astronomy, that unless you are versed in mathematics, optics and half a dozen kindred sciences, you can never hope to make anything out of it,— which shows clearly to my mind that, on this occasion at any rate, Lord Rosebery has followed his own advice, a thing which, by the way, he does not always do. Now with all deference to the noble lord whom I have just quoted, and to the legion of those who, so far as they think on the subject at all, are disposed to agree with him, I unhesitatingly affirm that not only is astron-

* A paper, somewhat abridged, read before the Royal Astronomical Society at Toronto.

omy one of the loftiest and most ennobling subjects that can engage the human mind, (in which we are all agreed), but it is at the same time one of the most fascinating of intellectual pursuits. Moreover, it is the one science above all others that offers almost boundless interest to the amateur, with the least possible labor, inconvenience and expense. Suppose, for example, you are minded to go in for chemistry for a recreation. You have first to learn something of the nature of the substances with which you propose to experiment, otherwise you are very apt to poison yourself, or blow yourself up. You have to provide yourself with a laboratory, and lay out a certain amount of money on an equipment, before you can make a start. So also with geology. You have to master a huge number of technical terms, to take long tramps, to climb mountains, to break your back cracking stones on a hot day. So it is with almost any science you can name. Even gardening has its inconveniences. But from astronomy you can derive an enormous amount of pleasure and satisfaction without straying from your own doorstep. Your equipment is provided for you. All you have to do is to lift up your eyes, and draw upon your powers of observation and reflection to a very limited extent. I do not deny that a telescope adds greatly to the pleasure of the study, but its cost need not be great, with proper care it will last a life time, and in any case it is not indispensable. Let us begin without one.

And now you are placing yourself under the guidance of one whose acquaintance with the things of which he is going to speak is of the most elementary character; who is possessed of no technical knowledge of astronomy; who has long ago forgotten the little mathematics he learned when a boy; whose life has been spent in earning his living, in pursuits far removed from the stars; but who from a child has accustomed himself to lift up his eyes and behold the wonders of the heavens; whose ears have not been quite deaf to the music of the spheres; and whose artistic tastes not wholly indifferent to the masterpieces of creation. Do not be afraid of getting beyond your depth — I could not lead you there if I wished. Nor do I propose to say

anything that a child of tender years could not follow with perfect ease.

I suppose the least reflective person that ever lived, is conscious of the fact that day and night are due to the apparent movement of the sun. Day after day we see him — or can see him if we are so minded — rise in the east, mount the sky till he reaches due south, and then gradually descend to the western horizon, to reappear in the east next morning. It does not require any superhuman effort to perceive that the moon and the stars do the same thing, and thus the conviction is forced upon our minds, either that the world we live in is rotating once in twenty-four hours, or else that it is the centre about which the whole company of heaven is good enough to turn.

But that is not all. We are, perhaps, looking at the sunset, — it may be from the depths of an easy chair, enjoying a quiet cigar, after the labors of the day. Very shortly after the sun's disappearance, we note that charming spectacle, the crescent moon, "like to a silver bow new bent in heaven," and, quite near, perhaps, a gleaming star. The sight is so captivating that next evening we look for it again, but the combination is no longer there. The new moon has travelled far to the eastward, and appears quite a distance — about twenty-six times its own breadth — from the star. Night after night it backs farther and farther away, until in a month it has circled completely round the heavens, and shows up again in the western sky. Now this movement is obvious. It can be seen simply by using one's eyes. Nor does it involve any severe mental strain to deduce therefrom that there must be more motions above than one. It is plain that everything cannot be going round in one piece, as it were, for the moon, while sharing in the diurnal revolution, is manifestly moving among the stars on her own account.

These two phenomena, the apparent daily rotation of the firmament about the earth and the monthly sweep of the moon round the heavens, are gross, palpable facts, patent to any one

who takes the trouble to look at them.

If I have succeeded in interesting you so far, we may proceed to consider certain other motions in the sky, less rapid and conspicuous than those I have indicated, but still readily discernible.

