Romance of the Moon

BY

MARY PROCTOR, F.R.A.S., F.R.Met.S.

(Daughter of the late Richard A. Proctor)

Author of "Evenings with the Stars," "Romance of Comets,"
"Romance of the Sun," "Legends of the Sun and Moon," Etc.

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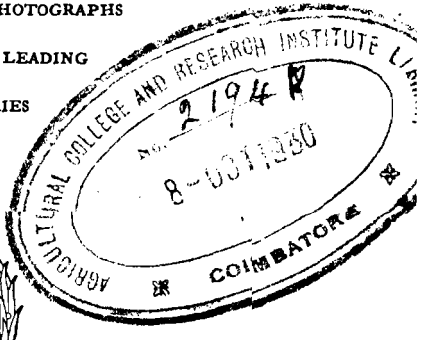

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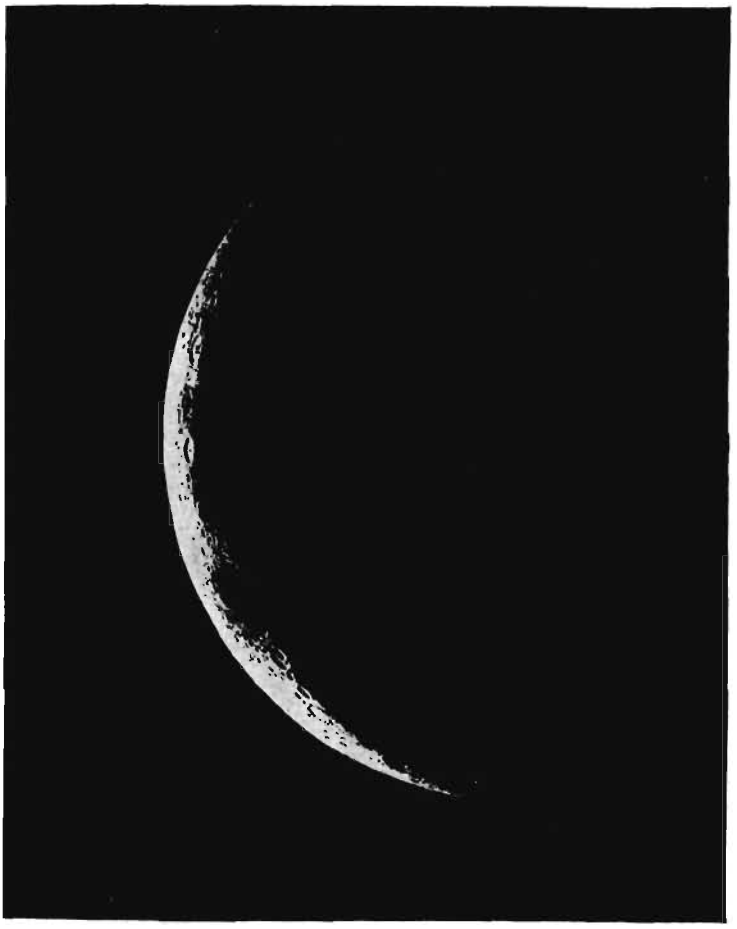
ROMANCE OF THE MOON



SUNRISE ON THE MOON

Photographed with twelve-inch refractor at
Yerkes Observatory, by R. J. Wallace

Dedicated

to

WALTER GOODACRE

F.R.A.S.

Past President of the British Astronomical Association. Director of the Section of the B. A. A. for the Observation of the Moon

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Illustrations

Preface

MANY books have been written about the Moon, mainly from the scientific standpoint, but although its romance may be obvious to the thoughtful reader, it is usually so involved in technicalities that for the uninitiated it is difficult to unravel the knotty problems. Yet the study of lunar markings, the aspect and scenery of the Moon, and the work of the tides appeals to all, artists, novelists, and poets vying with one another in doing justice to the theme. Thus, we have a blending of fiction and fact, though not on so fanciful a scale as suggested in the rocket to the Moon chapter, concerning the scientific facts of which Professor Goddard has so kindly supplied notes and illustrations.

The reader is invited to go for a ramble on the Moon, and lest he might be led astray, the well-known authority on lunar geography—*viz.*, Mr. Walter Goodacre—kindly looked over the manuscript, so as to ensure accuracy. For those who

wish to wander further afield into the highways and byways of *Moonland*, suggestions are made as to suitable books, notably Webb's *Celestial Objects for Common Telescopes* (sixth edition), containing a copy of Mr. Goodacre's enlarged map of the Moon. With the kind permission of the directors of the Yerkes and Mount Wilson Observatories, a few photographs of the Moon are used as illustrations, and an outline map of the Moon by the author, showing the position of places referred to in the manuscript. Professor R. H. Goddard kindly read the MS. of Chapter Seven, concerning his Moon-rocket theory, in connection with a method of reaching extreme altitudes.

MARY PROCTOR.

London, 1928.

ROMANCE OF THE MOON

CHAPTER I

THE MAGIC SPELL OF MOONLIGHT

". . . the moon
Rising in clouded majesty, at length
Apparent queen, unveil'd her peerless light
And o'er the dark her silver mantle threw."

—PARADISE LOST, Book iv.

IN OUR day, when we live so much by artificial illumination, we seldom revel in the transformation scenes which take place under the magic spell of moonlight. To appreciate fully the mysterious glamour which it casts over the scene, concealing harsh outlines crude in the glare of sunlight, one should make the journey across some desolate region, such as part of the route along the Santa Fé trail. Here one sees for miles, and for hours at a time, during the daytime, nothing but an ocean of sand girdled with the sky, and diversified only with occasional masses of scrub and cacti. Overhead the deep-blue cloudless sky forms a far-reaching canopy on which the Sun blazes in all its splendour, and is pitiless in the

dispensation of its heat. One longs for the evening, and the hour of sunset, when—if it be the time of Full Moon—the Queen of Night will weave her magic spell by illuminating the scene with her light.

Beneath its enchanting spell the far-reaching ocean of sand becomes a silver plain, and if perchance we are approaching the mountainous region of Arizona, we may see lofty pinnacles tipped with moonlight forming a sharp contrast to the rugged outlines of cliffs and shelving masses of rock leading down to the plain below, and still in shadow. A light seen twinkling here and there from a miner's hut on the hillside is the only sign of life, or the occasional sound of the mournful cry of a coyote. Otherwise stillness pervades this moonlit scene, save for the monotonous whirr of the engine as we rush onward to our destination. It is at such times that one not only revels in the beauty of moonlight, but appreciates its value and beneficial effects to the shepherds of old and tillers of the soil, who, according to all traditions, were to be found among the first watchers of the sky. For instance, the Moon's motions must have been de-

tected in very early times by the Chaldean shepherds, who—

> "Watched from the centres of their sleeping flocks,
> Those radiant Mercuries, that seemed to move,
> Carrying through Ether in perpetual round
> Decrees and resolutions of the gods."

It was this motion of the Moon, this apparent *power* in her to shift her position, so as to view our Earth from new standpoints, which doubtless suggested to the ancients the idea of worshipping her as a deity.

Moonlight and its various phases must have been of extreme importance to the shepherd watching his herds and flocks by night. We can understand how carefully he would note the change from the New Moon to the full throughout the whole month, or at least during the hours when moonlight illuminated the hills and valleys over which his watch extended, and thence to the time when the sickle of the fast-waning Moon shone for a while before dawn. To him, naturally, the lunar month, and its subdivision—the week—would be the chief measurer of time. He could not help observing the passage of the Moon along the ecliptic outlined by the signs of the zodiac in a

band some twenty moon-breadths wide, which marks the lunar roadway among the stars. His attention must also have been attracted by certain bright stars along the track, shining like beacon lights indicating the path where the Moon apparently travels. Their names are Arietis, Aldebaran, Pollux, Regulus, Spica, Antares, Altair, Fomalhaut, and Markab in the Square of Pegasus. These stars are used for determining longitude at sea, hence they are called *nautical stars*, and their true places for every day in the year are given in the *Nautical Almanac*.

"That a man," says Sir John Herschel, "by merely measuring the Moon's apparent distance from a star, with a little portable instrument held in his hand and applied to his eye, even with so unstable a footing as the deck of a ship, shall say positively within five miles, where he is on a boundless ocean, cannot but appear to persons ignorant of physical astronomy, an approach to the miraculous, and yet, the alternatives of life and death, wealth and ruin, are daily and hourly staked, with perfect confidence, on these marvelous calculations." The determination of the position of the moon with regard to the stars is equiva-

lent to a celestial Greenwich clock of which the stupendous dial is formed by the face of the heavens. The numbers engraved on the face of the clock are represented by the bright stars, while the hand moving over the dial is the Moon itself. By measuring the distance of the Moon from a neighbouring star, the captain of a ship can test his chronometer. For example, he may see that the Moon is so many degrees from the star Aldebaran, and referring to the *Nautical Almanac* he finds the Greenwich time for the date showing when the Moon is at this distance from that star. Comparing this with the indications of the chronometer, he obtains the required correction. Thus he is enabled to determine the precise position which his ship then occupies. Otherwise, he would never be able to find his way across the trackless deep, though nowadays this method has now fallen into disuse, and wireless has greatly simplified matters. The establishment of the wireless service of Time signals now makes it possible for a ship to pick up Greenwich time when hundreds of miles at sea, or to compare chronometers when ships come within wireless range.

Observations of the path of the Moon among

the stars must have been the first made by man, before the time the present division of the zodiac was adopted. We learn that the old Chaldean astronomers (as well as the Indian, Persian, Egyptian, and Chinese astronomers, who still follow the practice) divided the zodiac into twenty-eight lunar mansions, each mansion corresponding to nearly one day's motion of the Moon, among the stars. Rough observations of moonlight and its changes from night to night first taught men the true nature of the Moon—*viz.*, that it was an opaque globe circling round the Earth and borrowing its light from the Sun. They must have perceived that the Moon was only full when it was opposite the Sun, shining at its highest in the south at midnight when the Sun was at its lowest beneath the northern horizon. Before the time of full Moon they saw that more or less of the lunar disc was illuminated as it was nearer or farther from the position opposite the Sun, the illuminated side being towards the west—that is, towards the Sun; while after Full Moon the same effect was perceived in the illuminated side facing the east—that is, towards the Sun. They could not fail to observe the horned

Moon sometimes in the daytime, with her horns turned directly from the Sun, showing plainly by her aspect whence her light was derived. The ancient Chaldean astronomers could have little doubt as to the accuracy of this explanation, obviously suggested by observed facts which one can verify by the simple experiment of a terrestrial ball illuminated by a lamp.

Place a lamp on the centre of a table, and after lighting it extinguish any other light in the room. Let this light represent that of the Sun, and a white ball such as a billiard ball will do for the Moon, while the observer's head will answer the purpose for the Earth. Hold out the ball at arm's length between the head and the lamp, and the ball appears as a dark globe, since the light from the lamp is illuminating the other side only, the darkened side being towards the observer. This corresponds to the phase known as New Moon. Turning slowly to the left, the observer will note the outline of a silver crescent on the ball gradually increasing until Half Moon, or First Quarter stage is reached. As the path of the Moon is tilted five degrees to that of the Earth, the ball must be gradually raised so that

by the time it reaches the phase representing Full Moon, the light from the lamp will be shining over the top of the observer's head, full upon the ball. This explains why the Full Moon is seen shining in the sky, by observers standing on the darkened hemisphere of the Earth below.

The observer continues turning, finding all the phases reversed in, turn through the gibbous (humped or convex appearance of the illuminated portions of the Moon, when within a week of the Full), the Half Moon representing the Last Quarter; then a slender crescent is seen, and finally the New Moon phase.

It has been thought by some that in the beginning the Moon was always opposite the Sun, thus ever ruling the night, as Milton interpreted the account given in the Book of Genesis, when he says:

"Less bright the Moon,
But opposite in levell'd west was set
His mirror, with full face, borrowing her light
From him; for other light she needed none
In that aspect; and still that distance keeps
Till night, then in the east her turn she shines,
Revolv'd on heav'ns great axle."

It was only as a consequence of Adam's transgressions that Milton conceives the idea that the angels sought to punish the human race by altering the movements of the celestial bodies.

But the occurrence of eclipses must soon have shown the simple explanation of the phases of the Moon, as proof that she shines only with borrowed splendour from the Sun. They could hardly fail to infer that these darkenings of the Moon were caused by the Earth's shadow, near which the Moon must always pass when at the Full Moon phase, and through which she must pass at the time of eclipse. Solar eclipses, which are caused by the Moon coming between the Sun and the Earth, were probably observed later, for, though a total eclipse of the Sun is a much more striking phenomenon than a total eclipse of the Moon, yet the latter are far more common. A partial eclipse of the Sun may readily pass unnoticed, unless the Sun's rays are so softened by haze and mist that it is possible to look at the solar disc without straining the eyes. Whenever solar eclipses came to be noted, and we know from Chaldean discovery of the great eclipse period, called the Saros (a lunar cycle of 18 years, 11⅓

days), that they were observed at least two thousand years before the Christian era, the fact that the Moon is an opaque body circling round the Earth, and much nearer to the Earth than is the Sun, must be regarded as made evident. It must also have been made clear not only that an eclipse of the Sun happened when the dark globe of the Moon came between the Sun and the Earth, but that at the time of the total eclipse of the Sun the round black body of the Moon hiding the light of the Sun entirely from view would prove that the Moon possessed no light of its own, and likewise that in size it was apparently equal to the Sun. As a matter of fact, its diameter is about four hundred times smaller, but the Moon comes four hundred times nearer. Then, and then only, can we observe a total eclipse of the Sun.

To primitive races, the Sun was naturally enough the supreme deity, and when the marvellous corona became visible at the time of a total eclipse, what more natural than to interpret the radiant extension which then completely envelops the solar orb, as the wings by which the Sun-god makes his way each day across the heavens.

Cylinders, seals, and tablets unearthed in Babylonia have given much quaint and valuable information on this point, and the "winged solar disc" found among the Assyrian and Egyptian monuments all point to the same conclusion, though in many instances their origin is so remote that archæologists can assign no date. Yet undoubtedly the long streamers of the solar corona might easily have conveyed the idea of wings to the childlike minds of people in the olden times, as an explanation of prehistoric eclipses. Winged solar globes form the chief decoration over doorways, the entrance to shrines as at Edfu, and over tombs in Egypt indicating that they were placed under the protection of the solar deity.

Not only is the diameter of the Moon 400 times smaller than the Sun, but, as we have already seen, it is but a quarter the size of the Earth. Nevertheless, it is of the utmost importance as giver of reflected light from the Sun, and in occupying the position of a satellite to the Earth, accompanying it in its annual journey around the Sun. The very beginning of astronomy seems to have originated in the study of its motions and in the different phenomena it causes, such as

eclipses and tides. Observations on successive evenings soon make it apparent that the Moon moves eastward among the stars each night, completing its revolution from star to star again in about 27¼ days. In other words, it revolves about the Earth in that time; or rather, they both revolve about their common centre of gravity.

Let us watch the progress of the Moon, as the Queen of Night, during the course of a month, as she seemingly glides from star to star. Some fine evening, when wandering by the seashore or taking a ramble along a country road, we happen to look westward, and suddenly our attention is arrested by a glimpse of a pale and slender silvery crescent in the west, just as the Sun is going down. It is the New Moon. Apparently she is attempting to keep up with the Earth, but in vain, for scarcely have we become aware of her pale face over the western horizon than she vanishes with the stars which seem to be her escort. Next evening we look for her, and there she is still, though somewhat larger—the bright side towards the Sun and westward, and her horns turned eastward. This time she is farther from the west than the

night before, but her escort of stars is some way behind her. They disappear below the horizon, but she does not follow till later. The next night the fickle Moon is accompanied by a new group of stellar attendants in her journey towards the east, until finally at the end of two weeks she has gained the victory by overtaking the Earth and reaching the eastern horizon, where we see her rising in beauty just as the Sun is sinking in the west. But still she pursues her unseen path below the eastern horizon. Later and later she rises each night, until at length we see her no more, except in the early morning at sunrise as a silver crescent. Even this fades and disappears, lost in the radiance of the Sun's light, till, a day or so later, on raising our eyes to the western sky we see the same pale silvery crescent in precisely the same position as we saw her at first. Since then she tells us mutely a month has rolled away.

But the average time of the Moon's journey, or retardation of its rising and setting, is subject to great variations, so that when it is very far north, for instance, it will rise much earlier than when it is farther south, though having the same

right ascension. This is specially noticeable at the time of the autumnal equinox, when the Full Moon will be near the first point of Aries, the portion of the ecliptic which makes a much smaller angle with the eastern horizon than the equator. When the Moon is in Aries, it seems to drift along the eastern horizon from night to night, its time of rising varying but little. When this occurs near the full of the Moon it gives rise to the phenomenon known as the Harvest Moon, being the Full Moon nearest to the autumnal equinox. It is so called from the assistance its illumination renders to harvesters. Thus, the Moon which comes to the "full" nearest to September 22nd or 23rd will rise night after night at the same time; the nights are lengthening, while the time the Moon is above the horizon is lengthening still more. If the moon is full after September 23rd, it is sometimes called the Hunter's Moon, and in almost every year there may be said to be a Harvest Moon and a Hunter's Moon. In Norway and Sweden, under these circumstances, the Moon's orbit may actually coincide with the horizon, so that it will rise at absolutely the same

time for a great number of evenings in succession.

With regard to the amount of light given by the Moon, which is due entirely to reflected sunlight, it would require 600,000 full moons shining at once to equal the splendour of the Sun. Look some morning at the Moon when it is visible in daylight, and compare it with the Sun-illuminated clouds. The brightness of the Moon and that of the clouds are alike, since it is the Sun which illuminates both. The light of the Moon is white, though at night when seen against the darkened sky it appears silvery in hue. Who has not watched with delight this brilliant orb emerging from behind a bank of dense cloud, seemingly floating across the "pure cerulean," a vision of beauty so eloquently described by James Thomson in the lines:

> . . . Meanwhile the Moon,
> Full-orb'd, and breaking through the scattered clouds,
> Shows her broad visage in the crimsoned east.
> Turned to the Sun direct, her spotted disk—
> Where mountains rise, umbrageous dales descend,
> And caverns deep, an optic tube descries,
> A smaller Earth—gives all his blaze again,
> Void of his flame, and sheds a softer day.

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Now through the passing cloud she seems to stop,
Now up the pure cerulean rides sublime.
Wide the pale deluge floats, and streaming mild
O'er the skied mountain to the shadowy vale,
While rocks and floods reflect the quivering gleam,
The whole air whitens with a boundless tide
Of silver radiance, trembling round the world.