Those who have given the matter the slightest thought, must have noticed that we do not see the same stars in the same place, at all seasons of the year. For example, the grand constellation of Orion that adorns our winter skies, is not always in the same part of the heavens at the same hour, and in summer is not visible at all. A little very ordinary observation will enable us to discern the reason for this.

If you look out at nine o'clock in the evening about the 1st of December, you will see the well known Orion rising in the eastern sky. At New Year at the same hour he is considerably farther up. By February he is at his highest point — due south. On the 1st of March he is well to the west, and in April he hangs over the west horizon. In May he is no longer visible, but in the following December you will see him rising as usual.

Each star rises about four minutes earlier every successive evening, and consequently sets earlier by the same amount of time, for the paths of these stars never change, they continually pursue the same courses. They never get off the track. Although for six months of the year we do not see Orion, yet Orion is always there. He is due south in our sky once every twenty-four hours, and if we mortals do not always see him, it is because of the sun which blots out his feeble light. The stars then are always slowly moving towards the west, or what is the same thing, the sun seems to be moving eastward to meet the stars. That is to say, apart from his diurnal motion, the sun is actually moving backwards among the stars from west to east, just as we saw that the moon does, only with this difference. The moon goes completely round the heavens once a month, while the sun takes a year to complete his circuit. His motion, therefore, being slower, is less conspicuous. Moreover, we can readily mark the moon's eastward path by referring her to the stars which lie near her course. No such plan is directly possible

with the sun, because we cannot see the stars lying near him. But if we watch the first stars that glimmer in the western sky after sunset, we shall find that evening after evening they sink lower and lower until they disappear from sight, having apparently fallen into the grave of that luminary, while fresh constellations which have risen in the east, and passed the meridian, are ever following in the same downward path.

There is still more to note about the habits of that wonderful luminary, the sun. At the present time of year (December) the sun rises in the southeast, traverses a small arc in the sky and sets in the southwest. On the 21st December he rises at his most southeasterly point and sets at his most southwesterly — and hence is above the horizon the shortest time possible. Every successive day thereafter he rises a little nearer to the east point — backs away from the south, as it were — traverses a wider arc in the sky, and sets a little nearer to the west point until on the 21st March he rises due east, and sets due west, and the days and nights are equal. Still backing, he rises each day farther north, until the 21st June, which is the longest day. He then begins to retrace his steps, rising nearer and nearer to the east each morning, until on the 23rd September he rises due east and sets due west, and the days and nights are again equal. Continuing his wintry flight, he finally reaches his southern limit on the 21st December, and like Goethe's star, "without haste and without rest," begins anew his progress towards the north. If you mark the places of his rising and setting by referring to an object on the sky line — a house, a tree, or anything of that sort — you can observe these motions with the greatest ease.

I hope I do not bore you, for I have not yet exhausted the motions visible above. I have spoken of the sun, moon and stars, but in addition there are five bodies, which though commonly classed with the stars, differ essentially therefrom in that they move on their own account. They are called planets, from a Greek word meaning "wanderers." The stars never change their relative positions towards each other. Century after century, age after age, they form exactly the same groups in the

sky. As the ancient Egyptians beheld them in the beginning of history ; as they shone down on Abraham in far off Mesopotamia four thousand years ago — so do they appear to us to night. The planets on the contrary, are perpetually shifting their places — now apparently drawing near the sun — now receding from him — now moving in one direction, then stopping and backing up for a while, only to resume their original course, yet always keeping within a narrow belt in the sky.

These planets are Mercury, Venus, Mars, Jupiter and Saturn, but space will not allow a detailed description of their motions.

Let me here briefly recapitulate what our unaided observation shows us ;—

1. We have seen that the vault of heaven apparently turns round on itself, once every twenty-four hours.

2. That the moon, while sharing in this general rotation, circles about the earth from west to east once a month.

3. That the sun apparently makes the same circuit, only instead of performing the journey in a month, it takes him a year — in the course of which he oscillates north and south through an arc of about forty-seven degrees with undeviating regularity.