CHAPTER II

THE STORY OF THE MOON

"Soon as the evening shades prevail
The moon takes up the wondrous tale,
And nightly to the listening earth
Repeats the story of her birth."
—ADDISON, *Ode to the Moon.*

LOOKING backward through the dim vistas of the past, we see the Moon at that early stage of its career when it formed part of the Earth. At that epoch, the Earth was a soft molten mass "without form and void" and spinning round rapidly in a period of three hours, the greatest speed possible without flying to pieces. By degrees the strain became so great that the Earth bulged at the equator, and something was bound to give way. Then the inevitable happened. A huge fragment of molten matter was flung forth from the parent globe, and, whirling round rapidly, formed into the smaller globe we call the Moon. Meanwhile it has pursued an independent career as satellite to our planet, which it accompanies in

its yearly journey around the Sun. That the Moon was once part of the Earth uncounted millions of years ago is the secret we have learned from the tides, and this has been interpreted by mathematicians skilled in working out such problems. Their interpretation has been the result of profound thought and study, but finally results were obtained revealing for the first time one of the most interesting chapters in the history of our planet. It is beyond the scope of this book to give the mathematical reasoning and explanation regarding the effect of the tide-generating forces due to the attraction of the Sun and Moon. Nevertheless, it is possible to give an outline of the story of the Moon in language that will make it intelligible to the reader who may not wish to go into the subject more deeply. For those who wish to pursue a study thereof, a full explanation will be found in Sir G. H. Darwin's book, *The Tides, and Kindred Phenomena in the Solar System.*

According to the scientific evidence which has been obtained within the past thirty years, the history of the Moon indicates that at an early period of its career it was composed of molten matter, this plastic material yielding gradually to tidal

influence. For a while, after its ejection from our planet, the Moon and the Earth were actually touching one another as though linked by invisible bonds. They were spinning round their common centre of gravity in a period of about 5 or 6 hours. During the vast period of time which has elapsed since the birth of the Moon, it has gradually been receding from the Earth, until by now its mean distance is 240,000 miles, equivalent to 30 times the diameter of our planet. This ever-widening gap is due to friction caused by the tides, which tend to check the speed with which the Earth is rotating. Masses of water held back by the Moon act as a brake in exerting a dragging effect. Though the delay caused by this means may be almost imperceptible, yet it is continuous, and as effective in its way as the constant dripping of water which eventually wears away a stone. During the millions of years dealt with in astronomical calculations, the tidal influences which are at work will lead ultimately to stupendous results.

At first, when the Moon went round the Earth in the same period as the Earth rotated on its axis, the day and the month were equal in length. Gradually the *month* has been lengthening, as

well as the day, and after vast periods of time have elapsed the day and the month will again be equal. When this last stage of equilibrium is reached, the Moon and the Earth will be revolving about one another in a period equal to 55 of our days, as they are at present. The two bodies will then rotate as though they were rigidly connected, ever facing one another. This may not occur until 150,000,000 years hence, but it will assuredly happen if the Earth survives long enough. It is true, the increase in the length of the day will have been gradual, possibly a gain of a second or so a century, so that a vast period must intervene before the length of the day and the month will have reached the critical epoch. Meanwhile, mankind will doubtless have become accustomed to the change.

When the time comes, 150,000,000 years hence, our remote posterity will have a night seven hundred hours long, and when the Sun rises in the morning they will have a day lasting 700 hours. How they will dispose of their time to the best advantage is a problem not easy to solve, yet we can picture them looking back on the record of our short periods of work, rest, and play with feelings

of mingled curiosity and wonder. Turning to the literature of our time and its history, they may marvel that so much was accomplished in so brief an interval.

The history of the Earth at present, according to the results obtained by mathematicians regarding the progress of tidal evolution, would seem to have arrived at a point midway between the period when the Moon started its career as a planet, and the final stage. This does not refer to an actual measurement in the number of years, for vast as is the period of time which has elapsed since the Moon was ejected from the Earth, they fall far short of that vast period of time which must intervene between the present moment and the hour when the next critical state of the history of the Earth-Moon system will occur. At that period the day will once more be equal to the month, just as it was at first, yet how wide a difference there will be between the beginning and the end. The length of the day or the month at the end will have exceeded these periods many hundreds of times, as compared with their duration at the beginning.

In his book, *The Time Machine*, H. G. Wells

has drawn an impressive picture of what it may be like on the Earth at that remote period:

> "At last a steady twilight brooded over the Earth, a twilight only broken now and then when a comet glared across the darkening sky. The band of light that had indicated the Sun had long since disappeared; for the Sun had ceased to set—it simply rose and fell in the west, and grew ever broader and more red. All trace of the Moon had vanished. The circling of the stars, growing slower and slower, had given place to creeping points of light. At last the Sun, red and very large, halted motionless upon the horizon, a vast dome glowing with a dull heat, and now and then suffering a momentary extinction. At one time it had glowed for a little while more brilliantly again, but it speedily reverted to its sullen red-heat. I perceived by this slowing down of its rising and setting that the work of the tidal drag was done. The Earth had come to rest with one face to the Sun, even as in our own time the Moon faces the Earth."

Some may ask, where are the proofs that tidal action will produce such changes that after vast periods of time the length of the day and the month will be equal. Why does the Moon always turn the same face to the Earth? It was Helmholtz who showed that this was the consequence of ancient tides, and his most simple and satisfactory explanation, demonstrated by mathematical reasoning, has been universally accepted. Much of the original theory of the tides was due to Lord Kelvin, but it was Sir George H. Darwin who pointed out that as the Moon is receding from us, it must, if we look far enough back into the remote past, have been once in actual contact with the Earth. It is to Darwin also that we owe many other parts of this fascinating theory, whether in its mathematical or in its astronomical aspect. In his book on *The Tides*, in which he makes his claim in support of the theory of tidal evolution, he links together all the various features of the Earth-Moon system, explaining not only why the Moon always turns the same face to the Earth, but other points that form the foundation of the doctrine of tidal evolution, such as the consideration of the fact that the Sun as well as the Moon

is a tide-producer on the Earth, though on a smaller scale, owing to its greater distance. According to his theory:

> "Although the solar tides cannot have had any perceptible influence upon the Earth's movement in its orbit, they will have affected the rotation of the Earth to a considerable extent. Let us imagine ourselves transported to the indefinite future, when the Moon's orbital period and the Earth's diurnal period shall both be prolonged to fifty-five of our present days. The lunar tide in the Earth will then be unchanging, just as the Earth tide in the Moon is now fixed; but the Earth will be rotating with reference to the Sun, and, if there are still oceans on the Earth, her rotation will be subject to retardation in consequence of the solar tidal friction. The day will then become longer than the month, whilst the Moon will at first continue to revolve round the Earth in 55 days. Lunar tides will now again be generated, but as the motion of the Earth will be very slow relatively to the Moon, the oscillations will

also be very slow and subject to little friction. But that friction will act in opposition to the solar tides, and the Earth's rotation will to some slight extent be assisted by the Moon. The Moon herself will slowly approach the Earth, moving with a shorter period, and must ultimately fall back into the Earth. We know that there are neither oceans or atmosphere on the Moon, but if there were such, the Moon would have been subject to solar tidal friction, and would now be rotating slower than she revolves." [1]

As kindred phenomena Darwin cites the case of the two little moons of Mars, discovered by Professor Asaph Hall, 1877, with the 26-inch telescope at the Washington (D. C.) Observatory. Here we see an object lesson of the future fate awaiting our planet, for not only was the discovery made that the planet was attended by two satellites, but that the nearer has a month shorter than the day on Mars. The presence of these satellites had hitherto been unsuspected, though when Galileo, in 1610, made known his discovery

[1] *The Tides, and Kindred Phenomena of the Solar System,* by G. H. Darwin, pp. 259-260.

of the four satellites of Jupiter, Kepler wrote as follows to one of his friends:

> "Such a fit of wonder seized me at a report which seemed to be so very absurd, and I was thrown into such agitation at seeing an old dispute between us" (referring to his friend Wachenfels) "decided in this way, that between his joy, and the laughter of both, confounded as we were by such a novelty, we were hardly capable; he, of speaking, or I, of listening. On our parting, I immediately began to think how there could be any addition to the number of the planets without overcrowding my 'Cosmographic Mystery,' according to which Euclid's five regular solids do not allow more than six planets round the sun. . . . I am so far from disbelieving the existence of the four circumjovial planets, that I long for a telescope, to anticipate you, if possible, in discovering *two* moons circling round Mars, as the proportion seems to require, *six* or *eight* round Saturn, and perhaps one each round Mercury and Venus."

Although the last two planets have not fulfilled his prediction, yet he came very near to facts in the case of Saturn, which has ten satellites, and great would have been his amazement could he have known that Jupiter also has nine; moreover, that there were two planets—*viz.*, Uranus with four moons, and the outermost planet, Neptune, with one lonely attendant discovered in 1846 by Lassell, these planets being unknown in his time. The diameter of the Neptunian satellite is estimated at 2,000 miles, nearly the size of our Moon, which is 2,160 miles, yet it is so faint that it is difficult to see. However, due allowance should be made for the fact that the planet Neptune is about 30 times as far from the Sun as we are, its distance being about 2,800,000,000 miles.

With regard to the moons of Mars, they are exceedingly small, and can be seen only with the most powerful telescopes. The outer one, Deimos, as estimated by Professor Pickering, has a diameter of less than 40 miles. It is at a distance of 14,600 miles from the centre of the planet, and has a period of 30 h 18 m—that is, 5 h 41 m hour longer than the day on Mars, which lasts, 24 h 37 m 22 s 67. Consequently, it rises in the east

like other stars, but its orbital eastward motion among the stars is so nearly equal to its daily motion westward that it is nearly 132 hours between two successive risings. This is more than four of its months, so that it passes through all its phases, New, Crescent, Full to New Moon again, four times in the interval. The innermost moon, Phobos, is at a distance of only 5,800 miles. Its diameter is about 8 or 10 miles, and its month, is but 7 h 39 m long, not one-third of the *day* of Mars. Owing to this fact it rises in the *west* every night for the inhabitants of Mars (if any such exist), and sets in the east after about 5½ h. Of course, both the satellites are frequently eclipsed.

> "Their orbits appear to be exactly circular, and they move exactly in the plane of the planet's equator; and they *keep* so, maintained in their relation to the equator by the action of the 'equatorial bulge' upon the planet."[1]

The speculations of Kepler regarding the possibility of the planet Mars having two planets

[1] *General Astronomy*, by A. C. Young, p. 366.

may have suggested Dean Swift's statement concerning the satellites of Mars, in his book on *The Travels of Mr. Lemuel Gulliver.* After describing his arrival in Laputa, Gulliver tells about the astronomers who discovered "two lesser stars, or satellites, which revolve about Mars; whereof the innermost is distant from the centre of the primary planet exactly three of his diameters, and the outermost, five; the former revolves in the space of ten hours, and the latter in twenty-one and a half; so that the squares of their periodical times are very near in the same proportion with the cubes of their distance, from the centre of Mars; which evidently shows them to be governed by the same law of gravitation that influences the other heavenly bodies."

As we have already seen, the period of Deimos is about 30 hours, and that of Phobos somewhat less than 8 hours, whilst the Martian day is only half an hour longer than our own. The month of the inner satellite is less than the planet's day, sometimes rising twice in a single Martian night. These facts are illustrative of the conditions foreseen regarding the future of the Earth and Moon. According to Darwin:

"It seems legitimate to suppose that solar tidal friction has retarded the planet's rotation until it has become slower than the revolution of one of the satellites. It would seem as if the ultimate fate of Phobos will be its absorption in the planet. . . . The theory of tidal friction would certainly lead us to expect that Jupiter and Saturn should work out the same results for their relatively small satellites, that the Earth has produced in the Moon. . . . We find that evidence favourable to the theory of tidal friction is furnished by the planets Mercury and Venus, and by the satellites of Jupiter, Saturn and the Earth, whilst the Martian system is yet more striking as an instance of an advanced stage in evolution."[1]

With regard to the planet Mercury, Schiaparelli, who observed the planet in the clear skies of Milan, concluded that its period was 88 days; in other words, that the planet in its orbital motion round the Sun always turns the same face towards it, and so behaves to the Sun as the Moon

[1] *The Tides, and Kindred Phenomena in the Solar System,* by G. H. Darwin, pp. 268-269.

does to the Earth. This value for the rotation period seems more probable than the shorter one of 24 h 5 m assigned by Schröter, a contemporary of Herschel, but the true value of the rotation period of Mercury still remains an open question. The same remark applies to the actual rotation period of Venus, which is a subject of dispute. Cassini found a period of 23 h 15 m, and Schröter a period of 23 h 21 m. Schiaparelli concluded that it was 225 days, the same time in which the planet takes to revolve around the Sun; therefore, as in the case of Mercury, this planet would always turn the same face to the Sun.

Nevertheless, according to Dr. Jeffreys in his recent work (1924) on the origin, history, and physical constitution of the Earth, with regard to tidal friction, he remarks, "It can be definitely asserted that no satellite other than the Moon has produced a considerable effect on the rotation of its primary," and in the Summary at the end of the chapter on Tidal Friction, he writes: "Friction, either in oceanic or bodily tides, must produce a continual diminution in the rate of rotation of the Earth, and continual increases in the mean distances of the Sun and Moon from the Earth.

These changes together make the Moon and Sun appear to have, relative to the stars, slow secular accelerations which can be found by comparison of modern observations with ancient ones of eclipses and occultations.

"Tidal friction is capable of explaining how the Moon came to recede from close proximity to the Earth to its present distance. . . . The Moon will ultimately recede till its period of revolution and the period of the Earth's rotation are both equal to about 47 of our present days. When this takes place the Moon will gradually approach the Earth again, ultimately passing within Roche's limit [1] and being broken up. (It may be remarked that on the resonance theory on account of the great extension of the earth at the time, the Moon was outside Roche's limit when it was first formed.)"

Dr. Jeffreys concludes his summary with the statement that:

[1] A certain distance within which a celestial body cannot approach another without causing a great disturbance in one or both bodies, on account of the disrupting effect of tidal strain as the result of mutual attraction. This danger limit, according to the discovery of E. Roche in 1848, is reached when the distance between two bodies approaching each other is less than about two and one-half times their radii.

"Tidal friction readily accounts for the fact that the Moon always keeps the same face towards the Earth; it is sufficient that this condition should have been brought about before the Moon solidified, for afterwards it could have been maintained by purely gravitational causes. In the same way, Mercury has probably been made to keep the same face towards the Sun. This result is probably applicable to all satellites whose periods are less than that of the Moon. No planet except the Earth has had its rotation much affected by tides raised by a satellite. It is difficult to make any inference about Venus, except that its rotation period has not been lengthened to such an extent as that of the Earth. The orbits of some satellites may have been appreciably affected by tidal friction, notably Jupiter's satellite I and Phobos, but further inferences cannot be made without more knowledge about the physical conditions on their primaries." [1]

Thus we see how every planet throbs in response

[1] *The Earth, Its Origin, History and Physical Constitution,* by H. Jeffreys, pp. 234, 236, 237.

to the tides produced in it by accompanying satellites. All the planets react on one another, and in the same way, it may be said, as expressed by Sir R. S. Ball:

> "Every star has a distinct tidal wave produced in it by every other star. You may say that such tides are infinitesimal, but you must remember that infinitesimal causes sufficiently often repeated can achieve the mightiest results." [2]

[2] Lecture on "The Corridors of Time," given October 24, 1881, at Midland Institute, Birmingham, by Sir R. S. Ball.

CHAPTER III

THE WORK OF THE TIDES

"Time and tide wait for no man."
—*An old saying.*

"The tide rises, the tide falls,
The twilight darkens, the curlew calls."
—LONGFELLOW.

LET us go for a ramble by the seashore when the Moon is full, and its light illumines the waves with a silvery pathway reaching as far as the encircling horizon. If we listen to the murmur of the waves rippling to and fro over the sands, we hear a story as wonderful as that of the Moon itself. For those who are able to interpret its meaning, the tides which cause the ebb and flow of the sea depend upon the action of the Sun and Moon. According to Professor Darwin, if the Earth were entirely covered with deep water, and considering only the lunar tide, the tide-waves would run around the globe regularly, and if the depth of the water were not less than fourteen miles, the two tide crests would keep on the line

joining the centres of the Moon and Earth. If the depth were somewhat less, the tide crests on the equator would follow the Moon at an angle of 90°, but in the high latitudes they would still move as in the deeper ocean, while in some intermediate latitude there would be a belt of eddying currents without rise or fall.

But the depth of the ocean varies in different regions, the shore line is irregular, and, moreover, the continents of North and South America with the southern Antarctic continent make a barrier almost from Pole to Pole, leaving only a narrow passage at Cape Horn. As a result it is quite impossible to determine by theory what the course and character of tide-waves must be and we are obliged to depend upon observations. For instance, while it is possible to predict the time of tides around the coasts of the British Isles with fair accuracy, yet it is quite another matter in other parts of the world such as India, where the two successive tides are very unequal and they vary apparently very irregularly.

According to A. R. Hinks, Gresham College Lecturer on Astronomy, in his book on that subject: "Far more scientific procedure is then re-

quired to predict the tides with the accuracy demanded by navigators in the Eastern seas. First the tides for a series of years must be observed at various ports. Then the observed tidal curve must be analysed into its separate components by the method known as harmonic analysis. When that is done the tides for future years can be predicted by the beautiful machine, the property of the government of India, which used to stand in the Science Museum at South Kensington and is now in the National Physical Laboratory at Bushey House." (It has since been transferred to the Indian Survey Department in India, according to information received by the author from the Director of Bushey House in a letter dated August 3, 1927.) "Every year a series of pulley wheels in this machine are set in motion and the pen, actuated by the combined motion of all the pulleys, draws in a few hours the predicted curves for the year, one after the other, for the principal Indian ports."

This is an illustration of the value of observations regarding the tides, and a very simple observation at the seaside on our own part will serve to indicate that the tides consist in a regular rise

and fall of the ocean surface, the average interval between the time of high tide on successive days at any place being 24 h 51 m, which is precisely the same as the average interval between two successive passages of the Moon across the meridian. In fact, the odd 51 m has been termed the Moon's "earmark." It has also been observed that when the Moon is at its nearest point to the Earth, or in perigee, the tides are nearly 20 per cent higher than when she is at the most remote point of her orbit from the Earth, or at apogee.

The *Nautical Almanac* gives the time of the Moon's transit across the meridian and sets forth its movements in full detail. Apply to the time given the correction proper for the seaport we have selected, let us say for our summer holiday, and we shall always have a sufficiently good tide-table to guide us in going for a sail or choosing a suitable time for a swim. But if one does not possess the *Nautical Almanac* and is unacquainted with the methods for making the necessary corrections, a few simple observations will show that it is not only the hour of high-water which changes from day to day, but the height as well. The rise and fall of the sea may be roughly estimated by

observing the height of the water on posts which jut out of moderately deep water or by noting rocks along the seashore which are continuously covered by the sea waves at one part of the month, while they are laid bare at others. It will then be seen that about the time of New and Full Moon the range from low to high water is greatest, while at the Moon's first or third quarter they are least.

As the Moon in its apparent daily motion passes across the continent of America each day and comes over the Pacific Ocean, it starts a "parent" wave in the Pacific and a second one is produced twelve hours later. Let us follow its course from start to finish and see the devious windings in and out and the various obstacles, as it were, that it encounters on the way, causing its delay so that it is nearly sixty hours old when it arrives at the London port.

> "The parent wave appears to start twice a day in the Pacific Ocean off Callao on the coast of South America. From this point the wave travels northwest through the deep water of the Pacific at the rate of about 850 miles an hour, reaching Kamschatka in

ten hours. Through the shallow water to the west and southwest the velocity is only from 400 to 600 miles an hour, so that the wave is six hours old when it reaches New Zealand. Passing on by Australia and combining with the small wave which the Moon starts in the Indian Ocean, the resultant tide crest reaches the Cape of Good Hope in about twenty-nine hours and enters the Atlantic. Here it combines with a smaller tide-wave, twelve hours younger, which has 'backed' into the Atlantic around Cape Horn, and it is also modified by the direct tide produced by the Moon's action upon the waters of the Atlantic.