4. Lastly, that there are five stars lying near his track and that of the moon, which behave in an extraordinary fashion — advancing, retreating, standing still, but which on the whole travel round the sun at varying intervals running from 88 days in the case of the closest and most nimble, to well nigh 30 years, in the case of the farthest and least active. These then are the phenomena which presented themselves to the gaze of the ancient observers of the sky, and sorely must they have perplexed them. Their first attempt at a solution of the diurnal turning of the heavens was that the earth stood unmovable in the centre of the universe — that all we see above was fixed in a crystal sphere which revolved daily about the world.

I have not time, nor, I fear, the requisite knowledge to

explain in any detail the cumbrous machinery whereby the ancients sought to reconcile these various motions with the immovability of the earth.

Once the true position of the sun was recognized, the wayward motions of the planets in our skies became clear. On the assumption of an immovable earth they were well nigh inexplicable; but start the earth moving round the sun with the other planets, and the mystery is solved. What seemed intricate and involved beyond measure, becomes simplicity itself. Here is a striking illustration of the truth of the observation that everything depends on the point of view. The movements of Mars or any other planet as seen from this earth at rest, are, indeed, a puzzle. But when we come to realize that we are moving also — that both of us are circling about a common centre — then it becomes at once apparent that the convolutions of the planets are only partly real — that they are a combination of our own motion with theirs. Could we stand on the sun, in the centre of our system, and view the planets circling about us, all these complexities would disappear, and we should see the several planets holding their majestic courses through space with the most perfect simplicity and regularity.

I have briefly referred to the principal motions of the heavenly bodies that are apparent to our eyes. You know now that when the heavenly bodies appear to rise and set daily, it is not *they* that are turning — it is the earth on which we stand that is rotating once every 24 hours. When, with an independent movement, the stars appear to be forever disappearing in the west, it merely means that the earth is travlling round the sun, and thus presents to our view, in the hours of darkness, different portions of the heavens at different seasons — exposing the whole panorama in the course of a year. Once a month the moon travels round the earth, presenting different phases, because the sunlight is falling on her at different angles. The to-and-fro motion of the sun north and south of the east and west points,

is simply due to the inclination of the axis of the earth, which causes the north pole to bend alternately toward and away from the sun. Surely the ability to read these pages of the book of nature, should fill us with a genuine satisfaction.

"Well, suppose it does," I think I hear some one say, "that is not quite the same thing as *recreation* — where does the purely recreative part of astronomy come in."

I had not forgotten the lighter aspect of the science, but before touching upon it I judged it desirable to make a general review of the celestial mechanism. Having done this, I will now proceed to show how it is possible to spend many a delightful hour in exploring the mysteries of the skies.

For this a telescope is necessary. Now a telescope to the uninitiated is apt to suggest a costly instrument with a correspondingly expensive equipment — an observatory with its revolving dome and all sorts of complex contrivances. But this is another of the many fallacies which obscure the pursuit of astronomy. The very slightest optical aid proves of immense assistance in the study of the skies. An opera glass will disclose wonders. A telescope, having an object glass of two inches in diameter, will, of course, show much more — while a three-inch glass will prove a veritable mine of pleasure. Such a telescope requires no elaborate equipment. You can tuck it under one arm, and carry it and its stand along with you till you find a suitable spot for observing — as far removed as possible from the glare of electric lights and the tremor of passing trains or street cars. For $75 one can obtain an excellent glass, and often one can be picked up for half the money. I once had a good glass which I purchased second-hand for $30.

Now just one word as to the mechanism of a telescope. The principal feature is the glass at the far end, called the object glass. When we speak of a two or a three-inch glass, we mean that the breadth of this glass is two or three inches from rim to rim. It costs more than the other parts of the instrument put together, and upon its quality the excellence of the instrument mainly depends. Let me, in passing, urge you never to wipe

this glass if you can possibly help it. The cumulative effect of wiping or rubbing can be seen by holding up an old pair of spectacles to the light. Better far a little dust, than those unsightly scratches every one of which means so much loss of light. The function of this glass is to form an image of the objects to which it is directed, and the eye-piece, which is really a microscope, magnifies this image before it enters the observer's eye. These eye-pieces are not expensive and can be slipped in and out of the telescope with great facility. A good telescope is supposed to bear a magnifying power of 100 to every inch of the object glass, but this presupposes perfect conditions of both glass and atmosphere. It is a mere theoretical perfection, and in practice few glasses will be found to bear with advantage more than half that power.

Let us now suppose ourselves the happy possessor of a good 3-inch glass, fitted with four eye-pieces, magnifying say 40, 80, 110 and 200 diameters respectively. We adjust the 110-power eye-piece and point our telescope to the new moon, remembering that it is the property of an astronomical telescope to invert the object, so that north appears south, and south north. Inasmuch, however, as the heavenly bodies are globular in form, the inversion, so long as we remember it, is of no practical disadvantage.

It is difficult for one who looks for the first time through such a telescope as I have described, to repress a cry of wonder and delight as his eye is suddenly illuminated with the charming spectacle which meets his gaze. The marvellous brightness of the golden sickle of the new moon; the clear cut form of the mountains, craters and valleys that lie before him; the startling contrast afforded by the shadows flung across the brilliantly lit plains, fill him with astonishment, while the thought that he is actually looking upon scenes in another world — all these combine to impart a feeling of unmixed pleasure. The sight, of course, can be varied by changing the eye-pieces. The low power of 40 will enable the observer to view the moon as a whole — that is to say to include it all within the field of view — while

200 may be employed on exceptionally fine nights to study the formation of some individual plain or crater. With the growth of the crescent, new objects are continually carried into view as the sun rises upon them, and the march of the advancing light forms a most entrancing picture. One sees near the dividing line between the light and dark portions of the moon, bright touches of gold amid the surrounding gloom—these are the mountain tops catching and reflecting back the sunlight while their bases still lie in the shadow. Contrary to general expectation, full moon is the least attractive of the lunar sights, for the reason that the whole sphere is flooded with the sun's radiance—there is no light and shade—no shadows to be seen—everything is bathed in a silvery glow, and the picture becomes less enlivened with variety.

One of the most interesting of phenomena to the amateur astronomer is to observe occultations of stars by the moon. We have seen that our satellite travels round the sky once a month. This motion is fairly rapid—indeed the moon moves towards the east, a space equal to its apparent breadth every hour. It is inevitable, therefore, that she should frequently come between us and a star. Astronomers call this "occulting" the star, and these various occultations are all predicted beforehand and recorded in the Nautical Almanac. There are two forms of occultations. One when the star disappears behind the dark side of the new moon, the other when it is first covered by the moon's bright limb. The first is more often witnessed by amateurs, for the reason that it takes place at a more convenient time in the evening when the dark side of the new moon is the one advancing towards the east, and consequently is the side to overtake and extinguish the star. The reverse process takes place in the case of the waning moon seen in the small hours of the morning, for then the bright side leads the way. The way to watch an occultation is to find out from the Almanac when it is going to take place, hunt up the star with your telescope a few minutes before hand, and watch the dark (though generally visible) body of the moon encroaching upon it. Gradually it steals along,

ever drawing nearer and nearer, until suddenly out goes the little star. The instantaneous disappearance of an occulted star is one of the most interesting features of the phenomenon, and is a standard proof of the non-existence of an atmosphere on the moon. For, were our satellite surrounded with an envelope of air, it is manifest that the star would lose its light gradually (owing to the interposition between us and it of the lunar atmosphere) before it was actually blotted out of sight by the dark body of the moon. Instead of this, the star shines with its accustomed brightness right up to the last second, and disappears with startling suddenness, to reappear on the other side of the moon in a manner equally abrupt. The time of an occultation varies with circumstances. If the central portion of the moon comes square between us and the star, it takes about an hour, but the star may disappear behind the moon at any angle, or the moon may just graze it — sometimes escape it by a hair's breadth, in which case the phenomenon is known not as an occultation, but as a "close approach." I wish I could convey to you the sense of importance which invests an amateur when he has successfully observed the occultation of a star or planet by the moon. The 40-power eye-piece is commonly the best for occultations, as it enables you to view the whole of the advancing limb of the moon, as well as the intervening space between it and the star.