"The tide resulting from the combination of these waves then travels northward through the Atlantic at the rate of about 700 miles an hour. It is about forty hours old when it first reaches the coast of the United States in Florida and it arrives at all the principal ports along the coast within two or three hours of the same time. It is forty-one or forty-two hours old when it reaches New York and Boston. To reach London it has

to travel around the northern end of Scotland and through the North Sea and is nearly sixty hours old when it arrives at that port. In the great oceans there are three or four such tide crests following nearly in the same track, but with continual minor changes, owing to the variations in the relative positions of the Sun and Moon and their changing distances and declinations. If we take into account the tides in rivers and sounds, the number of simultaneous tide crests must be at least six or seven; that is, the high water at the extremity of its travel up the Amazon River, for instance, must be at least three or four days old, reckoned from its birth in the Pacific."[1]

Delays may be accounted for, owing to currents produced in the sea by islands, headlands, and funnel-shaped waterways such as the Bay of Fundy. The bay has a width of 87 miles at its mouth, while the head diverges into several small streams, in one of which the tide acquires a range of almost fifty feet. The effect of this great

[1] *General Astronomy*, by C. A. Young, pp. 310-312.

onrush of water, termed a bore, which is caused by its rushing through a narrow gorge and then pouring forth into a large basin upstream, has been graphically described as follows by Dr. W. Bell Dawson, the superintendent of the Canadian Tidal and Current Survey:

> "The bore is best seen at Monckton, which is situated on the Petitcodiac River one of the streams into which the Bay of Fundy branches at its head. At high-tide the river at Monckton forms a sheet of water half a mile in width; while at low-tide it is reduced to a stream of about 500 feet wide, running in a devious channel amongst bars and mud flats which now are exposed to view. The first sound of the approaching bore is very similar to the noise of a distant train heard across the water. It then increases to the usual hissing and rushing sound of broken water, but there is no mingling in this sound of any roar such as a waterfall makes when falling into deep water. About ten minutes after the first sound is heard the bore arrives, advancing over the current of the river with a front of

broken or foaming water which has a height of two or three feet."[1]

In its rise and fall the tide in the Bay of Fundy exhibits the characteristic features of the semi-daily tide of the north Atlantic coast and its increased range of the tide may be accounted for by its being 87 miles at its mouth, with an average depth of 280 feet dwindling down to a few small shallow streams at its head. In an encyclopædia published in U. S. A. about 1860, the statement was made that the Bay of Fundy was "remarkable for its extraordinary tides which rush up from the sea with such rapidity as sometimes to overtake the swine feeding on . . . the shores." (In this connection a story is told that reflects considerable credit on the intelligence of the swine. According to this account, before descending to the lower stretches of the shore laid bare by the falling tide, the swine of the neighborhood would always leave one of their number stationed on a high bluff looking toward the sea. On the approach of the rapid rise of water, this sentry would squeal a

[1] *The Tide*, by H. A. Marmer, Assistant Chief, Division of Tides and Currents, United States Coast and Geodetic Survey, p. 84.

warning to the herd feeding below, this warning giving them sufficient time to scamper to safety.)

The Bay of Fundy is a large body of water and over the whole of its area the rise and fall of the tide are considerable. Apparently it represents a very large reservoir of power. As Sir R. S. Ball states in his book on *Time and Tide*:

> "Engineers are well aware of the potency of the tide as a vehicle for transporting stupendous quantities of sand or mud. A sand-bank impedes the navigation of a river; the removal of that sand-bank would be a task perhaps conceivably possible by the use of steam dredges and other appliances whereby vast quantities of sand could be raised and transported to where they can be safely deposited in deep water. It is sometimes possible to effect the desired end by applying the power of the tide. A sea-wall judiciously thrown out can be made to concentrate the tide into a much narrower channel. Its daily oscillations will be accomplished with greater vehemence, and as the tide rushes furiously backwards and forwards over the

obstacle the incessant action will gradually remove it and the impediment to navigation may be cleared away. Here we actually see the tides performing a piece of definite and very laborious work to accomplish which by the more ordinary agents would be a stupendous task." [1]

But this reasoning could not well apply to the Bay of Fundy, when certain facts are considered, although it represents a very large reservoir of power. According to Mr. Marmer "it may help in visualizing this matter to state that in a period of six hours the tide brings into the Bay of Fundy with an area of 6,000 square miles very nearly as much water as, on the average, falls in the form of rain during a week over all of the United States with an area of more than 3,000,000 square miles." [2] A sea-wall judiciously placed can be made to concentrate the tide into a much narrower channel, but imagine the insurmountable difficulty of impounding the whole of the Bay by a dam across its mouth, which is nearly 90 miles long. Yet the tides in this region are doing good work by

[1] *Time and Tide,* by R. S. Ball, p. 42.
[2] *The Tide,* H. A. Marmer, p. 225.

gradually transforming the dreary mud-flats which are seen at low-tide and covering them with deposits of red mud which are rising higher and higher until they can be dyked.

Other places where the range of tide is high are Port Gallegos, Argentina, where it is 36 feet; Frobisher Bay, Davis Strait, 35 feet; Cook Inlet, Alaska, 30 feet; Magellan Strait, Chile, 30 feet; Colorado River, Mexico, 22 feet; and a few others. There are fifteen places in all which have a range of 20 feet or more, but it is noticeable that a number of the places which possess large tidal-power possibilities are situated near the Arctic regions or in localities remote from centres of population. About 60 miles south of the great Yang-tse-kiang, a large river, the Tsien-tang-kiang, flows into the China Sea. At most places the bore occurs intermittently, but in this case it travels up the river at every tide, the water sometimes rising as much as 20 feet; then it rushes up the river in a wall 12 feet high. After the bore has passed there is sometimes an after-rush that carries the water up 8 feet more.

The Chinese owners of junks which navigate the river have an ingenious way of avoiding danger

at such times. According to observations made by Captain Moore of the Royal Navy, in command of the surveying ship *Rambler* in 1892, he became aware of the dangerous tidal currents in the estuary. He noted that at various places on the banks of the river there were shelter platforms, and immediately after the passing of the bore the junks run upstream with the after-rush and make for one of these shelters, where they allow themselves to be left stranded on a raised platform. At the end of the platform there is a sort of round tower jutting out into the stream. The object of this is to deflect the main wave of the bore so as to protect the junks from danger. After the passage of the bore the water rises very rapidly on the platform, enabling the junks to float in safety. Captain Moore gives a graphic account of the spectacle afforded by the junks as they go upstream and describes how on one occasion he saw no less than 30 junks swept up in the after-rush at a rate of ten knots past the town of Haining towards Hangchow, with all sails set, but their bows in every direction.

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follows: Many hundred years ago there was a certain general who had obtained many victories over the enemies of the Emperor, and who, being constantly successful and deservedly popular among his countrymen, excited the jealousy of his sovereign, who had observed for some time and with secret wrath his growing influence.

The Emperor caused him to be assassinated and thrown into the river Tsien-tang-kiang, where the general's spirit avenges itself by bringing in the tide from the ocean with such force as to overwhelm Hangchow, which at that time was the magnificent capital of the Empire. As Captain Moore's interpreter, who had been for some years in America expressed it, "His soul felt sort of ugly like arter the many battles he had won for the Emperor."

The spirit so far succeeded in its scheme of revenge as to flood a large portion of the country, when the Emperor, becoming alarmed at the distress and loss of property, endeavoured to enter into a sort of compact with it by burning paper and offering food upon the sea-wall. This did not, however, have the desired effect, as the high-tide came in as before, so at last he decided to erect a

pagoda at the spot where the worst hole had been made in the embankment. Hence the origin of the Bhota Pagoda, for the Chinese believe a pagoda is pleasing to the good spirit. After it was built the flood-tide did not flood the country as before, though it still continued to come in the shape of a bore. Possibly the repairs to the embankment had something to do with the beneficial results. Moreover, the bore may be intermittent and liable to great variability, depending on the silting of the estuary changes.

> "The people at Haining still continue to pay religious reverence to the bore and on one of the days when Captain Moore was making observations some five or six thousand people assembled on the river-wall to propitiate the god of the waters by throwing in offerings. This was the occasion of one of the highest bores at spring-tide, and the rebound of the bore from the sea-wall and the sudden heaping up of the waters as the flood conformed to the narrow mouth of the river, here barely a mile in width at low-water, was a magnificent spectacle. A series of breakers

were formed on the back of the advancing flood, which for over five minutes was not less than twenty-five feet above the level of the river in front of the bore. On this occasion Captain Moore made a rough estimate that a million and three-quarters of tons of water passed the point of observation in one minute." [1]

A relatively small bore is observed annually on the river Severn in England, though in September, 1897, when Captain Moore was on the banks of that river at spring-tide, he states "there was no proper bore and only a succession of waves upstream and a rapid rise of water-level." Suggestions have been made regarding the harnessing of the River Severn, which brought Gloucester its commercial importance. Had it not been for the Severn, Gloucester probably never would have become a prominent city. The river at Gloucester is tidal and is remarkable for the ever-recurring phenomenon "the bore." This is caused by the rush of the advancing tide up the narrow channel of the Severn. Owing to the configuration of the

[1] *The Tides*, by G. H. Darwin, pp. 54-65.

estuary, the tide gathers itself in a great head of water, which, in its rapid advance, suddenly reverses the current of the river. When the tide is at its highest it reaches above Tewkesbury. Under favourable conditions the spectacle of the onrushing "bore" is a very impressive sight frequently observed by hundreds of people. Twice in twenty-four hours 300,000,000 tons of water sweep up and down the estuary of the Severn, and competent engineers assert that if these great tides were harnessed they would provide 500,000 horse power continuously during a ten-hour day. "Such a force," according to T. C. Bridges, "is sufficient to lift 7,000,000 tons a foot each minute, and is far greater than the power at present taken from the Niagara Falls, which yield only 385,000 horse power. To obtain similar power from fuel it would be necessary to burn no less than fifty thousand tons of coal weekly, so that the water power yielded by the Severn would save the country two and a half million tons of coal a year. Power from the Severn could easily be conveyed as far as London, and would be of untold value to all the big towns in the Western Midlands."

The Bristol Channel also concentrates a great

wave which gives Chepstow and Cardiff a tidal range of 37 or 38 feet at spring-tide, and forces the sea up the river Avon, giving Bristol a wonderful tide. There is hardly any more interesting spot in our island for the observation of tides than is found on Clifton Suspension Bridge. Arrive at the time of low-tide and ships are seen stranded high and dry on the muddy banks, but a patient wait will be rewarded by seeing these same ships well under way as they resume activity at high-tide, gliding down the well-filled river. Here we have an instance where tides are doing good work. We can witness such scenes produced by the activity of the tides, though on a greatly reduced scale as far as their height is concerned, at the great harbours of Liverpool or Southampton, enabling ocean steamers to start on their way across the Atlantic Ocean.

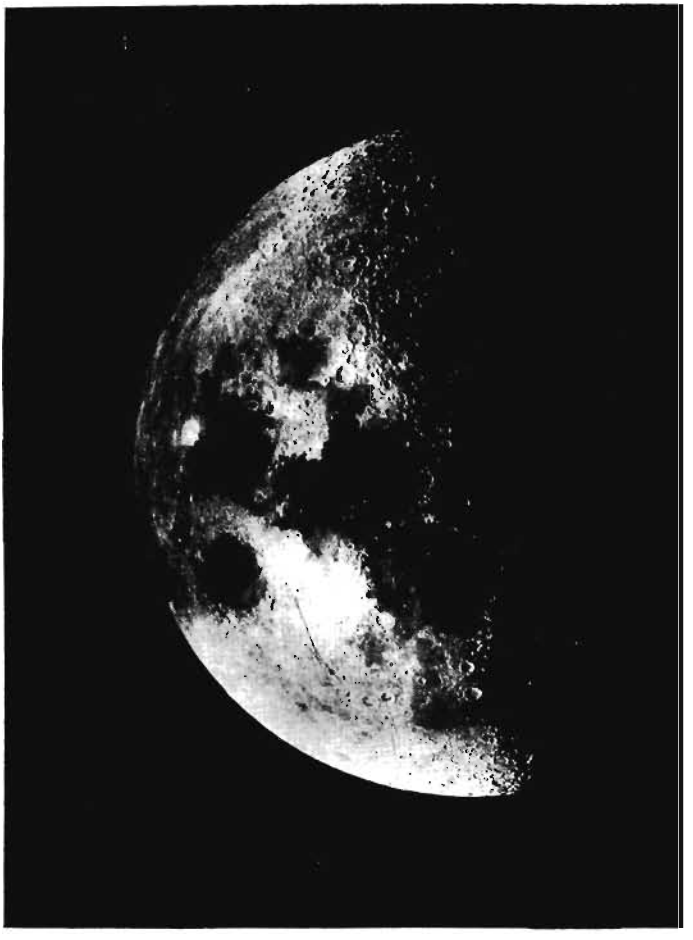
Great waves caused by earthquakes are sometimes erroneously described as tidal waves, the word "tidal" in this case simply denoting a wave of phenomenal size. The word tidal should be used only in reference to regular and persistent alternations of rise and fall of sea-level. When

an earthquake occurs beneath the sea the whole body of the ocean above it is moved slightly, and the movement then spreads away on all sides in long, low waves that travel with great speed. When nearing the shore the speed and length of the wave are decreased, but the height is greatly increased. The wave may then rush far in on a lowland coast, causing great destruction, such as happened in August, 1883, after the tremendous explosion of the volcanic island Krakatoa. On coasts near the scene of the explosion, the waves rushed upon the land with a velocity of 400 miles an hour, reaching a height of from 50 to 80 feet, flooding the lowlands, sweeping away many villages, and drowning thousands of the inhabitants. Accounts are given of a large vessel which was carried a mile and a half inland and stranded 30 feet above sea-level.

On the evening of June 15, 1896, an earthquake in the north Pacific caused a tidal wave from 10 to 50 feet in height on the coast of northern Japan, flooding the coast for 175 miles. Many villages were destroyed and thousands of acres of arable land were flooded. But the most

disastrous tidal wave the world has ever known, or at any rate recorded, is that which occurred at Lisbon, after the great earthquake of November, 1755. After the first shock, houses fell in ruins and a great multitude fled to the hills for safety. After the second shock a far more terrible catastrophe was at hand, for a strange heaving swell was observed to pass over the river, though no wind stirred the air. The waters seemed to be drawn away to meet a vast wave which swept onwards at great speed, overwhelming the quay, whereon many had crowded for safety. Numberless vessels anchored on the river were sucked down by the tremendous waves, and not a trace of them ever seen again. A third shock followed, and again the river was swept by a gigantic wave, working such destruction that many feared "the city of Lisbon was doomed to be swept entirely from the face of the earth."

These and many other catastrophes which have been caused by tidal waves give evidence of the terrible energy of the earth's subterranean forces, but are in no way the result of lunar tides. Nevertheless, despite the fact that earthquakes and accompanying tidal waves are agents of destruction,



THE MOON—AGE SEVEN DAYS

Photographed with forty-inch refractor at
Yerkes Observatory, by G. W. Ritchey

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"yet the phenomenon is surpassed by no other as a regenerative and restorative agent. But for earthquakes our continents would continually—however slowly—diminish in extent through the action of the sea waves upon their borders, and of rain and rivers on their interior surfaces. 'Had the primeval world been constructed as it now exists,' says Sir John Herschel, 'time enough has elapsed, and force enough, directed to that end, has been in activity, to have long ago destroyed every vestige of land.' It is to the reproductive energy of the earth's internal forces that we are indebted for the very existence of dry land. To the same cause, undoubtedly, we owe that gradual process of change in the configuration of continents and oceans which has been for ages and is still in progress—a process the benefit derived from which cannot possibly be called in question." [1]

[1] *The Borderland of Science*, by R. A. Proctor, p. 263.

CHAPTER IV

THE MOON, A WORLD OF WONDER

"The moon, whose orb
Through optic glass the Tuscan artist views
At evening, from the top of Fiesole
Or in Valdarno, to descry new lands,
Rivers, or mountains, in her spotty globe."

—MILTON.

FROM the earliest period, the Moon has been a world of wonder, speculation, and romance. We can imagine the "incredible delight" of Galileo when he turned the "magic glass" (recorded as the first telescope) in the direction of our fair satellite. Hitherto, philosophers conjectured that it was made of glass, the dark markings being the reflection of land and sea areas on the Earth. Humboldt affirmed that this opinion had been preserved to his day as a popular belief among the people of Asia Minor. He says, "I was once very much astonished to hear a very well educated Persian from Ispahan, who had certainly never read a Greek book, mention, when I showed

him the Moon's spots in a large telescope in Paris, this hypothesis as a widely-diffused belief in this country. 'What we see in the Moon,' said the Persian, 'is ourselves; it is the map of the Earth.' According to another theory, the spots on the Moon were supposed to be the shadows of opaque bodies floating between it and the Sun."

It was not until the beginning of the seventeenth century, when telescopes were first made, that some idea was gained regarding the surface and contour of the Moon. There were several claimants to priority in the discovery of what was at first termed the "magic glass," but there are three names which take first rank in the list of those possessing distinct claims to this much-contested honour—Lippershey and Jansen, spectacle-makers in the town of Middleburg, and James Metius, the son of a professor of mathematics, but who was not interested in that subject, preferring to devote his time to the construction of mirrors and burning-glasses. He had many of various forms in his possession, and on one occasion he looked through two lenses, one convex and the other concave, by putting one in front of the other. It happened that they were situated at the

proper distance apart for magnifying objects, whereupon he placed them in opposite ends of a tube, and in this manner he constructed the first telescope.

Almost the same story is told about Lippershey, who, on placing a concave before a convex glass, accidentally discovered that the weather-vane of a neighbouring church, and other objects appeared nearer, larger, and inverted. Having fitted the glasses securely in a tube, he placed the instrument in his shop, and amused his customers by showing them the magnified image of the weather-vane. The Marquis of Spinola, who was then at The Hague, passing the shop one day and seeing the toy—as some termed it—which was attracting so much attention in the window, went in and bought it, afterwards presenting it to the Archduke Albert of Austria. The latter, on looking through it at ships nearing the harbour, found that it was possible to see them by means of this "magic glass" when they were miles away and therefore beyond the reach of unaided human vision. Consequently, he saw the importance of such an instrument in enabling one to see ships at a great distance out at sea, and realised the value of such

a device in war time. Accordingly, when Lippershey, who apparently also realised this fact, presented a petition on the 2nd of October, 1608, to the States General of Holland for a patent, a committee was appointed to consider his claim.

After deep thought and careful consideration, they came to the conclusion that the instrument would be of far more value if it enabled one *to look through it with both eyes*, and they conferred with Lippershey as to whether it would be possible for him to improve on his device for this purpose. On the 4th of October it was resolved that certain members should test the instrument, by observing with it from the turret of Prince Maurice's mansion. It was further resolved that if the suggestion should be found useful, an engagement should be entered into with the inventor, to execute three such instruments of rock crystal, and that he should be enjoined not to divulge the invention to anybody. On the 6th of the same month, the Assembly agreed to give Lippershey 900 florins for such an instrument. On the 15th of December they examined the instrument invented by Lippershey *to see with both eyes*, and approved of it, but as many others had a knowl-

edge of this new invention which enabled one to see at a distance, they did not deem it expedient to grant him an exclusive privilege to execute such instruments. However, they gave him orders to execute, for the use of the Government, two other instruments to see with both eyes, allowing him the same remuneration for his services as in the first instance." [1]

Incidentally, the origin of the binocular may thus be attributed to Lippershey, who made one by combining together lenses in various ways which would suggest themselves to an optician. As Grant states in his *History of Physical Astronomy*:

> "Attempts have been made to depreciate the merit of the Dutch inventor, on the ground that his discovery was made by chance. Nevertheless, although he may have been unacquainted with the principles, upon which the construction of the telescope depends, yet how few original discoveries or inventions, in either the arts or the sciences, have been achieved by the aid of purely theoretical considerations; and, on the con-

[1] *History of Physical Astronomy*, by R. Grant, p. 519.

trary how many have been suggested to their authors by circumstances apparently unconnected with the object of their researches, and, therefore, to a certain extent, fortuitous!"[1]

The news of the invention found its way to Padua and aroused the interest of Galileo, at that time one of the professors at the university, and among the first to detect its possibilities. Happening to be in Venice during the month of May, 1609, he learned in that city that a Belgian had invented an instrument by means of which distant objects appeared nearer and larger. The report was confirmed by a letter he received from Paris, and upon his return to Padua he pondered over the news, and spent a sleepless night considering whether it might not be possible to apply the new invention so that it would bring the Sun, Moon, and planets within closer range. He was an expert in optics, a subject on which he lectured at the university, and he devised the construction of the telescope during many hours of deep thought that night and carried out the design the next day. He adopted a plan like that of the Dutch spectacle-

[1] *History of Physical Astronomy*, by R. Grant, p. 520.

maker, but achieved a similar result, attaining his end by means of the laws of refraction.