But we must pass on. Jupiter is, perhaps, the easiest of all planets for the amateur observer. There is a charm about him which no possessor of a telescope can resist. You turn your three-inch glass upon him with a power of 110, and a great white globe floats into view attended by four satellites of a golden hue.

The first thing that strikes you about Jupiter is his oblate form. He is quite perceptibly flattened at the poles and correspondingly bulged out at his equator. This is due to his swift rotation. Jupiter turns on his axis in 10 hours — about two-fifths of the time our earth takes to rotate, and as he is immensely larger than our globe, it follows that a point on his surface, par-

ticularly if near his equator, must move with great rapidity. Consequently the markings on his face seem to be perpetually shifting as the great planet turns round under our eyes.

Jupiter's disk is marked with certain horizontal bands commonly called "belts," which extend across the surface of the planet. In telescopes such as ours, these belts are usually of a dusky hue. They change in number and breadth from time to time, sometimes exhibiting curious and beautiful scalloped forms. One night will reveal a difference in this general aspect, owing to the swiftness with which Jupiter turns on its axis.

Undoubtedly, the most interesting of all the phenomena presented by Jupiter, are those connected with his satellites. These little moons are four in number, and their ceaseless changes of position invest them with a peculiar fascination. The innermost satellite revolves about Jupiter in 42½ hours, the second in 3½ days, the third in 7 days, and the fourth in 16½ days. To-night they may appear two on each side; to-morrow night, three on one side and one on the other, and so on. Sometimes one satellite may be behind the body of Jupiter while another is crossing his disk, that is, coming between us and him, in which event one frequently sees, not only the satellite, but also its shadow like a little black spot on the face of the planet. To see the tiny moon edge up close to its great primary, preparatory to disappearing behind its huge body, or to be projected on his face, is an absorbing pleasure. Perhaps, still more entertaining are the frequent eclipses which the satellites suffer by getting into Jupiter's shadow. The exact second of these eclipses, both as regards disappearance and reappearance, is predicted in the Nautical Almanac. Suppose, for instance, the third satellite is scheduled for eclipse at 16 minutes and 10 seconds past 9 o'clock p.m. You have your telescope ready, at say 9.15. You turn it on Jupiter. The third satellite is shining like a little golden bead. You are watching it closely. At 9.16 its appearance is unchanged. A few moments later, however, it begins to pale, and quickly is completely extinguished. The disappearance is not so startlingly sudden as the occultation of a star by the moon,

for the little satellite, being a body of considerable size, takes a certain time to roll into the shadow ; still it is very rapid, not taking more than a few seconds.

Again, supposing the Almanac says that the second satellite will re-appear on the left side of Jupiter at 10.27 p.m. You have a friend with you, and have been showing him Jupiter, who is riding high in the sky, accompanied by three of his moons. Number 3 on the left, numbers 1 and 4 on the right — so your friend, who has his eye to the glass, tells you at 10h. 26m. 30s. You reply that he must be mistaken, that the configuration in the Almanac shows two moons on each side of Jupiter for to-night. He looks again, and lo, even as he gazes, a little moon gradually emerges from the darkness, and serenely takes up its position alongside of number 3, as though nothing had happened. All this occurs 450 millions of miles away, yet the godlike intelligence of man has bridged this vast gulf, and predicts with unerring accuracy what is going to happen in these distant worlds. And without any trouble or inconvenience on our part, we are permitted to enjoy this spectacle at our ease. Am I not right in calling this "recreation?"

Before tearing ourselves away from this most attractive planet I may just say one word as to the much debated question of the visibility of Jupiter's moons to the naked eye. It has been alleged that individuals gifted with rarely acute vision have detected one or more of these tiny objects. Thus, a German named Nernst asserted that he saw one satellite, and drew a diagram of its position — but when the telescope was applied, it was found that three satellites had approached very near one another, and their united brightness had caught the piercing eye of the observer. Miss Clerke tells the story of a Siberian who stated that he had seen "a bright star eat up four little stars and cast them up again," which exactly describes the eclipses, transits and occultations of these moons, as they would appear to the untutored eye of a savage. There is no doubt that the closeness of these little bodies to Jupiter is the main reason why, at any rate, the third satellite cannot be seen, for could it be viewed by

itself against the dark background of the sky, it is large enough to be readily visible to a keen eye. Whether it, or the whole four, have been detected in the bright light of the planet, is doubtful. For one cannot help asking the question how is it the ancients did not see them? There was no suspicion of their existing until Galileo pointed his telescope to Jupiter on the 7th January, 1610.