Taking a small pipe out of an old organ, he fitted a concave glass in one end and a convex glass in the other, and with this primitive telescope he found that objects appeared three times nearer and nine times larger. But now "having spared neither expense nor labour," he made a more capably finished instrument which magnified an object nearly a thousand times superficially and brought objects more than thirty times nearer. (Both telescopes are now kept in the Museum of Florence and duplicates are in the Science Museum of South Kensington and elsewhere.) A few days after he had constructed his instrument he hastened with it to Venice, having received an invitation to exhibit it to the Doge and senate. The following is an extract from a letter he wrote from Venice to his brother-in-law, Benedetto Laudaucci:

> "You must know then that about two months ago a report was spread here that in Flanders a spy-glass had been presented to Prince Maurice so ingeniously constructed

that it made the most distant objects appear quite near, so that a man could be seen quite plainly at a distance of two miles. This result seemed to me so extraordinary that it set me thinking, and, as it appeared to me that it depended upon the theory of perspective, I reflected on the manner of constructing it, in which I was at length so entirely successful that I made a spy-glass which far surpasses the report of the Flanders one. As the news had reached Venice that I had made such an instrument, six days ago I was summoned before their highnesses the signoria and exhibited it to them, to the astonishment of the whole Senate. Many noblemen and senators, although of a great age, mounted the steps of the highest church towers at Venice in order to see sails and shipping that were so far off that it was two hours before they were seen steering full sail into the harbour without my spy-glass; for the effect of my instrument is such that it makes an object fifty miles off appear as large and near as if it were only five."

On his return to Padua, Galileo became deeply interested in telescope observations of the heavens, and when the wonderful results obtained by means of his telescope became known they aroused the greatest excitement. We are told that the senators in their anxiety to see the new world discovered in the Moon, were constantly clambering up the steps leading to the tower, till Galileo "became annoyed at their importunity." The hope which cheered on Galileo in his study of the Moon's surface was the possibility of discovering "the footsteps of human intelligence." The giant telescopes of today have proved conclusively that this hope must be abandoned. According to the Rev. T. W. Webb:

> "If it should be thought probable, as it very reasonably may, that the lunar surface is habitable in some way of its own, we have reason to suppose that, where the conditions of life are so extremely dissimilar, its traces would be as undecipherable by our experience as a brief inscription in a character utterly unknown. We ought not, in fact, to be surprised at such a difference between bodies

belonging to distinct classes; it would have been unreasonable to have looked for a duplicate of a primary planet in its attendant. Waiving, then, any disappointment from this cause, we shall find the Moon a wonderful object of study." [1]

From the first observation of the Moon by Galileo when, to use his own words, it appeared as if it had been distant only two semi-diameters of the Earth, is dated the new era of modern selenography. The actual distance of the Moon from the Earth is 238,840 miles, or about 30 times the diameter of our planet, and, yet by means of the instrument designed by this master intellect, the most astonishing discoveries were made regarding its surface. It was found to be mountainous and in other ways a world like our own, sculptured with valleys, plains, and so-called seas and oceans, to which Galileo and other observers gave such fanciful names as, the Sea of Serenity, the Ocean of Storms, the Bay of Rainbows, the Lake of Dreams, the Marsh of Sleep, and other fanciful names adding a charm to the study of

[1] *Celestial Objects for Common Telescopes*, by Rev. T. W. Webb, sixth edition, p. 79.

lunar landscapes and giving some idea of the vivid imagination of the early selenographers. As one would expect, the names of Tycho, Copernicus, and Kepler were assigned to large and imposing craters, others were named after great philosophers, such as Aristotle, Pythagoras, Aristarchus, and Plato, while careful search reveals a minute crater Galileo apparently reserved for himself. Intermingled with these are craters named in more recent times, after modern astronomers such as Arago, Flamsteed, Airy, Janssen, Le Verrier, Herschel, Lockyer, Secchi, Huggins, Newcomb, and Ball. In fact, the index to the names on the map of the moon, as given in Webb's *Celestial Objects for Common Telescopes* (6th edition), shows endless variety.

The names of lunar mountains such as the Alps, Apennines, Altai, Cordilleras, Caucasus, etc., were suggested by their terrestrial counterparts. When Galileo perceived bright points of light separated by dark spaces from the edge of the crescent Moon, he recognised the fact that these points were the tops of mountains illuminated by sunlight while the surrounding valleys were still in darkness. Evening after evening he watched the

shadows falling across the plain below, and by this means he was enabled to make an estimate of the height of lunar mountains, known to exceed that of many terrestrial mountains. For instance, the loftiest peak in the Apennines rises, according to Schröter, to 21,000 feet; Schmidt reduces it to 18,000 feet—in any case a superb elevation, and three times the height of Mount Wilson, California, and exceeding the height of Pike's Peak, Colorado, which is 14,000 feet. Many of the peaks in the lunar group known as the Leibnitz Mountains have colossal elevations, several measuring nearly 30,000 feet; and Neison on his map gives a probable height of nearly 36,000 feet to a huge mass, lying a little beyond the limb.[1]

When Galileo advanced his views about mountains on the moon, his opponents challenged the statement, asserting that there exists a crystalline shell, filling up the cavities and having an outer surface perfectly smooth, as Aristotle taught. To this argument Galileo gave an answer precisely suited to the value of the objection. "Let them

[1] *Celestial Objects for Common Telescopes*, by T. W. Webb, p. 139.

be careful," he replied, "for if they provoke me too far, I will erect on their crystalline shell invisible crystalline mountains, ten times as high as any I have yet described."

In fact, many of the lunar mountains equal the highest ranges on our planet. Could we, in a journey over the rugged surface of the Moon, visit the great chain of mountains Galileo named the Apennines, we should find that it is surmounted by a peak 21,000 feet high. The range extends for nearly 640 miles, and while on one side it ascends gradually, the other side is broken up into awful precipices of stupendous depth. The great valley of the Alps is another extraordinary sight. It is from three to six miles in width and breaks through the Alps in a straight cleft, extending nearly 83 miles, being bordered by a chain of lofty mountains one of which at the eastern end is known as Mt. Blanc, which reaches a height of 14,000 feet.

Many of the deep valleys on the Moon may have been rivers in bygone times. There are more than a thousand of these lunar valleys which are said to resemble the cañons of Colorado. Some few run to a distance of 150 miles, and are

about a quarter of a mile in depth. Their origin is probably volcanic, and one is forcibly impressed with this theory when viewing the scene of the great Tarawera catastrophe in the Taupo region of New Zealand. On a small scale, it may be said to bear a strong resemblance to the seamy, scarred surface of the Moon, especially when seen on a bright, sunshiny day. The sharp, jagged peaks of the surrounding hills, which are covered with grey pumice ejected at the time of the eruption at Tarawera, on the morning of June 9, 1886, glisten white against the dark blue sky peculiar to New Zealand. On this eventful occasion Mount Tarawera, never before suspected of the least volcanic energy, the sacred mountain of the Arawa tribe, and near Wairoa, the point of departure for the famous Pink and White Terraces, was suddenly shaken to its very depths. The crown of the mountain was blown off and the mud from the interior was flung far and wide over the surrounding landscape. Flames burst forth, shooting upward to an incredible height into the sky, and overhead hung a black cloud like a funeral pall.

The mountain stretches about three and a half

tion in sight; until the guide pointed to fragments of iron sticking up vertically in the ground —the roof of a school, and one native dwelling still standing—the *whare* of the guide Sophia, that sheltered many lives that night beneath its sloping roof. Then he told us the tragic story of what occurred on Wednesday, June 9, 1886, and listening, we understood the loneliness of this deserted region.

The violent upheaval which caused the destruction conveys some idea of the underground forces at work on our planet, not only in New Zealand, but in Iceland, Yellowstone Park, Vesuvius, and elsewhere, quiescent maybe for a time, but apt to remind us of their potency when least expected, as on August 1, 1927, when a flow of lava poured over the lowest point of the rim of the outer crater of Vesuvius and began a slow descent down the Valle del Inferno. Such craters on a large scale are suggestive of the active agents once at work in carving and outlining, as in sculpture, the surface of the Moon, and time has petrified similar traces on our planet at Wairoa and Tarawera and elsewhere which tell their own weird story.

Compare a photograph of a section of the thermal region of New Zealand, where mud volcanoes and craters[1] abound, with a photograph of the Moon in a region pitted with what might be termed craterlets, and the resemblance is remarkable and might easily be mistaken for a lunar scene if the surrounding foliage and flowers, which come down to the edge of these mud pools, is skilfully obliterated. As another instance of the underground energy pervading the hot-water region of New Zealand, visit the neighborhood of the Kerapiti Blow-hole, the so-called "safety valve" of New Zealand. It is situated on a high tableland of pumice soil, stretching out for miles between hills and mountains, and is covered with patches of grey green manuka scrub, the only vegetation that here attains any growth. There are innumerable signs of concealed activity, such as geysers, boiling springs, blow-holes sprinkled here and there in overwhelming variety, giving

[1] "Mud volcanoes," according to Humboldt, "continue in a state of repose for centuries. When they burst forth they are accompanied by earthquakes, subterranean thunder, the elevation of a whole district, and (for a short time) by the eruption of lofty flames. After the first forcible outburst, mud volcanoes present to us the picture of an incessant but feeble activity."

evidence of the ever-restless forces underground. There is a perpetual throbbing sound as of engines at work, a clanging of chains suggestive of restless spirits striving for release, sudden outbursts of scalding steam hissing and spurting from a small opening in the ground, and numberless evil-looking fountains of sulphurous vapour. But none are so impressive as the Kerapiti Blow-hole, at Wairakei! What would happen if that small slit in the earth were closed, and the internal—one might almost say infernal—source within compressed made a successful effort to escape, is too fearful to contemplate. The eruption at Mount Tarawera and its fearful results would seem tame in comparison, said our guide, as he piloted us in safety over ground throbbing with the energy of a miniature earthquake.

Duly impressed, we followed our guide as he led us along a narrow track among the manuka bushes, and before long we heard a low, continuous booming sound, such as the continuous rumble of London traffic. This sound increased in volume until we arrived at a dry, reddish pit among the manuka trees, with a small slit at one side just below the brink, and out of the slit we

saw a tremendous white head of steam—not intermittent like other displays we had seen *en route*, but a continuous performance lasting night and day, year in and year out, since when—who knows? Maybe from the beginning of time on our planet, reminiscent of the early period while it was passing through the glowing vaporous stage when it was still "without form and void."

In his pamphlet, *Uncanny Country*, the author, B. E. Baughan, tells us that

> "practical persons are apt to feel troubled by the 'waste of energy' perpetrated by Kerapiti. Fling a stick at him, and he will hurl it thirty feet into the air; his temperature is said to attain 225° F., his pressure is about 160 pounds to the square inch, but how are you going to plant machinery upon ground that reverberates beneath your tread? To the imaginative he is especially to be recommended as a spectacle to be seen at night. The solitude and dark all round—the one huge voice, incessant—the one sight . . . hurled volume after volume of vapour, mysteriously intensified by the sorcery of the

> torches, weirdly lurid in their light, the felt force, the hidden cause, the indecipherable purpose: here is matter for admiration and wonder; and, as an addition, experience also, if you can, laid upon all that billowing and bellowing, the calmness and the cold white touch of moonlight."

So strange is the fascination of this region, that we resolved to follow this advice, determined to see the famous Blow-hole not only by day, but by night. The Maori who accompanied us that evening had provided himself with a tin of kerosene and some old sacks, which, on being ignited, were flung into Kerapiti. They emerged almost instantaneously, ascending in the column of steam in a shower of glittering sparks mingling with its moonlit radiance. It was a weird sight, accentuated by the excited Maori yelling, "Taupo! Taupo!" as he stamped excitedly as near to the Blow-hole as safety permitted. This was apparently an invocation to frighten away the devil who was supposed to be the cause of the sinister display.

But what does Kerapiti, and all this wonder-

land, mean? What has it to do with the Moon? —is a query answered by Hochstetter, an authority on the subject of thermal activity. The hot springs, blow-holes and other evidence of subterranean disturbances suggest a connection with underground volcanic fires. The scientific explanation is simply that "surface water, sinking through fissures into the bowels of the earth, where it becomes heated by the still existing volcanic fires"; and so converted into high-pressure steam, which, rising again towards the colder surface, is there condensed into hot water. "The periodical eruptions essentially depend upon the existence of a frame of siliceous deposits with a deep, flue-shaped tube, and upon the sudden development of larger masses of steam from the overheated water in the lower portions of the tube."

Another explanation is given by Dr. A. S. Wohlmann, in his account of the *Mineral Waters and Health Resorts of New Zealand*, from which the following quotation is of interest: "At a varying depth down the geyser-shaft, soft siliceous water will be encountered, and this will reach down for a considerable distance to deep layers

of superheated water—that is, to water heated to a point far beyond the surface boiling-point. . . . If, either from the decrease of pressure or from an increase of temperature, this water were to boil, there would be a sudden and explosive outburst of steam, and the superincumbent column of water in the geyser-tube would be shot into the air." Increase of temperature must take place from below, resulting in decrease of pressure either from the lower layers of water in the tube being pushed up higher into it by fresh accessories from below, or by the withdrawal of water from above, through evaporation or other means, and "when a point is reached at which the pressure below overcomes the resisting weight of the column of water above, the geyser 'plays,' until the pressure of steam below is no longer able to overcome the force of gravity above." Then the geyser dies, until, "after a longer or shorter period of quiescence, the column begins to boil again and the whole series of phenomena is repeated."

Hochstetter gives the following version of a quaint Maori legend, which he considers accurately suggests the connection of the hot springs with volcanic fires:

"Among the first to come from Hawaiki to New Zealand was the chief Ngati-roi-rangi, who set off with his slave, Ngauruhoe, to explore the new country. He travels through the country, stamps springs of water from the ground to moisten scorched valleys, scales hills and mountains, and beholds towards the South a big mountain, the Tongariro. He determines on ascending that mountain; he ascends the snow-clad Tongariro, and there they suffer severely from cold, and he shouts to his sisters, who had remained upon Whakaari (White Island), to send him some fire. They sent him the sacred fire they had brought from Hawaiki. They sent it him through the two Taniwhas (mountain and water spirits living underground) by a subterranean passage to the top of Tongariro. The fire arrived in time to save the life of the chief, but the slave, Ngauruhoe, was already dead, and on this account the hollow through which the fire made its appearance, the active crater of Tongariro, is called to this day after the slave Ngauruhoe, and the sacred fire still

burns within this underground passage between that mountain and the coast."[1]

To return to the account of the Tarawera eruption, the apparent magnitude of the disaster is realised when one recalls the fact that it resulted in the opening up of a great fissure in the crust of the earth for a distance of eight and a half miles, and the destruction of all life within five miles on either side of it, showing the appalling consequences that would have resulted if such an occurrence had taken place in a densely populated district. Various theories have been advanced as to the cause of the eruption, and among the most interesting is one that assumes imprisoned forces within Tarawera, either through subsidence or shrinkage of the cooling rocks, or through the accumulation of imprisoned forces beyond the resisting power of the walls of the subterranean hollow in which they were confined, or by some deep-seated movement in the Earth's crust, the sequence of events leading up to the final disaster. Professor James Park, in his *Geology* of New Zealand, states:

[1] *Uncanny Country,* by B. E. Baughan, p. 11.

"The origin, or cause, of the Tarawera eruption in 1886, like that of most volcanic eruptions, although a source of much investigation, is still a matter of mere conjecture. The welling up of a molten magna, with the resultant fissuring and sudden admission of the waters of Lake Rotomahana to the uprising, glowing mass, and the collapse of the dome that supported the floor of the lake, accompanied by the instant contact of the waters with the highly-heated igneous mass lying immediately under the line of fracture, is the hypothesis that has received the most attention and support."

Another theory associates the eruption with some deep-seated and extensive changes in the condition of the Earth's crust, specially manifest along those recognised belts or apparent lines of fault upon which volcanoes are distributed. In November, 1882, Karabetow Mountain, in the Caucasus, which was not known as a volanco, broke out in eruption, and the lava stream from its crater flowed a distance of half a mile. In December of that same year the island of San-

torin, in the Grecian Archipelago, was the scene of a volcanic disturbance, and there was evidence of a submarine volcano near Missolonghi. In the beginning of January, 1883, and later on in the same year, the Peak of Teneriffe emitted clouds of steam. On May 22nd, the volcano of Karang, in the island of Krakatoa, Straits of Sunda, burst into eruption after a period of perfect quiet during at least two centuries. About the middle of June there were earthquake disturbances in Austria, and a terrible volcanic disaster at the island of Omatepee, Lake Nicaragua, during the same month. On July 28th, over 4,000 persons were killed by earthquakes in Ischia, accompanied by an eruption at Vesuvius. On August 13th occurred the great eruption of Krakatoa already referred to, when the island of Krakatoa sank beneath the sea, causing a tidal wave 100 feet high, resulting in great loss of life. Tidal irregularities were observed at points as widely separated as the shores of New Zealand and the coast of South Africa.

These and other instances of internal upheavals and volcanic disturbances seemed a prelude to the great eruption of Tarawera in 1886,

which, now that its pent-up forces have found a possibility of escape, may slumber peacefully for many centuries. At least, according to the best authorities, it is unlikely that such an event will occur again for some time.

All these facts, such as vast upheavals and volcanic disturbances, point to the conclusion that they are brief revivals of the conditions which prevailed on the Earth while it was still in the plastic stage, but we have nothing on Earth to be compared to the gigantic upheavals which must have taken place on the Moon, although probably they did exist, but have been filled up by later eruptions or by the denuding action of rain and frost. Its vast craters dwarf into insignificance even the extinct crater plain twenty miles in diameter at Mauritius, or the craters of the Sandwich Islands, Kilauea and Haleakala—the one a fused, the other a frozen lake of lava. Yet they afford an analogy, for Dana has shown in the case of Kilauea "that the whole floor slowly rises till the weight of the lava becomes too great for the sides of the volcano to bear. It then breaks out in a lateral eruption, when the floor immediately sinks. The two active vents, Mauna and

Kilauea, are both basaltic volcanoes. Difficulties no doubt remain, but we can hardly wonder at them, while geologists are still so little agreed about 'elevation-craters' and submarine volcanoes on our own globe." [1]

Various theories have been advanced regarding the origin of lunar craters. One theory attributes them to volcanic origin, and after reading accounts of thermal activities on the Earth as described above, one seems almost convinced, yet there are no volcanic formations on the Earth which resemble at all closely the lunar craters. The meteoric hypothesis suggested by my father in 1873 in his book *The Moon*, is omitted in the edition of this work published in 1878. In *Old and New Astronomy*, his unfinished work, prepared in 1888, he expressed his views regarding the Moon as a planet, as follows, thus incorporating his final opinion on the subject:

> "The Moon is now so utterly unlike the Earth that it is difficult to imagine that there was ever even such general resemblance as is implied in regarding her as a planet. She is

[1] *Celestial Objects*, by Rev. T. W. Webb, pp. 63-84, also note by Rev. T. E. Espin.

not only arid and airless, but even were she clothed with sea and air she would yet differ greatly from the Earth because of her long day of more than four weeks. The Moon's characteristic peculiarities, however, telling us as they do of her immense age, enable us more readily to understand her condition. How long must the Moon have existed as a planet to have grown old, decrepit, and dead as we see that she has?

"There is no difficulty in understanding that, even if formed as long ago, or later, the Moon would have been much older than the Earth. With 81 times as much mass and only 13½ times as large a surface, our Earth would have cooled through the various stages of her life much more slowly—in fact, each stage would have lasted just as much longer as 81 exceeds 13½, or be six times as long. Suppose the Earth and Moon both white-hot 60,000,000 years ago, then the Moon would have reached the Earth's present stage 50,000,000 years ago, and would correspond now to 300,000,000 years of Earth-life—so that the Moon would tell us of the

Earth's condition 240,000,000 years hence. And though this result is based on assumptions, it yet presents truly the general inference we may safely form that the Earth will not be in the same stage of planetary life as the Moon until many millions of years have passed. (If each stage of the Earth's life is six times as long as the corresponding stage of the Moon's, then—on any assumption whatever—the Earth will only reach the Moon's condition after a period five times as long as the interval which has elapsed since they were both simultaneously in the same stage of planetary life.)

"But even with this knowledge it remains difficult to understand why the Moon should be so unlike the Earth. The waters of the Earth may soak their way beneath the crust (as our underground caves, and even our hot wells and volcanic outbursts show they are doing) till they all disappear. Our air can hardly, however, become thinned to the condition of lunar air. And even if it did, and every trace of water had vanished, the Earth would not be as the Moon is. There

are no great craters on the Earth as on the Moon: there are scarcely any great mountain ranges on the Moon as on the Earth. In these chiefly, but in other important respects, also, the Moon and the Earth are so unlike that the uniformitarian theory here appears to fail us. The more the Moon is studied, the clearer seems to be the evidence that she gives respecting the life-history of a planet. She tells us more, perhaps, of the future of our Earth than of the past; but she tells us of the past, too. That the Moon is waterless and practically airless, too, now, is certain, and therefore there is probably no life on her surface, though for those who like such fancies the belief is always open that there may be creatures on the Moon utterly unlike any with which we are acquainted on Earth. Yet the Moon's face tells us of a remote youth—a time of fiery activity, when volcanic action even more effective (though not probably, more energetic) than any which has ever taken place on this globe, upheaved the earth's crust.

"So soon as we consider carefully the features of her surface we see that there must have been three well-marked eras of vulcanian activity. The system of radiating streaks tells us of that stage of the Moon's history when her still hot and plastic crust parted with its heat more rapidly than the nucleus of the planet and so, contracting more quickly, was rent by the resistance of the internal matter, which, still hot and molten, flowed into the rents, and spreading, formed the long broad streaks of brighter surface. The next stage of the Moon's history (after many thousands perhaps millions of years had passed) was one in which the cooled crust, still plastic, contracted little, while the still hot nucleus contracted steadily, so shrinking from the crust, which under the action of gravity closed in upon the nucleus in such sort as to form a wrinkled or corrugated surface. The third era of lunar vulcanian disturbance was that of mighty volcanic eruptions, during which the great craters were formed which are so numerous on

the lighter tinted higher regions of the Moon's surface."[1]

A few pages further on in the book, my father writes:

"Thus we should not expect to find the great craters belonging to the early stages of the Moon's vulcanian history converted into such wrecks as alone attest on the Earth the former existence of similar terrestrial crater-mountains. But we may yet fairly look for evidence of considerable denudation during the time, short-lasting though it may have been, when the Moon's atmosphere and oceans were capable of doing denuding work. Accordingly, we find that while the immense craters remain still the most striking feature of the Moon's surface, they attest the action of subaërial denudation during a period which, though it may have been short compared with the corresponding period of our Earth's history, must still be measured by hundreds of thousands of years. But we see in the evidence of such denuding action the

[1] *Old and New Astronomy*, by Richard A. Proctor, pp. 516-517.

last important traces of subaërial denudation in the Moon. Not there as on this Earth have lands and seas interchanged after the manner described by Tennyson when he says:

"'There rolls the deep where grew the tree;
O Earth, what changes hast thou seen!
There, where the loud street roars, hath been
The stillness of the central sea.
The hills are shadows, and they flow
From form to form, and nothing stands;
Like mists they melt, the solid lands,
Like clouds they shape themselves and go.'"

CHAPTER V

A RAMBLE ON THE MOON

How like a queen comes forth the lonely Moon
From the slow opening of the clouds;
Walking in beauty to her midnight throne!
—GEORGE CROLY, *Diana.*

TO OBSERVE the Moon from the time of its illumination at sunrise until the hour when it becomes enshrouded in gloom is to embark on an enterprise of endless delight. The observation must necessarily be made at intervals during the course of an ordinary lunar month of twenty-nine days, twelve hours, and forty-four minutes, since the time elapsing between sunrise and sunset is equivalent to a period of 304 hours. We see the Moon wax and wane from the time it appears as a silver crescent in the western sky for a brief interval after sunset until, when it has passed through all its phases, it once more greets us in crescent form in the west.

Much pleasure may be derived by means of a

binocular or a good field-glass, serving as an introduction to a more extended study of the Moon by the use, later on, of a telescope or photography. Some readers may be surprised at the idea of a binocular being raised to the dignity of an astronomical instrument, but it has many advantages for the amateur who is not the fortunate owner of a telescope. It is easily brought into operation, is not affected by atmospheric disturbance, and has a splendidly wide field of view. In my father's book, *Half Hours with the Telescope*, he notes the surprise with which, when carefully steadied and focussed on certain regions of the heavens, its revelations are frequently received. Moreover, as we have already seen, it embodies the principles on which telescopes were first constructed, and permits the use of both eyes at the same time, thus affording a stereoscopic effect.

More or less successful attempts have been made from time to time to fit binocular eyepieces to large telescopes. Thus, Huggins once used a Ross binocular on his 8-inch equatorial—the effect produced with a 3-, 2-, or 1-inch objective was very beautiful, but he doubted if the idea possessed any practical utility. The new prism binoc-

ulars that have come into use within the past few years are excellent for general views of the Moon. Their defining powers are superb, and one who has never seen the Moon with such a glass is always greatly surprised and delighted with the view which it affords of the broad general features of the lunar surface. Moreover, it shows the disc in its natural position as seen with the naked eye, and not reversed as it appears when seen with a telescope. The western edge is at the right hand and the north at the top, while in a telescope the eastern edge is at the left hand and the south at the top.

If we watch the Moon as it waxes and wanes, we see the true nature of the sharp contrasts of light and shadow in its bleak, rugged scenery. Solitary peaks rise from the level plains, casting their long narrow shadows athwart the smooth surface. Vast plains of a dusky grey hue become visible and the surface is seen marked with hollows and pits or covered with fragments of rocks. Occasionally a regular symmetrical formation comes into view, such as Copernicus, its exterior wall bristling with terraces rising gradually from the plain beyond, but descending as a steep

THE MOON—AGE NINE AND THREE-QUARTER DAYS
Photographed through colour filter, with forty-inch refractor, at Yerkes Observatory,
by G. W. Ritchey

precipitous cliff to the flat floor on the interior, in many cases thousands of feet below ground level.

The consequences of the slow march of the Sun across the lunar sky begin to show themselves from the moment of lunar dawn which has not any counterpart on the Earth. There is no atmosphere to collect the rays of sunlight, painting the eastern horizon with softest tints of rainbow hue, but from the black horizon the Sun suddenly darts its bright untempered beams upon the mountain tops, crowning them with dazzling brilliancy, while the valleys below are still in utter darkness. Here we find no blending of day or night, or the marvellous glowing and gilding which make sunset or sunrise so gorgeous as seen from our planet. Only upon some rare occasions is the lunar scenery suffused with coloured light, such as during an eclipse of the Sun when the solar rays reach the Moon's surface, after passing through the earth's atmosphere.

Such a scene as observed on the Moon makes one feel envious when we consider the brief period of totality during a total eclipse of the Sun, as we see it here. For us the duration can never exceed eight minutes, but for the privileged spec-

tators on the Moon(could any such exist?) a view of the corona would extend over several hours. As the Sun passed behind the Earth, the latter would appear encircled with a line of golden light, deepening in places to glowing crimson, due to the absorption of all but the red and orange rays of the Sun's light by the vapour of our own atmosphere. This circle of light would be the ring of twilight round our globe and it would only appear red in those places where the atmosphere chanced to be in that condition favourable for producing what on Earth we know as sunset and sunrise. The Sun would be shining through a great thickness of atmosphere, reddening it, just as we see it at sunset or dawn. Thus, from the surface of the Moon at the time of a total eclipse of the Sun, the observer would see the ring of light around the black Earth-globe brilliantly crimsoned. The other parts would be tinted with shades of red and yellow and the whole effect would result in our planet presenting the appearance of a dark sphere encircled with gold and rubies, suspended in the lunar sky. At such times it is the Earth which causes a total eclipse of the Sun for the lunar spectator.

During the course of a lunar day, when the first rays of sunlight are illuminating the crescent Moon, we are able to see the reflection of what is popularly termed "Earth shine" on the Moon's surface. The age of the Moon is then about three days and with a binocular a clear view may be obtained of the New Moon in the Old Moon's arms. This is too faint to be photographed and only the part illuminated with sunshine is visible.

Let us imagine that we have landed on lunar soil so that we may pursue our ramble from sunrise to sunset, the accompanying map enabling us to identify the more prominent seas, bays, or mountain heights. These can be easily detected by means of a binocular as they gradually come into view. A glance, during the daytime, at the photograph of the Moon (which, however, shows the Moon inverted) is helpful in locating various regions, so that they are more easily recognised when the observations are made at night. When these fundamental markings are known, (and it may require some time to obtain a complete record, owing to cloudy skies) further knowledge may be acquired by means of a small telescope or a large one if the observer is able to obtain

access to an observatory where visitors are invited on special evenings in the week.

There are a few in England, but in America the advantages for thus obtaining knowledge at first hand is considerable. On Saturday afternoons during the summer months from June 1st to September 30th, between 1.30 and 4.30 P.M. and between 10 A.M. and 12 A.M. during the remainder of the year, visitors are admitted to the Yerkes Observatory at Williams Bay, Wisconsin. A member of the staff demonstrates the operation of the large telescope, a refractor with a 40-inch lens, and explains the work of the Observatory. Interesting astronomical photographs are displayed in the corridors. Over ten thousand visitors annually avail themselves of this opportunity. However, owing to the pressure for time for their scientific use, it has been impossible to permit visitors to see through the telescopes at night.

At the Lick Observatory, California, the observatory is thrown open to visitors on Saturday evenings, and they are allowed to look through the great lens of the 36-inch refractor, a privilege of which thousands avail themselves during the course of the year. James Lick, donor of the

great telescope, made this conditional, so that the people in the surrounding valleys of Mount Hamilton, whereon the Observatory is situated, should enjoy the advantages he had thus placed at their disposal.

The same privilege has recently been extended in connection with the great reflectors on the summit of Mount Wilson, in southern California, where visitors are made welcome on Friday nights and are given an opportunity to obtain a glimpse of the heavens through the 60-inch reflector. When the weather is unfavourable they are shown over the dome containing the great 100-inch Hooker telescope and its mechanism is explained by a member of the staff. Moreover, an illustrated lecture is given in a bungalow near by, where a member of the staff shows photographs taken with the great reflectors and gives the story of the Observatory from the time when the first buildings were erected, up to the present climax of this great venture which has proved such a stupendous success.

There are numberless smaller observatories in U. S. A. where such privileges are extended, and quite recently (1927) an Amateur Astronomers'

Association has been founded affiliated with the Amateur Astronomical Societies of other cities, the headquarters being in New York City at the American Museum of Natural History, in Central Park. Thus correlative interest is maintained and the query arises, what are we doing along these same lines in our country? It is true we have the British Astronomical Association for amateurs with its monthly Journal which compares not unfavourably with *Popular Astronomy*, published at Carleton College, Northfield, Minnesota. There are also a few observatories where the directors are doing useful work in behalf of research students and amateurs, but the larger observatories, such as the Royal Observatory, Greenwich, the Cambridge Observatory, and the Oxford Observatory, are entirely too much occupied with special work to admit visitors.

With the dour weather and cloudy skies which prevail in our country, enthusiasm might well be at a low ebb, but is it? The British Astronomical Association numbers 1,000 or more and many have joined the ranks of the Royal Astronomical Society. After the keen interest displayed by young and old at the total eclipse of the Sun, June 29,

1927, no one can say we lack enthusiasm, but rather the opportunity. Hundreds flocked to the shadow track to observe the total eclipse of the Sun on that eventful occasion. Some climbed Mount Snowdon in the drenching rain; others patiently awaited the moment of totality under the most trying weather conditions, but, unfortunately, without success. Yet we are already looking forward and planning for our next total eclipse of the Sun, due in the British Isles in 1954, or twenty-seven years hence. Dr. A. C. de la Crommelin, doubtless taking into consideration the fact that hundreds of boys and girls had journeyed northward on the eve of the 1927 eclipse to well-selected points of vantage along the shadow track only to meet with disappointment, found, on revising the calculation regarding our next eclipse, which would not be until 1999, that, owing to some slight error in the calculations, the coming eclipse of 1954 would give them another chance. It is true the most favourable vantage-point will be the island of Unst, in the Shetlands, but by that time doubtless many will own aëroplanes and rapidly cover the distance from the south of Eng-

land to the Shetland Islands by means of some such conveyance.

While on the topic of amateur astronomy and before starting on our lunar ramble it is interesting to note that, despite the disadvantages with regard to weather, our country boasts of many who have adopted astronomy as a hobby and accomplished valuable work in that direction, notably James Nasmyth, a practical engineer by profession and the well-known inventor of many mechanical devices such as the trip-hammer, etc. He took up the study of astronomy merely as a delightful recreation in which he indulged after the daily exertions at the Bridgwater Foundry. He made a small but very effective telescope which he used at his home at Patricroft (near Manchester, overlooking the banks of the Bridgwater Canal) at the time he began his survey of the heavens. His book on *The Moon*, written in conjunction with James Carpenter, F.R.A.S., and illustrated with his own exquisite drawings of the lunar surface, has become more or less of a classic.

To quote his own words as given in his autobiography:

"Need I say with what exquisite delight the harmony of the splendour of the heavens filled me? I began as a learner and my learning grew with experience. My observations were at first mainly general; by degrees they became particular. I was not satisfied with enjoying these sights myself; I made my friends and neighbours sharers in all my pleasures; and some of them enjoyed the wonders of the heavens as much as I did. In my early use of the telescope I had fitted the speculum into a light square tube of deal, to which the eyepiece was attached, so as to have all the essential parts of the telescope combined together in the most simple and portable form. I had often to remove it from place to place in my small garden at the side of the Bridgwater Canal in order to get it clear of the trees and branches which intercepted some object in the heavens which I wished to see. How eager and enthusiastic I was in those days!

"Sometimes I would take the telescope in my arms, in the clear small hours of the morning, and plant it in some suitable spot

where I might get a peep at some special planet or star then above the horizon. It became bruited about that a ghost was seen at Patricroft. A barge was silently gliding along the canal near midnight when the boatman suddenly saw a figure which, as he declared—'moved among the trees with a coffin in its arms.' The place was haunted, but the ghost was merely myself and the coffin was my telescope which I was quietly shifting from one place to another in order to get a clearer view of the heavens at midnight."[1]

In 1842 Nasmyth began his systematic researches upon the Moon and in the chapter entitled "The Moon as a World" he writes:

"Seated in silence and in solitude at a powerful telescope, abstracted from terrestrial influences and gazing upon the revealed details of some strikingly characteristic region of the Moon, it requires but a small effort of the imagination to suppose oneself actually upon the lunar globe, viewing some distant landscape thereupon, and under these circum-

[1] *An Autobiography*, pp. 315-316.

stances there is an irresistible tendency in the mind to pass beyond the actually *visible*, and to fill in with what it knows must exist, those accessory features and phenomena that are only hidden from us by distance and our peculiar point of view. Where the material eye is baffled the clairvoyance of reason and analogy comes to its aid." [2]

In the preface to his *Autobiography* he tells that,

"during upwards of thirty years of assiduous observation every available opportunity has been seized to educate the eye not only in regard to comprehending the general character of the Moon's surface, but also to examining minutely its marvellous details under every variety of phase, in the hope of rightly understanding their true nature as well as the causes which had produced them. This object was aided by most careful drawings of each portion or object when it was most favourably presented in the telescope. These drawings were again and again repeated, re-

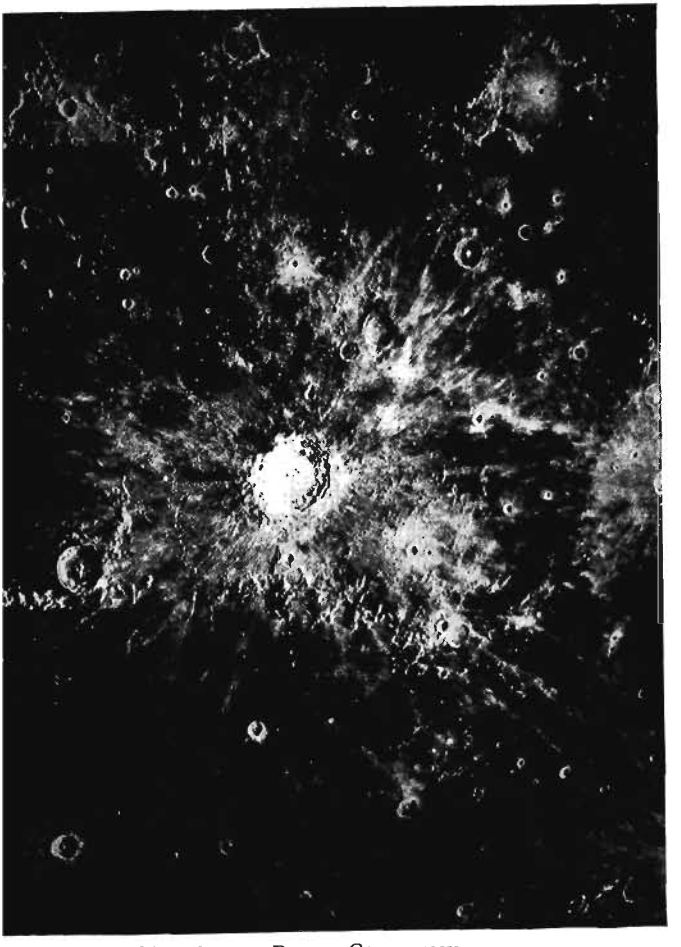
[2] *Ibid.*, p. 158.

vised and compared with the actual objects, the eye thus advancing in correctness and power of appreciating minute details, while the hand was acquiring, by assiduous practice, the art of rendering correct representations of the objects in view.

"In order to present these illustrations with as near an approach as possible to the absolute integrity of the original objects, the idea occurred to me that by translating the drawings into models which, when placed in the Sun's rays, would faithfully reproduce the lunar effects of light and shadow and then photographing the models so treated, we should produce most faithful representations of the original."

The result was in every way highly satisfactory, yielding marvellous pictures of the details of the lunar surface.

These drawings are now superseded in value by the photographs which have been obtained at the leading observatories, yet from another viewpoint they illustrate the careful, painstaking efforts of an amateur thoroughly captivated by



THE REGION ROUND COPERNICUS
Photographed with one hundred-inch reflector at
Mount Wilson

the study of the Moon. Another amateur astronomer whose book, *Celestial Objects for Common Telescopes* is specially helpful to owners of small telescopes was Rev. T. W. Webb, appointed Vicar of Hardwick in 1852. In addition to descriptive accounts of lunar details the sixth edition of the first volume contains a map of the Moon in four sections, by Mr. Walter Goodacre, F.R.A.S., which is invaluable and should be in the hands of all amateurs. We are told that "the post brought an appalling amount of correspondence from them to Hardwick," and the letters were all answered "carefully, kindly, and encouragingly," a boon to the beginner who is in earnest. "Everything in nature had a charm for Mr. Webb and the amount of his knowledge and powers of observation were well known to anyone who had the privilege of going on a country walk with him."