The most interesting planet to the telescopic observer after Jupiter, is Saturn. Saturn shines with a dull white light. Owing to its vast distance from us, it is by no means so bright as Jupiter, nor are its markings so distinct. Belts it has, but they are shadowy and ill-defined. Saturn has many moons, but only one conspicuously visible in a three inch telescope. It is called Titan, and is about the size of the planet Mars. Neither it or its fellows, even in the largest telescope, compare in interest with Jupiter's moons. This is owing partly to their deliberate movements, and partly to the inclination of the plane of their orbits to that of Saturn. Consequently they do not appear to come between us and their primary to anything like the extent as do the moons of Jupiter.

But what is lacking in Saturn's moons is amply made up for in the wonderful rings which encircle the planet.

There is a division in the main ring which shows like a narrow black line running round the entire length. It is said to be easily visible in a good 3-inch glass, but I never succeeded in seeing it with such an instrument.

The rings, however, show up perfectly well, except at intervals of 15 years, when, owing to the relative position which Saturn occupies to the earth at these periods, we see the rings edge on, which means we do not see them at all. Just now they are exceptionally well placed for observation, and there is this compensating advantage about Saturn, to make up for his immense distance from us, that for some reason, of which I am ignorant, he bears magnification better than any other planet. Where Jupiter will stand a power of 100, one can commonly use 150 on Saturn.

Mars is, perhaps, the next most interesting planet under the telescope, though occasions for viewing him with advantage do not often occur. Mars is the first planet outside the earth. We go round the sun in one year, Mars in 687 of our days. As we both go racing round, it is obvious that sometimes the earth catches up to Mars, and Mars, the earth and the sun are in a straight line, the earth being in the middle.

If the orbits of Mars and the earth were both circular, these two planets would come as near to each other as possible every 26 months. Unfortunately, while our path round the sun is nearly a circle, that of Mars is very distinctly oval, or more correctly, elliptical in form, so that sometimes when we are both in line with the sun, the interval separating our orbits is much greater than at other times. When the two planets happen to pass each other at the point where their orbits make the closest approach, which happens once in 15 years or thereabouts, Mars glows like a great red star in the heavens, but even then he is not particularly interesting in a 3-inch telescope. With a power of 110 one can see white patches at his poles, which are supposed to be snow, and certain of the bolder markings are just visible. The famous canals are quite beyond anything but the largest instruments.

We come now to Venus, the beautiful evening star, which under certain circumstances approaches us more nearly than any other of the heavenly bodies, the moon only excepted. On these occasions she shows as a slender crescent. A moment's reflection will show why. Venus travels round the sun in an orbit interior to that of the earth. As she is a dark body shining only by reflected sunlight, it is manifest that she must undergo to us the phases of the moon. When she comes directly between us and the source of her illumination, that is the sun, she must have her dark side turned toward us, and consequently is invisible. As she moves onward in her course, she gradually turns her bright side towards us, and consequently shows first as a crescent, then as a semi-circle, and lastly with a full face, though we never see her full, for the reason that being then on the far

side of her orbit with the sun between us and her, she is lost in the solar brightness. It is when she is on our side of the sun, she shines best, the loss of illuminated surface being more than compensated for by her nearness of approach. It is, therefore, as a half moon or crescent that we propose to view her.

Now it must be confessed that like Mars, Venus is a disappointing object. This arises from her very beauty. She is so brilliant that we cannot detect any markings upon her. She appears to be perpetually swathed in cloud, so that after we have gratified our eyes by looking at this dazzling little miniature moon, there is really nothing more to see.