After studying the subject of lunar details with Webb's book, then, it is advisable to read Elger's book on the Moon and study its accompanying maps. Pickering's *The Moon, a Summary of Recent Advances in Our Knowledge of Our Satellite,* and my father's book, *The Moon, Her Motions, Aspect, Scenery and Physical Condition,*

which gives an exposition of the mathematical as well as the popular side of the subject, are also helpful in enabling one to acquire a more complete knowledge from the technical standpoint.

Then there is *An Atlas of Astronomy*, by Sir R. S. Ball, for those who have not the time or opportunity to go into the study of lunar detail so minutely but merely wish to become acquainted with the names and position of the main markings. This book contains a series of maps of the Moon, from the time it is but a narrow crescent until the fourteenth day, when it has reached the zenith of its splendour as Full Moon. The plates have an accompanying key-map on the opposite page, a few moments' study of which, in the daytime, would be sufficient to make these markings recognisable in the evening without further reference to the map.

The names and positions of the various seas, bays, oceans, and so forth soon become as familiar as those of London, Paris, or New York on a terrestrial map and greatly enhance the pleasure of a ramble on the Moon. (The writer had exceptional opportunities in becoming acquainted with the geography of the Moon under the guidance of

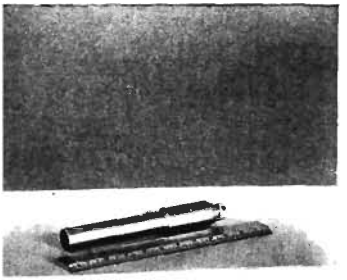
her father, and many a delightful evening was spent in "discovering" the whereabouts of the Sea of Serenity, the Bay of Rainbows, and other lunar regions as they alternately came into view. On these evenings—weather permitting—the observatory at home was a scene of intense excitement, leading eventually to a life-long interest in astronomy.)

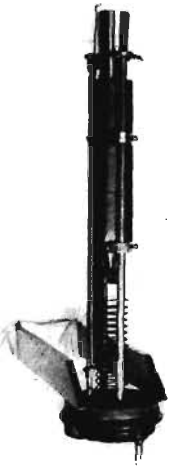
There are three more books which may be recommended for studying the Moon from the popular standpoint and especially for those who have only a binocular at their disposal. All three can be obtained in any well-equipped library. The first is *A Day on the Moon*, by Abbé Th. Moreux, director of the Brûges Observatory; the second is *The Moon, a Popular Treatise*, by Garrett P. Serviss, and of inestimable value, owing to the reproduction of a series of 21 photographs of the Moon. These show its phases from the time its age is 3.85 days until it has reached the age of 26.89 days, thus completing a lunar day and night.

These photographs were taken with the 12-inch telescope of the Yerkes Observatory by Mr. James Wallace, who employed a colour filter that

ful field-glass. Undoubtedly one might say that by means of photography all has been learned that *can* be learned concerning the surface of the Moon; but this does not apply to the changes which are seemingly taking place thereon. For this a continuous series of photographs would be requisite, if such could be obtained.

After this somewhat lengthy preamble regarding ways and means by which a ramble on the Moon may be accomplished we are ready to start on our journey, the map serving as a guide to the main outlines which can be observed with a binocular. It is the hour of dawn on the Moon and we have the advantage of seeing the New Moon in the Old Moon's arms. The part which we see in the photograph is illuminated with sunshine, while the remainder of the moon reflects only the Earth shine which is too faint to be photographed with the amount of exposure required to make a good picture of the crescent. The Earth, which sends to the Moon about fourteen times as much reflected sunlight as the Moon sends to the Earth, is a large Moon to the imaginary inhabitants of the Moon. Consequently, an earth-lit night on the Moon is far more bril-



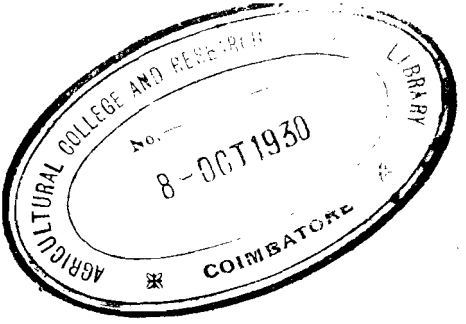


(Upper Left) First form of powder rocket used to secure a high velocity of the ejected gases. It consists of a combined chamber and nozzle (the end of the nozzle shows black). The gas velocity was about one and one-half miles per second, average velocity. Shown complete and taken apart.

(Upper Right) Tank used in tests of small powder rocket *in vacuo*. Rocket was fired at upper end of tank, and the gases, shot downward, were prevented from rebounding by being slowed down gradually, by friction.

(Lower Left) Rocket and support (also lead sleeves to increase the weight) used in the experiments *in vacuo*. The pipe-cap at the top of this photograph screws on the top of the long tank shown above.

(Lower Right) At work on latest model in physical laboratory at Clark University.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liant than a moonlit night on the Earth. To those who have enjoyed the splendour of a moonlit night in the tropics, and especially when crossing the Pacific Ocean, some idea may be conveyed of what that splendour would mean increased about fourteen times in brilliancy.

While pausing on the shore of the flat, smooth plain to which the name of the Sea of Crises or Mare Crisium was given a couple of centuries ago, let us glance upward at the great Earth-Moon and picture to ourselves how others would see us if the Moon by any possibility were inhabited. Her orb, beautiful from its size and splendour, and the variegated bluish and yellowish patches indicating land and water, half hidden, half revealed, by ever-changing masses of drifting cloud, would appear girt round with a ring of diffused starlight glowing through its atmospheric veil. Since the Moon has no sky, properly so called, the stars would shine with intense brilliancy as seen projected against the lunar heavens.

Homer's famous description of a moonlit night corresponds far better with the lunar scene than with night on the Earth, for whereas on Earth the

glory of the moon hides the heaven of stars from our view, on the Moon, in the far greater splendour of the full earth:

> "the stars about the Earth
> Look beautiful . . .
> And every height comes out, and jutting peak
> And valley, and the immeasurable heavens
> Break open to their highest, and all the stars
> Shine."

After duly contemplating our planet as seen across the intervening 238,840 miles, let us turn our attention once more to the region of the Moon for the time being, supposedly underfoot. We are standing on the shore of the Sea of Crises, which presents the appearance of an empty seabed. It is, in fact, a deep depression about 350 miles in length by 280 in breadth. One can readily picture it as it may have appeared in the days of old, filled with water, thus forming a deep navigable sea. There is a stupendous promontory on the southwestern border, called Cape Agarum, which projects 50 or 60 miles into the sea, the highest part rising some 11,000 feet above its floor. On its summit would be a suitable site for a lighthouse, sending forth searching beams along

the steep, abrupt ridges leading to the valley below.

To the north of the Sea of Crises and just on the border line between day and night, there is a perfect oval ring called Langrenus, south of which is the still larger crater Vendelinus. Beyond Vendelinus there is another ringed plain or walled valley with a conspicuous mountain in the centre which is named Petavius. The three craters form a chain and Petavius is more wonderful than either of them. It is nearly 100 miles long from north to south, and a curious thing about it is the way its vast floor rises in the centre, which is 800 feet higher than the surrounding surface. According to Webb, "the central mass consists of several detached peaks and it suggests the idea that, in the days of long ago, it may have been rent asunder by some violent explosion which also caused the clefts on the floor which radiate from it."

Each evening as we return to our ramble on the Moon we find that more plains and craters have come into view under the advancing illumination of sunrise, notably the crater mountain Proclus, which is, however, at its best as a shining

nountain at the time of Full Moon. It then shares the honours with Aristarchus, Copernicus, Kepler, and Menelaus, which are not as yet visible, being hidden beneath the impenetrable darkness of a lunar night. From the foot of Proclus spreads the Marsh of Sleep, which leads most appropriately—as far as names are concerned—to the Sea of Tranquillity. What suggested these romantic names to Galileo and others who first mapped-out the lunar markings we have no record, but it is well they are retained, since they add a poetic interest to the study of the geography of the Moon.

Continuing on our ramble we cross a narrow neck of land to the shores of the Sea of Fertility along the western border. The name is suggestive of a smooth stretch of water—fanned by gentle breezes and bordered by luxuriant vegetation, while in reality it is a rugged desolate region dented by numberless extinct craters, while the shore line is surrounded by steep hills and surmounted by jagged peaks. A promontory curves eastward towards the Sea of Nectar, which is bordered by three craters, named, respectively, Theophilus, Cyrillus, and Catharina.

the deepest of all the craters, if we regard the general line of the ring which ascends from 14,000 to 18,000 feet above the interior chasm. Its central peak is over 5,000 feet high and its diameter is 64 miles. According to Webb, "no scene in the least approaching to it exists on the Earth. It is a grand object when filled with night, through which its glittering central peak comes out like a star." Cyrillus is equally large and built up in a series of terraces sloping down to the outer plain. Catharina, its mountainous wall containing peaks rising 16,000 feet above the interior, is the largest of the three. One wonders if the sunlight ever reaches its profound abysmal depths, yet as a matter of fact the whole of the interiors of Cyrillus, Catharina, and Theophilus are visible in sunshine for about 14 days in each lunation.

To the south of the Sea of Tranquillity our ramble leads us to the Sea of Serenity, with the Lake of Death and the Lake of Dreams nestling on its northwestern border. The Sea of Serenity covers nearly the same area as the Caspian Sea and is a magnificent view when seen with a powerful telescope. It presents the appearance of a sea of glistening silver, slightly greenish in hue, with

a remarkably bright streak through the centre. After apparently starting from the crater Tycho, it traverses a distance of 2,000 miles, heedless of every obstacle encountered on the way. For instance, there is a large crater named Saussure, not far from Tycho and directly in a line with the Sea of Serenity. But is our ray deflected in consequence? Not an iota, for it climbs up one side just as a vein of trap or volcanic rock pierces the sedimentary strata upon earth and down to the interior, crossing over to the other side, where it again ascends till it reaches the summit, whence it descends and pursues its way to the terminus.

What then can we make of such phenomena, Saussure being only one of the craters whence the rays extending from Tycho pass onward undeterred from their course by valley, crater, or mountain ridge. According to my father's theory,

> "Are not our terrestrial trap dykes or veins their fitting similitudes? Piercing the other rocks as if shot up from below, these singular veins pass onward across valley and over mountain; their direction *their own*—independent for the most parts of the rocks they

have cut; they appear, too, in *systems*, some limited in magnitude and evidently radiating from a known source; others of vast extent and usually considered parallel but probably owing their apparent parallelism to the fact that we trace them only through a brief portion of their course. Accept this analogy—and none other appears within reach—and the rays or bright lines of the Moon assume an import quite unexpected—they become *indices to those successive dislocations that constitute epochs in the progress of our satellite.*"[1]

The streak crossing the Sea of Serenity can be plainly seen on the map showing the Moon when its age is 9.22 days. The magnificent crater Tycho, which Webb describes as the metropolitan crater of the Moon, is far southward and the sunlight can be seen illuminating the interior on the western side, its rim clearly outlined in the sunlight. It presents a magnificent appearance as the Sun rises over it, gradually illuminating the enormous cavity in its centre and bringing into view

[1] *The Moon*, by Richard A. Proctor, first edition, p. 253.

a very wilderness of hillocks and craterlets in its neighbourhood, eight large ones being specially prominent, reaching like a pendant from Tycho towards the Central Gulf which occupies almost a central position on the Moon.

At the time of Full Moon the crater Tycho becomes the central pivot from which a series of streaks, glistening in the sunlight, radiate in all directions. This crater is 54 miles in diameter and its depth is 17,000 feet, or nearly 3 miles, so that the summit of our Mt. Blanc would drop out of sight beneath the ring. From the ninth to the fourteenth day it is interesting to watch its gradual illumination until it stands revealed as the most radiant spot on the Moon, not even excepting Copernicus, which is its most important rival.

Like Tycho, this crater, which we reach after passing across the Sea of Clouds, is the centre of a system of light-streaks, somewhat resembling those of that crater, but very much shorter. It is 56 miles in diameter, thus exceeding that of Tycho, which is only 54, but it is not quite so deep. In describing its appearance, Serviss remarks that, "it has a cluster of peaks in the centre whose tops may be detected with a field-glass as a speck of light

when the rays of the morning Sun, slanting across the valley, illuminate them while their environs are yet buried in night." The highest peaks on the rim are 11,000 feet above the floor and the inner mounds rise to 2,200 feet. When the Moon is in the first quarter nothing can be more beautiful than the lights and shadows of the rocky cliffs and walls exhibited by this crater.

The stony desert out of which Copernicus rises is known as the Ocean of Storms, bound on the western border by the Apennines and the Sea of Vapours, on the north, by the Carpathian Mountains, on the east, by the Ocean of Storms and on the south, by the Sea of Clouds. Northward the Bay of Rainbows, and the Bay of Dew are to be seen when the Moon is nearing the fourteenth day, by which time it has attained the zenith of its splendour as Full Moon.

But what has happened meanwhile? The familiar objects which greeted us at sunrise are now lost in the glare of sunlight. The Sea of Crises has grown dim, but the shining mountains of Proclus, Aristarchus—once mistaken by Herschel for a volcano—Tycho, Copernicus, Menelaus, and Kepler glow vividly, while the crater

Maginus, to the south of Tycho, and Clavius near by, which are most impressive when the sun is rising upon them, absolutely vanish. As the two great selenographers, Beer and Mädler, have expressed it, "the full Moon knows no Maginus." During the next two weeks the Sun sets over the Moon, and gradually the seas, craters, and mountain ranges vanish, the Sea of Crises and the Sea of Fertility being the first to disappear, soon followed by the others, till night prevails.

The foregoing is merely an outline sketch of the delights of a ramble on the Moon which can give endless pleasure from month to month until the positions of the main outlines become as familiar as a journey to foreign lands after repeated visits. It is an interest which grows on repetition, and soon the binocular is replaced by a telescope, however small, and preferably one which can be easily handled and carried to the most suitable spots for making observations on moonlit nights. According to my father's views on the subject:

> "I cannot indicate a more pleasing occupation for the possessor of a telescope, 2¼

inches aperture (or any larger size up to four inches), than to go over the Moon's disc, examining each object seriatim and carefully comparing what is seen with the account given by Mr. Webb. In particular, it is a most useful and instructive exercise to observe the varying appearance of particular objects as they come into sunlight, as sunlight grows fuller upon them, and afterwards, as sunlight passes away from them, until at length they are in darkness.

"The most convenient objects to select for this purpose (though it need hardly be said that the true lunarian astronomer will not be content with observing these only) are those which lie near the terminator of the Moon rather early during her first quarter, for these will be again on the terminator rather early in the third quarter. Thus they can be observed in the early evening and then later and later, until, when the terminator is just leaving them, they must be observed after midnight, but not very late; whereas, those objects which are first reached by the advancing terminator during the Moon's

second quarter are left by the receding terminator during the fourth quarter and to be well studied at this time must be observed in the early morning hours.

"Those students of astronomy, however, who are ready to observe at any hour of the night from twilight to dawn can study any part of the Moon from sunrise to sunset at that part. It will be obvious that, thoroughly to examine any spot on the Moon, it must be observed during many lunations. Apart from the circumstance that unfavourable weather breaks the continuity of the observations, the interval of many hours elapsing between successive observations suffices to render the study of any spot during any single lunation imperfect.

"This is especially the case with objects near the eastern and western limbs because the Moon must be nearly new (either before or after conjunction with the Sun) when sunrise or sunset occurs at such points and the Moon can only be observed a short time in the morning when she is approaching conjunction and a short time in the evening soon

after conjunction. But even for other parts of the Moon the difficulty exists. An observer may watch the progress of sunrise at any spot near the terminator of the half Moon, hour after hour, for several hours in succession, but he must be interrupted for a much longer period, after the Moon has approached the horizon too low for useful study, until she is again at a fair elevation.

"Now in the interval—say sixteen or seventeen hours—sunrise or sunset at the spot will have made great progress notwithstanding the great length of the lunar day. For sixteen hours on the Moon (about a forty-fourth part of the lunar day) correspond to more than half an hour on the Earth and we know that in every part of the Earth the Sun's place on the heavens alters considerably in half an hour. In fact, in sixteen hours, the Sun, as seen from the Moon, changes his place by about eight degrees and this most importantly affects the position and dimensions of the shadows thrown by any lunar heights, especially near the time of sunrise

and sunset. It is further to be considered that the circumstances under which a lunar spot is studied vary markedly during the progress of a lunation." [1]

[1] Footnote to first edition, pp. 220-221, of the book on *The Moon*, by Richard A. Proctor.

CHAPTER VI

A GLIMPSE OF LUNAR SCENERY

"Meanwhile the Moon
Full-orb'd, and breaking through the scatter'd clouds
Shows her broad visage in the crimsoned east
Turned to the sun direct, 'her spotted disk
Where mountains rise, umbrageous dales descend,
And caverns deep, an optic tube descries
A smaller earth—gives all his blaze again,
Void of his flames, and sheds a softer day."

—JAMES THOMSON.

SINCE the days of Galileo, when magic glasses thrilled the first observer who gazed upon the Moon and learned that it was but "a smaller Earth," telescopes of increasing size and power have been constructed culminating in the giant reflectors at the Mount Wilson Observatory in Southern California. Such instruments enable an observer to acquire a more intimate knowledge of the lunar surface not only visually, but by means of photography. They may serve eventually to solve such problems as to whether suspected changes are taking place on the Moon, and help to

unravel the mystery of the Systems of Bright Rays which are so perplexing.

Various theories have been advanced as to their origin, and in his presidential address, at the British Astronomical Association, October 29, 1924, Mr. W. Goodacre, the well-known authority on lunar detail, in discussing the Systems of Bright Rays, drew attention to the fact that these rays are not confined to any one portion of the disc. He referred to the well-known systems radiating from Tycho, Copernicus, and Kepler, as well as other centres associated with Proclus, Anaxagoras, Stevinus, and Aristarchus.

> "Of their true nature," he remarked, "we are still in ignorance, though many minds have been occupied in trying to unravel their mystery. The few facts we have established about them are that they are surface markings, not rising above the level of the ground on which they lie. They are not subject to any periodical changes, and reappear month by month without any alteration of position or feature. They are not like certain other markings which wax and wane in a regular

way in each lunation. At the same time I think they differ in constitution among themselves. If we examine a good photograph, we see that the Tycho rays differ a good deal in appearance from those emanating from Copernicus and Kepler. The Proclus rays, on the other hand, have a likeness to those of Tycho.

"They also differ considerably in brightness, the Tycho rays being brighter than those of Copernicus. It may be that the material forming the rays in the latter case is spread out more thinly—the Copernican rays, from the forms they assume, look like thin snowdrifts on an irregular surface. As to the nature and origin of these rays, there is a general consensus of opinion that they are formed by the emission of some crystalline vapour, which has come up to the surface through cracks too small for us to see, and which vapour has been deposited on either side throughout their whole length. The nimbus of light which surrounds the large crater rings, and from which the streaks radi-

may have been deposited as the direct result of volcanic eruption.

"Professor W. H. Pickering has pointed out the significant fact that the streaks are really short stretches of bright surface end to end, and not continuous, and that there is generally a small bright crater located at the end of the streak nearest the radiant point. This is quite true, and can readily be seen on some of the streaks radiating from Copernicus. These craterlets will be found along the course of the streak, and not on either side. The theory that crystalline emanations caused the rays finds support in the fact that scattered all over the surface we find small bright craters standing on or surrounded by a nimbus of light, the natural assumption being that the bright material has been ejected from the crater. If these craterlets were larger in size and had been formed at the same time as Tycho and Copernicus when eruptive energy was more violent, it is possible that the emanations would have been deposited at greater distances in the form of rays."

Some years ago Mr. H. G. Tomkins, F.R.A.S., advanced the ingenious theory that the bright rays were composed of salt left by the drying up of old oceans, as illustrated in the extensive salt deposits on the surface of N. W. India. In a lecture on the Moon delivered at the Town Hall, Calcutta, on March 1, 1912, he referred to this theory, giving an account of the alkali tracts which exist for miles and miles over the plains of the Punjab and over large tracts in other countries (a country in which salt wells and saline soils abound is Germany, and there are some in France.) They are enormous plains covered with saline efflorescence.

> "The salt is of sodium type, and some of it is nearly pure sodium chloride such as we eat every day. Other plains consist of sodium sulphate. The source of the material is in the soil. Whether it is a bed below the surface or not, is not quite certain, but that it exists in enormous quantities not far below the surface is clear. Moreover, it seems likely that similar supplies are really present in nearly every part of the globe, though

climatic conditions keep them out of sight. In desert regions and arid tracks, however, the alkali plains as they are called, abound. Now the behaviour of these salts is, as follows:

"Given the supply, water dissolves it and keeps it in the soil; a hot sun, however, and dry weather cause upward currents to be set up in the crust and the saline water flows up to the surface, bringing with it the salt in solution. When it reaches the surface the water is dried up and the salt is left. This effloresces and forms the plains we see. Rain immediately dissolves the salt and washes it again into the soil, but on the sun reappearing the process is repeated. A curious feature of the alkali is its appearance along the tops of mounds or ridges." [1]

With the help of District Officers it was possible for Mr. Tomkins to put his theory to a practical test, by mapping out the tracks in the Punjab, and the result obtained was sufficient to show that in

[1] *Lecture on the Moon*, by H. G. Tomkins, F.R.A.S., delivered at Calcutta. Session 1911-12.

India there is what looks very like a ray system with a salt range as the centre. There is a strip lying between the Ganges and the Jamuna in the United Provinces, extending for practically 600 miles, which is a watershed.

> "Thus, we have the slight elevation we require by theory and the water supply on either side to carry off the salt. The deposits, however, are not so prominent as in the Punjab higher up the ray, and this we should expect.
>
> "Now how does this idea fit in with the conditions on the Moon? It fits in very well indeed. Firstly, of all the elements, sodium is probably one of the most universal in all bodies of the universe. We know it exists on the Earth, and if, as seems likely, Sir George Darwin is correct in his belief that the Moon once upon a time was part of the Earth, it must be there also. We are not, therefore, unduly stretching our credulity if we assume its presence on the Moon also. . . . Certainly there are traces of what looks like the action of a liquid in some directions. However that

the so-called seas. These—that is, all which have been observed with a telescope or photographed, have been named and mapped, so that there is no remaining space on the surface of the Moon ever turned towards us, on which to write the legend "unexplored." There are mountain-chains, trough-like valleys remarkable for their straightness, thousands of circular valleys with raised rims, thousands of bright streaks which are neither ridges nor hollows but mere bands of colour, and hundreds of narrow depressions which have been called rills. Thus, a lunar landscape, despite the absence of trees, verdure, or vegetation (though suspected by Pickering and others), is as varied in its way as a terrestrial scene, but lacking the soft blending effects of light and shadow, due to the absence of atmosphere.

With regard to certain colour changes on the Moon suggestive of the possible growth of vegetation, Captain Noble, in his well-known *Hours with a Three-inch Telescope*, draws attention, on page 36, to one valuable piece of evidence furnished by the ray system. It is, that the proof afforded by their continuous visibility and the homogeneous character of their brightness

throughout their course indicates "that the reflective substance of which they are composed is absolutely everywhere uncovered." Did anything in the shape of vegetation, for example, exist in the Moon, it must obscure portions of these light streaks. That they pass undimmed, then, from their origin to their termination, shows plainly enough that they traverse "a rocky desert, devoid of life or living thing."

Having surveyed the mysterious ray system which has so far baffled elucidation, let us turn our attention to that superb crater, Copernicus, which dominates the lunar landscape when the Moon is nine or ten days old, vying with the Bay of Rainbows, an outlet from the Ocean of Storms, in presenting a perfectly charming spectacle to the observer, even if viewed with the limited power of a 3-inch telescope. Copernicus is specially interesting as being evidently the result of a vast discharge of molten matter which has been ejected at the centre of a portion of the lunar crust extensively upheaved. A glance at the photograph taken with the 100-inch at Mount Wilson gives evidence of the violence of the outbreak as shown in the wonderfully complex system of bright

streaks radiating in every direction from the crater as their common centre. These are seen at their best at the time of Full Moon. The upheaval caused by the cracking of the crust must have been followed by the ejection of molten matter forced up through the resultant cracks and spreading on either side of them in some cases to a distance of 100 miles or more.

Picture to yourself a vast circular plain 56 miles in diameter, the following illustration giving some idea of the stupendous magnitude of this crater. We may try to realise its vastness by considering that one of our average English counties could be contained within its ramparts, or by conceiving a mountainous amphitheatre whose opposite sides are as far apart as London and Canterbury, but even these comparisons leave us unimpressed with the true magnitude which this crater would present if observed by a spectator on the Moon. "We read of an army having encamped in the once peaceful crater of Vesuvius, and of one of the extinct volcanoes of the *Campi Phlegroei* being used as a hunting preserve by an Italian king. These facts give an idea of vastness to those who have not had the good fortune to see the actual dimensions

of a volcanic orifice for themselves."[1] But it is impossible to conjure up a vision of the magnitude of Copernicus, and how it would appear could we visit the Moon and stand within its ramparts, for want of a terrestrial object as a standard of comparison.

According to Webb, this crater contains a central mountain 2,400 feet high, two of whose peaks are conspicuous, and a noble ring composed not only of terraces, but distinct heights separated by ravines: the summit, a narrow ridge, not quite circular, rises 11,000 feet above the bottom—the height of Etna, after which it was named. Piazzi Smyth observed remarkable resemblances between the cliffs of the interior and those of the great crater of Teneriffe. A mass of ridges leans upon the wall, partly concentric, partly radiating; the latter are compared to lava, and the whole is a grand object when it comes into sight a day or two after first quarter. Vertical illumination brings out a singular cloud of white streaks related to it as a centre, and some portions have a bluish tinge. The ring is said to sometimes resemble a string of pearls, as many as fifty specks answering

[1] *The Moon*, by Nasmyth, pp. 191-192.

to that description being counted at one time.[1] The Mount Wilson photograph shows a remarkable amount of fine detail, and seven small mountains near the centre of the crater. Serviss tells us "that the peaks of these mountains may be detected with a field-glass, as a speck of light when the rays of the morning sun, slanting across the valley, illuminate them while their environs are yet buried in night."[2]

While some observers wax eloquent about the splendours of Copernicus and Tycho already referred to elsewhere as being the metropolitan crater of the Moon, Neison seems inclined to consider Clavius as the most impressive of all the lunar formations, and Serviss, after advising everyone to take advantage of any opportunity provided to see this crater with a powerful telescope when the sun is either rising or setting upon it, proceeds to quote Neison's spirited description of the scene, which reads as follows:

> "The sunrise on Clavius commences with the illumination of a few peaks on the western wall, but soon rapidly extends along the

[1] *Celestial Objects*, by T. W. Webb, sixth edition, pp. 121-122.
[2] *Astronomy with an Opera Glass*, by G. P. Serviss, p. 136.

whole wall of Clavius, which then presents the appearance of a great double bay on the dark night side of the Moon penetrating so deep into the illuminated portion as to perceptibly blunt the southern horn to the naked eye. Within the dark bay some small, bright points soon appear—the summits of the great ring-plains within—followed shortly by similar light-points near the centre, due to peaks on the walls of the smaller ring-plains, these light islands gradually widening and forming delicate rings of light in the dark mass of shadow still enveloping the floor of Clavius. Far in the east, then, dimly appear a few scarcely perceptible points, rapidly widening into a thin bright line, the crest of the great southeastern wall of Clavius, the end being still lost far within the night side of the Moon.

"By the period the extreme summit of the lofty wall of Clavius on the east becomes distinct, fine streaks of light begin to extend across the dark mass of shadow on the interior of Clavius, from the light breaking through some of the passes on the west wall

and illuminating the interior; and these streaks widen near the centre and form illuminated spots on the floor, when both east and west it still lies deeply immersed in shadow, strongly contrasting with the now brightly illuminated crest of the lofty east wall, and the great circular broad rings of light formed by the small ring-plains within Clavius. The illumination of the interior of Clavius now proceeds rapidly and forms a magnificent spectacle: the great brightly illuminated ring-plains on the interior, with their floors still totally immersed in shadow; the immense steep line of cliffs on the east and southeast, are now brilliantly illuminated, though the entire surface at their base is still immersed in the shades of night; and the great peaks on the west, towering above the floor, are thrown strongly into relief against the dark shadow beyond them."[1]

In the neighborhood of Clavius is Newton, an immense oblong enclosure about 140 miles in length, the deepest formation of its kind on the

[1] *The Moon,* by Edmund Neison, pp. 425-426.

Moon. One peak on the east is said to rise no less than 24,000 feet above the interior, which is quite level. On account of its situation and depth, neither the Earth nor the Sun is ever visible from some parts of its interior. Its shadow and those of its gigantic neighbors—for the Moon is here crowded with colossal walls, peaks, and craters—may be seen breaking the line of sunlight below Clavius, when observed with an opera-glass, according to Serviss, who made a careful and detailed survey of the lunar surface with this instrument, which, though small, is helpful to the amateur observer. The same author also draws our attention to the double chain of great crater-plains reaching half across the centre of the Moon, and notable as containing "some of the grandest of these strange configurations of conjoined mountain, plain, and crater. At such times, with a field-glass some of them look like enormous round holes in the inner edge of the illuminated half of the Moon." The author is here referring to Theophilus, Cyrillus, and Catharina, three of the finest walled plains on the Moon, mentioned earlier in the book. This chain of craters may be seen at the time when the sunlight on the Moon

has reached the edge of the Sea of Nectar. The walled plain Catharina is near the northwestern extremity of the Altai Mountains, a range of lofty cliffs, 280 miles in length, surmounting a high tableland.

Looking westward, we find the Alps another mountain mass of great elevation, whose highest peak, named Mt. Blanc, is said to rise to an elevation of 14,000 feet. This range presents a fine spectacle when seen near the time of sunset or sunrise. The mountainous country westward is traversed by a wide valley, known as the great Alpine Valley, the finest of its class, on the Moon, and its dimensions are 75 miles in length, and from 4 to 6 miles in width.

To the north of this range are the Apennines, the greatest of the lunar mountain chains. The range extends some 460 miles across the borderland between the Sea of Mists and the Gulf of Heats on one side, and the Sea of Clouds on the other. The rugged cliffs are exceedingly steep on the side facing the Sea of Clouds, and at the time of sunrise on the Moon immense shadows of gigantic peaks jutting upward from the summit of a mountain range are thrown across the sea.

Their southwestern slopes are comparatively gentle, rising gradually from the level of the Sea of Vapours. At their upper, or southern, end in the direction of Copernicus they cease abruptly in a cup-shaped ring, named Eratosthenes, famed as the spot where, according to Professor W. H. Pickering, vegetation is said to thrive. This crater is depressed 8,000 feet below the level of the surrounding region, while its wall, which is some 15,500 or 16,000 feet high, above the interior is surmounted by towering peaks on places rising to 16,000 feet.

Weary with our journey, here let us pause awhile, surveying the scene from one of the loftiest peaks of the Apennine range. It is the hour of dawn, and shadows black as night slope across the adjoining seas and plains, unsoftened by the atmospheric agency which here on our planet so skilfully blends darkness with light. This harshness intensifies the scarred and furrowed appearance of our satellite, wrinkled and worn with old age. All the beauty the Moon may have had in the days of its youth has long since disappeared, and distance alone "lends enchantment to the view." Even the moonlight is borrowed from the

Sun, thus endowing it with seeming loveliness. Under its witchery the Moon becomes the Queen of Night, and poets sing of her beauty, which is all a dream, vanishing when the sunlight is eclipsed. Fortunate mortals who have had a glimpse of her charms through one of the most powerful telescopes of the day may have some idea of the vision revealed. The writer has the memory of the sheer loveliness of the Moon, when on one memorable occasion she gazed fascinated upon the shimmering silvered Sea of Serenity, through one of these magic glasses. Involuntarily, she recalled those well-known lines by Tennyson:

"Dead, but how her living glory lights the hall, the dune, the grass!
Yet the moonlight is the sunlight, and the Sun himself will pass."

CHAPTER VII

FACT AND FICTION REGARDING THE MOON ROCKET

"Philosophers dwell in the moon, speculation and theory girdle the world about like a wall."
—FORD, *The Lover's Melancholy*, Act III, Scene 3.

SO MANY vague rumours have been afloat regarding the possibility of sending a rocket to the Moon, with the additional thrill of passengers inside, that it seems advisable, in a popular book such as this, to give the plain, simple facts as they actually are, according to a leading authority on the subject—*viz.*, Professor Robert H. Goddard, of the Physics Department, Clark University, Worcester, Mass. He is at present engaged on the development of a small model which will have a sufficient vertical range to demonstrate clearly the correctness of the principles involved, and illustrate the possibility of sending a rocket to the Moon.

In 1914 Professor Goddard publicly sug-

gested a propellant consisting of liquids, which was tested experimentally in 1921, and by this means it was found possible to obtain propulsive force without excessive heating. After a satisfactory demonstration has been made, the next attempt will be an exploration of the atmosphere in the wide unknown region extending upward from 20 to 400 miles. Among the most interesting matters to be investigated in this region are whether or not the conclusions from meteoric studies are correct, that the upper limit of the atmosphere is at 37 miles, where the temperature rises from −53° C. to 27° C., in a region of ozone; or the conclusions from auroral studies are correct, that the upper limit is at 56 miles, where the temperature falls, there being a region above consisting largely of nitrogen at a temperature below 60°A., and extending upward for hundreds of kilometres. In this connection it should be stated that Professor W. J. Humphreys, of the United States Weather Bureau, has suggested a very simple and clever means of carrying out the most difficult of the measurements, namely, that of temperature.

A further question of interest which may be

asked is, *To what extent does the Moon figure in this investigation?* It should be understood, first, that calculations for minimum initial mass of rocket, which take account of both air resistance and gravity, have shown that, for an average velocity of ejection of gases from the rocket of 12,000 feet a second, an initial mass of rocket of but 40 pounds is necessary for each pound mass given a sufficient velocity (acquired far above the dense part of the atmosphere) to escape from the earth's predominating gravitational attraction. Actual laboratory tests have produced an average speed of ejected gases of closely 8,000 feet per second, and results from tests *in vacuo* indicate that this corresponds to a speed of 9,700 feet per second *in vacuo*. There is every reason to believe, from results so far obtained and from well-established theory, that a sufficiently high velocity can be secured, with a rocket which consists chiefly of propellant material.

> "The object of this work is, however, much more than the performance of some simple spectacular stunt. It is the development of a new method, and although experience has

shown that it is hopeless to discuss publicly all the matters which have been studied, both theoretically and experimentally, it is confidently predicted that this method will lead to achievements of the very greatest interest, which can almost certainly be realised in no other way. New methods are slow of development, but it would be well worth while if the means were at hand to make an attack simultaneously upon all the problems connected with this investigation."[1]

Actual experimental investigations were not undertaken until 1915-16, at which time the tests concerning ordinary rockets, steel chambers and nozzles, and trials *in vacuo,* were performed at Clark University. The experimental results were submitted, in manuscript, to the Smithsonian Institution, in December, 1916, and a grant of $5,000 was advanced from the Hodgkins Fund towards the development of a reloading or multiple-charge rocket, and this work was begun at Worcester Polytechnic Institute in 1917, and was undertaken as a war proposition. It was con-

[1] See *Monthly Weather Review,* February, 1924, 52: pp. 105-106.

tinued from June, 1918, up to very nearly the time of the signing of the armistice, and most of the experimental results were obtained at the Mount Wilson Observatory of the Carnegie Institution of Washington, D. C.

In a pamphlet entitled *A Method of Reaching Extreme Altitudes*, by Professor R. H. Goddard, and published in Vol. 71, No. 2, of the *Smithsonian Miscellaneous Collections*, an account is given of the various methods employed, of which the following is merely an outline. It was while making a search for methods of raising recording apparatus beyond the range for sounding balloons (about 20 miles) it occurred to Professor Goddard that it might be possible to develop a theory of rocket action, in general, taking into account air resistance and gravity. The problem was to determine the minimum initial mass of an ideal rocket necessary, in order that, on continuous loss of mass, a final mass of one pound would remain at any desired altitude. When the problem was solved it was found that surprisingly small initial masses would be required, *provided the gases were ejected from the rocket at a high velocity*, and also pro-

vided that *most of the rocket consisted of propellant material.*

It was desirable to perform certain experiments with the object of finding just how inefficient an ordinary rocket is, and secondly to determine to what extent the efficiency could be increased in a rocket of new design. By the application of several new principles an efficiency far greater than that of the ordinary rocket is possible.[1] The principles concerning efficiency are essentially three in number. The first concerns thermodynamic efficiency and is the use of a smooth nozzle, of proper length and taper, through which the gaseous products of combustion are discharged. By this means the work of expansion of the gases is obtained as kinetic energy and also complete combustion is ensured.

The second principle is embodied in a reloading device whereby a large mass of explosive material is used, a little at a time, in a small, strong combustion chamber. This enables high chamber pressures to be employed, impossible in an ordinary

[1] As these principles are of some value for military purposes, Professor Goddard has protected himself as well as aërological science in America, by certain U. S. letters patent.

paper rocket, and also permits most of the mass of the rocket to consist of propellant material.

The third principle consists in the employment of a primary and secondary rocket apparatus, the secondary (a copy in miniature of the primary) being fired when the primary has reached the upper limit of its flight. By this means the large ratio of propellant material to total mass is kept sensibly the same during the entire flight. This last principle is obviously serviceable only when the most extreme altitudes are to be reached. In order to avoid damage when the discarded casings reach the ground, it is suggested that each should be fitted with a parachute device. By means of these experiments the application of the above principles will convert the rocket from a very inefficient heat engine into the most efficient heat engine that has ever been devised.

Having obtained average velocities of ejection up to nearly 8,000 feet per second in air, it remained to determine to what extent these represented reaction against the air in the nozzle, or immediately beyond. Although it might be supposed that the reaction due to the air is small, from the fact that the air in the nozzle and im-

mediately beyond is of small mass, it is by no means self-evident that the reaction is zero. For example, when dynamite, lying on an iron plate, is exploded, the particles which constituted the dynamite are moved very rapidly upward, and the reaction to this motion bends the iron plate downward; but reaction of the said particles against the air as they move upward may also play an important rôle in bending the iron. The experiments were undertaken with the view of finding to what extent, if any, the "velocity in air" was a fictitious velocity. The experiments were performed with a small tool steel and nickel-steel chambers. The experiments demonstrated a velocity of the ejected gases 20 per cent *greater*, in the vacuum that must exist at 30 miles altitude, than at sea-level.

The magnitude of the highest velocity, 8,000 feet per second, exceeded the parabolic velocity at the surface of the Moon. With reasonable assumption as to the efficiency (50 per cent), and the mass of rocket as a whole to the mass of propellant (in the ratio 15-14), it should be possible to send a mass beyond the predominating attraction of the Earth, and in particular to the Moon, which would require practically as large a rocket

as for a much greater distance. A simple calculation will show that the total initial mass required to send one pound to the surface of the Moon is but slightly less than that required to send the mass to "infinity." The calculations for this case lead us to conclude that such an extreme altitude as over 400 miles can be reached by the employment of a moderate mass, *provided the efficiency is high;* it becomes of interest to speculate as to whether or not a velocity as high as the "parabolic" velocity for the Earth could be attained by an apparatus of reasonably small initial mass.