Mercury being a planet lying interior to us, of course puts on the same phases as Venus. Our telescope will show him on favorable occasions as a tiny crescent, but he is always near the sun and there is considerable difficulty in picking him up.

I have now gone over the principal sights of the solar system, but the telescope can show us much of interest lying in the vast beyond. Indeed, when one has grown familiar with the sights I have endeavored to describe, one naturally wishes to know what there is to be seen in the universe that stretches out on every side beyond the planetary worlds.

Now you can never expect to see the stars as you behold the planets. As regards the latter, we see their solid bodies, and in most cases we can reasonably infer that they consist of geographical divisions analogous to those of our own world. But with the stars it is quite different. They are so immensely distant that the most powerful telescope fails to disclose a real disc — they are merely points of light, and all the telescope can do is to magnify their brightness, without increasing their apparent size. Their great attractiveness consists in the fact that many of them are double, some triple, some even quadruple. Generally the main star is much brighter than its companions Occasionally, however, in the case of double stars the component parts are of almost equal size. Many of these double stars are plainly visible as such in a 3-inch telescope. To take a very

easy case. In the constellation of the Great Bear, the second star in the handle of the "dipper," known as *Mizar* has just above and almost touching it, a tiny star called *Alcor*. These form what is called a naked eye double — that is to say, the smaller star is visible to one of ordinarily good sight. With a 3-inch glass, *Mizar* shows as two bright stars, brilliantly contrasted in color, the larger being white and the smaller blue-green, while *Alcor* seems some distance away, and in the intervening distance are several faint stars. The lonely star called *Cor Caroli* some little distance below the first star in the handle of the dipper, is a wide double. One of the finest double stars in the whole heavens is Castor, the uppermost of the twins Castor and Pollux. A power of 110 is sufficient to separate its components, which are of almost equal size. The star called *Beta Cygni*, which forms the foot of the Cross lying under the bright star Vega, is, perhaps, the most beautiful of all the double stars. It is formed of two components, light yellow and deep blue, presenting a sharp contrast. This is an extremely easy object in a small telescope.

Speaking of Vega, there are two little stars towards the east, which form with Vega a small triangle, whereof Vega is the apex. Look at the northern of these two stars. An opera glass will divide it into two twinkling points. Now take the 3-inch telescope with a moderate power. Each of the two stars revealed by the opera glass appears double, and a tiny star is seen on one side of an imaginary line joining the two pairs.

And so I could go on indefinitely, but I fear I have trespassed on your patience as it is. Let me assure you that the whole heavens is a perfect mine of wonders, which declare the glory of God as nothing else vouchsafed to our mortal senses. A whole evening might be spent in contemplating — let us say the great nebula in Orion, which is, perhaps, the most stupendous work of Omnipotence of which we have knowledge. That sight is visible, though not, of course, in its full glory, in a 3-inch telescope.

I am very sensible of the fact that in the course of my remarks I have said many things that must have made astronomers present, stare and gasp. Astronomy is beyond all others an exact science, and I have not pretended to exactness. On the contrary there is hardly a statement I have made that does not require qualification. The paths of the planets are *not* in the same plane as that of the earth's orbit. Their orbits are *not* circular. The fixed stars do *not* maintain their relative distance towards each other—on the contrary, they are all in motion. My object, however, was to lay down a few general principles, and not to weary you with refinements. For the purpose of this evening's talk my statements are sufficiently accurate. It does not at all matter to our present purpose that 100,000 years ago the figure of the Great Bear was slightly different from what it will be 100,000 years hence, or that the orbit of Jupiter, instead of lying in the plane of the ecliptic, is inclined 1° 18′ 42″ thereto. When you all become so enamoured of the science as to set up for professional astronomers, you will, no doubt, discard my rough and ready methods, and revel in exactitudes in the most approved style.

Should any of you have been wearied by my attempts to translate into the phraseology of every day life, the language of the stars, I hope you will impute the fault to me, and not to this sublime study—so full of interest and beauty—which has numbered among its votaries so many of the best and brightest of mankind, and which, more than any other, lifts our minds from earth towards heaven.