Theoretically, a mass projected from the surface of the Earth with a velocity of 6.95 miles per second would, *neglecting air resistance,* reach an infinite distance, after an infinite time; or, in short, would never return. Such a projection without air resistance is, of course, impossible. Moreover, the mass would not reach infinity, but would come under the gravitational influence of some other heavenly body.

We may, however, consider the following conceivable case: if a rocket apparatus such as has here been discussed were, after passing through the denser part of the atmosphere, projected up-

ward with an acceleration of 50 or 150 feet per second each second and *this acceleration were maintained to a sufficient distance beyond*, until the parabolic velocity were attained the mass finally remaining would certainly never return.

It is of interest to speculate upon the possibility of proving that such extreme altitudes had been reached even if they were actually attained. In general, the proving would be a difficult matter. Thus, even if a mass of flash powder, arranged to be ignited automatically after a long interval of time, were projected vertically upward, the light would at best be very faint, and it would be difficult to foretell, even approximately, the direction in which it would be most likely to appear. The only reliable procedure would be to send the smallest mass of flash powder possible, to the dark surface of the Moon when in conjunction (*i.e.*, the "New Moon") in such a way that it would be ignited on impact. The light would then be visible in a powerful telescope. Further, the larger the aperture of the telescope, the greater would be the ease of seeing the flash, from the fact that a telescope enhances the brightness of point sources, and dims a faint background. From experiments

made to find the minimum mass of flash powder that should be visible at any particular distance, it was found that if Victor flash powder, varying in weight from 0.05 gram to 0.0029 gram, were exploded on the surface of the Moon, distant 238,840 miles, and a telescope of one-foot aperture were used—the exit pupil being not greater than the pupil of the eye (*e.g.*, 2 mm.)—we should need a flash of powder of 2.67 pounds to be just visible, and 13.82 pounds, or *less*, to be strikingly visible.

If we consider the final mass of the last "secondary" rocket plus the mass of the flash powder and its container, to be four times the mass of the flash powder alone, we should have, for the *final mass of the rocket*, four times the above masses. These final masses correspond to the "one-pound final mass," as determined by calculations somewhat too technical to be recorded here, but to be found in Vol. 71, No. 2, of the *Smithsonian Miscellaneous Collections*, containing a detailed account of Professor R. H. Goddard's experiments, in connection with *A Method of Reaching Extreme Altitudes*.

The plan of sending a mass of flash powder to

the surface of the Moon, although a matter of general interest, is not of obvious scientific importance. There are, however, *developments of the general method under discussion, which involve a number of important features not herein mentioned*, which could lead to results of much scientific interest. These developments involve many experimental difficulties, to be sure, but they depend upon nothing that is really impossible. It remains only to perform certain preliminary experiments, before an apparatus can be constructed that will carry recording instruments to any desired altitude.

The experimental tests *in vacuo* demonstrated a velocity of the ejected gases 20 per cent *greater*, in the vacuum that must exist at 30 miles altitude, than at sea-level. The magnitude of the highest velocity, 8,000 feet per second, exceeded the parabolic velocity at the surface of the Moon. In a letter written to the author, October 4, 1927, Professor Goddard remarks: "With reasonable assumptions as to the efficiency (50 per cent) and the mass of rocket as a whole to the mass of propellant (in the ratio 15 to 14), it should be possible to send a mass beyond the predominating

attraction of the Earth, and in particular to the Moon, which would require practically as large a rocket as for a much greater distance."

According to calculations made in this case, 438 pounds of rocket would be needed at the Earth for every one pound sent to the Moon, if smokeless powder is used as propellant, and that but 10 to 20 pounds of flash powder would be needed, exploding on the surface of the New Moon to be visible in a one-foot-aperture telescope at the Earth. Further, if liquid hydrogen and liquid oxygen were used as propellants, with the same assumptions, the weight of the rocket at the Earth, for propulsion to the Moon (or much farther), need be but 43.5 pounds for each pound sent to the Moon. In both cases, projection is supposed to take place from a mountain or a balloon, at an altitude of 15,000 feet. To secure the ratio of initial to final mass of rocket of 43.5 to 1, with 15 to 14 as the weight of rocket to propellant, use is necessary of several secondary rockets, fired in succession. In making the calculations to find the rate of burning of the propellant at each point of the flight that would make the initial weight of the rocket least, the resistance of the air was taken

into account, and the velocity of the rocket was found not to exceed 2,000 feet per second, until the rocket had reached a height exceeding 125,000 feet, where the density is under 0.015 of normal atmospheric density, thus avoiding any appreciable heat due to friction on passing through the atmosphere.

In an article published in the *Scientific American* in 1920 or 1921, Professor Goddard suggested the use of photo-sensitive cells (such as selenium or the newer potassium cell) to use the light from the narrow crescent of the Moon to steer the rocket automatically. His present work (1927) consists in the development of a small model to demonstrate the use of liquid propellants, but until this is completed, further work is not possible, nor can much be said of what new developments may result in consequence thereof. To quote from Professor Goddard's letter:

> "The main point now is that the method opens up an intensely interesting field of work, not only making possible an investigation of the structure of the high atmosphere and of the medium which carries the radio

> waves, but also, I believe, making possible a new chapter in astronomy. In this latter connection, the study of the ultra-violet spectra of the Sun and the high-temperature stars, made above the atmosphere, and the experiment of sending a flash to the Moon, should at least suggest interesting possibilities."

There are the facts in a nut-shell, and it is interesting to compare them with what is undoubtedly fiction, such as Jules Verne would have elaborated in an additional chapter to his book, *From the Earth to the Moon.* In 1924, a German scientist, Herr Von Hermann Oberth, after correspondence with Professor Goddard, put forward a much more sensational project. His idea was to construct a "rocket" large enough to hold two persons and capable of reaching the Moon with its aërial passengers. He proposed to use for fuel liquid hydrogen, and a mixture of water and alcohol, the liberated gases escaping from small holes at the back of the rocket to maintain the necessary propulsion. The weight of the fuel required for the trip he estimated at 30 tons, the total

weight of the rocket and its "crew" at 400 tons, and for the cost he made the modest estimate of £100,000. But, though volunteers came forward to undertake the adventure, so far nothing has materialised but a book on the subject, regarding rockets to reach interplanetary space. In this book Herr Oberth claims to have obtained his results quite independently of Professor Goddard.[1]

He says that he commenced working at the problem in 1907, and that the main ideas were evolved in 1909, while the calculations and suggestions made in his book were advanced during the years 1920-22. Among other calculations he states that an initial velocity of 11 kilometres per second would suffice to carry the rocket beyond the Earth's sphere of gravitational influence. The calculations are simplified by introducing the assumption that while the rocket is still within the Earth's atmosphere the fuel is used at such a rate as to give at each instant what is practically the "limiting velocity" at the instant.

In a review of the book, which appeared in *Nature* for August 23, 1924, the writer remarks:

[1] See, *Die Rakete zu den Planetenräumen*, 1923. München and Berlin.

"The prospect of propelling a body from our Earth to one of the heavenly bodies, notably the Moon, has excited certain types of individuals for some time, and many romances have been built up round the idea. . . . The author (Herr Oberth) discusses the theoretical as well as the chemical, physical, and even physiological aspects of such a venture. He examines the economic possibilities, but he does not appear to be very sanguine about his scheme being carried out." He estimates that as an initial outlay costing £50,000 on the basis of pre-war prices, 25 tons of alcohol and 4 tons of liquid hydrogen would be required. As the writer of the review above referred to remarks, "a voyage to the Moon would be an attractive trip to many adventurous spirits; and in these days of unprecedented achievements one cannot venture to suggest that even Herr Oberth's ambitious scheme may not be realised before the human race is extinct."

There is a report to the effect that a Society for Exploring Space has been founded in Vienna by Dr. Franz Hoeff. This intrepid explorer wishes to demonstrate that a rocket discharged on the Earth may be depended upon to fulfil its mission

of eventually reaching the Moon. The rocket would not contain human beings, but one and a half to six kilos of flashlight. According to exact calculations, this display could be seen with the larger telescopes if the rocket exploded on falling on the unilluminated side of the New Moon—that is, on the surface of the Old Moon when it is familiarly described as being in the New Moon's arms. It is alleged that such a rocket would start at a speed of more than 11 kilometres per second, and would arrive on the Moon's surface within 97 hours or even less. The "Moon flashlight rocket" would weigh about 5 hundredweight. The money for the experiment is to be raised by the new society, and if the first attempt be successful, a second and more ambitious experiment will follow.

In the *Evening Sky Map,* for July, 1927, we read about a message from Moscow, dated May 7th, regarding the still more daring project of Ivan Fedorof, a mechanic from Kiel, who has invented an apparatus called a "rocket," 30 metres long, half airplane and half giant projectile. He will be accompanied, he states, by the German "Moon fan" Max Vallier, and the three who

prove most fit of 75 Moscow volunteers. The inventor expects that landing on the Moon, which he thinks should be reached after 15 hours, may be difficult, but believes it feasible if gas explosions are used as brakes. The first expedition, for which the members will be provided with novel respirators, will remain on the Moon for two days—presumably terrestrial days, since a lunar day is equivalent to a month on our planet. Should they complete the trip successfully, returning to the Earth without suffering disastrous results, a second trip would be made, and gases obtained from the bottom of the lunar craters would be rendered breathable by a specially devised apparatus. Moreover, we are informed that a house would be built *as a terminus of a future line of aërobuses.*

Another scientist, M. Robert Esnault-Patterie, the famous French savant who invented the airplane joy-stick, has joined the ranks of those who are suggesting methods and devices for reaching the Moon, in a 49-hour journey. The type of vehicle he finds most probable for this future voyage to the Moon is a cigar-shaped rocket, propelled by gases or more likely by atomic particles driven out of the rocket's tail at extreme velocity.

The most remarkable feature of the project is the scheme for landing gently on the Moon. The rocket would make a half-loop 150 miles away, probably by means of a lateral auxiliary rocket, and then go forward tail first, the propulsive gases slowing up the descent to a safe landing speed.

The return landing on the Earth would be made in the same way, but the rocket would be turned about 2,000 miles away from the Earth's surface. During the last six miles the passengers could land with parachutes in order to make a very soft contact with the Earth. Naturally, he adds, with naïveté, "I am not planning to fly there myself, but I would be the first to go, if possible."

Professor A. W. Bickerton sums up the results which may be expected if such a venture is actually made, in the following statement printed shortly after the meeting of the British Association, in 1926, at Cambridge, when the Prince of Wales was president:

> "The Prince of Wales in his address before the British Association emphasised the necessity for scientific correlation. Never was there a more timely warning.

"This foolish idea of shooting at the Moon, revived both in America and in Moscow, is an example of the absurd length to which vicious specialisation will carry scientists working in thought-tight compartments. Let us critically examine the proposal. For a projectile entirely to escape the gravitation of the Earth, it needs a velocity of 7 miles a second. The thermal energy of a gramme at this speed is 15,180 calories. The energy of a gramme of a Krupp shell is about 100 calories; that of Big Bertha—the gigantic gun which bombarded Paris—is 400 calories. The energy of our most violent explosive—nitro-glycerine—is less than 1,500 calories per gramme. Consequently, even had the explosive nothing to carry, it has only one-tenth the energy required to escape the Earth. For to take a shell 4,000 miles high requires energy of unit mass equal to some 7,500 calories. Hence, the proposition appears to be basically impossible.

. . . . .

"But let us neglect this basic objection and assume we have an explosive 50 times as

strong as any now existing. Think of the difficulties meeting us. To moderate the speed a rocket is suggested; that is, in effect, you carry Big Bertha, instead of its projected shell. In other words, you use the kick of the gun to give the speed.

"Supposing you realise this to be a big blunder, and decide to travel in a roomy shell. You have now to construct the gun that will take an explosive whose energy is 50 times that used in Big Bertha. How will you construct the gun that will stand this strain?

"After overcoming these minor difficulties you enter the shell and detonate the explosive and start off at 7 miles a second. That is, you get a blow 50 times as hard as if struck by a Big Bertha shell. Clearly, you are flattened to a pancake. The bump is equal to a fall from a height of many thousands of miles.

"But, ignoring these incidents, assume that in some miraculous way our adventurers succeed in landing on the Moon. What do they find? A dead world with no air. How do

they breathe? Clearly they have to load themselves up with steel cylinders of compressed oxygen, requiring additional power to bring them. And as there is no food at the Moon they must bring their food tabloids and drink.

"Say they are landed in a crater desert 100 miles in diameter. They take a stroll, but it is not exhilarating, and so they decide to return. But it will take an energy of about 800 calories per unit mass to escape from the Moon. Assume a few more miracles—that they find a supply of high explosives, cranes to move the heavy shell into the mortar which they find ready. They again detonate and are shot away into space.

"Presently the Earth's pull tells, the speed increases and increases till the shell gets into the Earth's atmosphere. Soon, by friction with the air, the shell is red-hot. If the speed be reduced to half energy the stoppage of the motion will produce a detonation a score of times the energy of dynamite, and the shell will penetrate to a considerable depth. The experiment will result

in a volcanic outburst that will produce a miniature Arizona crater."

Such flights of the imagination are treated from a humorous standpoint by Abbé Moreux in his book entitled *A Day on the Moon*, as follows:

"On the day when men have at their disposal an explosive powerful enough to give to a shell an initial velocity of 7½ miles per second, the shell shot into the air would never come back to Earth. The so-called civilised nations could then find in the exercise of 'shooting the Moon' a strong counter-attraction to the folly of mutually murdering each other. Under such conditions the shots sent from the Earth might serve as mail-coaches and take letters to the Selenites in less than a working day of twelve hours. A despatch handed in at the Paris-Moon post at 6 A.M. would reach our satellite at 3 P.M. of the same day, always providing that the State did not lay hands on the monopoly of the new line. The slightest delay would have the most disastrous results. The Moon would have passed on, and the mail, finding no one to

receive it, would carry on its despatches to 'an unknown destination.' One might add, that on enquiry at the Paris post office, as to whether the despatch had been located, the reply from the lunar post office, would be the usual depressing reply, 'No trace.'"

Among the treasures in our National Library at the British Museum there is a MS. minus name or date, entitled *Selenographia, or News from the World in the Moon to the Lunatics of this World*, by Lucas Lunanimus of Lunenberge. Additional MS. No. 11,812. We are here told how the author, "making himself a kite of ye hight (?) of a large sheet, and tying himself to the tayle of it, by the help of some trusty friends, to whom he promised mountains of land in this his new-found world, being furnished also with a tube, horoscope, and other instruments of discovery, he set saile the first of Aprill, a day alwaies esteemed prosperous for such adventures." Nothing more has been recorded of the experience of our aërial tourist, who presumably took up his residence on the Moon permanently.

In 1638, a book entitled *The Man in the*

Moone, or a discourse of a voyage thither, was written by Dr. Francis Godwin, first of Llandaff, afterwards of Hereford. This was published under the pseudonym of Domingo Gonsales. The enterprising aëronaut went up from the island of El Pico, carried by wild swans. The author tells us: "The further we went, the lesser the globe of the Earth appeared to us; whereas still on the contrary side the Moone showed herselfe more and more monstrously huge." After eleven days' passage, the exact time that Arago allowed for a cannon ball to reach the Moon, "another earth" was approached: "I perceived that it was covered for the most part with a huge and mighty sea, those parts only being drie land which show unto us here somewhat darker than the rest of her body; that I mean which the country people call *el hombre della Luna*, the man of the Moone."

Lucian, the Greek satirist, in his *Voyage to the Globe of the Moon*, sailed through the sky for the space of seven days and nights, and on the eighth "arrived in a great and shining island which hung in the air and yet was inhabited. These inhabitants were Hippogypians, and their

king was Endymion.[1] Lucian may have borrowed his idea from the Druids, for whom the Moon was Paradise, the abode of the blest. It was—for them—a visible pledge of immortality, and for this reason occupied a prominent place in their religion. The order of all the Druidic festivals depended upon its phases; its presence was essential in all their ceremonies when its shining rays were invoked. The Druids are always represented in their ceremonials as having the crescent in their hands. Thus, astronomy and religion were intimately blended in their theology.

There are traces of the Druidic belief in a book by John Wilkins, a former Bishop of Chester, published in 1638, and entitled, "*A Discovery of a New World*, or a Discourse tending to prove, that 'tis probable there may be another habitable World in the Moone." He writes:

> "It hath beane the opinion amongst some of the Ancients that their Heavens and Elysian fields were in the Moone, where the aire is most quiet and pure. Thus Socrates, thus Plato, with his followers, did esteeme this

[1] Lucian's Works. Translated from the Greek, by Ferrand Spence, London, 1694, vol. ii, p. 182.

to be the place where those purer soules inhabit, who are freed from the Sepulchre, and contagion of the body. Plutarch also seemes to thinke there are two places of happiness, answerable to those two partes which he fancies to remaine of a man when hee is dead, the soule and the understanding; the soule he thinkes is made of the Moone, and as our bodies doe so proceede from the dust of this earth, that they shall returne to it hereafter, so our soules were generated out of that Planet, and shall be resolved into it againe, whereas the understanding shall ascend into the Sunne, out of which it was made, where it shall possess an eternity of well being; and farre greater happinesse than that which is enjoyed in the Moone.

"So that when a man dies, if his soule bee much poluted, then must it wander up and downe in the middle regions of the aire where hell is, and there suffer unspeakable torments for those sinnes whereof he is guilty. Whereas the soules of better men; when they have in some space of time been purged from their sinnes then doe they re-

turne into the Moone. Plutarch makes the Moon an inferior kind of heaven, and though hee differ in many circumstances, yet doth hee describe it to be some such place, as we suppose Paradise to be."

The same author in his treatise, *De facie in urbe Lunæ*, tells us that the theologians of the west considered the Moon as the residence of happy souls. They rose and approached it in proportion as their preparation had been complete, but, in the agitation of the whirlwind, many reached the Moon that it would not receive:

> "The Moon repelled a great number and rejected them by its fluctuations, at the moment they reached it; but those who had better success fix themselves there for good; their soul is like the flame, which raising itself in the ether of the moon, as fire raises itself on that of the Earth receives force and solidity in the same way that red-hot iron does when plunged into the water."

Wilkins in his remarks about the possible inhabitants of the Moon, cautiously states in his account of *The Discovery of a New World:* "I

dare not myself affirme any thing of the Selenites because I know not any ground whereon to build any probable opinion, but I think that future ages will discover more; and our posterity, perhaps, may invent some meanes for our better acquaintance with these inhabitants." Elsewhere he remarks:

> "There may be some meanes invented for a conveyance to the Moone, and though it may seeme a terrible and impossible thing ever to passe through the vast spaces of the aire, yet there is no question there would bee some men who durst venture this as well as the other. True indeed, I cannot conceive any probable means for the like discovery of this conjecture, since there can bee no sailing to the Moone; unless that were true which the Poets doe but signe that shee made her bed in the sea. We have not now any Drake or Columbus to undertake this voyage, or any Dædalus to invent a conveyance through the aire. However, I doubt not but that Time who is still the father of new truths; and hath revealed unto us many

things of which our Ancestors were ignorant, will also manifest to our posterity, that which wee now desire, but cannot know. Time will come when the endeavor of after ages shall bring such things to light as now be hid in security.

"Kepler doubts not, but that as soone as the art of flying is found out, some of their Nation will make one of the first colonies that shall inhabit that other world. But I leave this and like conjectures to the fancie of the reader; desiring now to finish this Discourse, wherein I have in some measure proved what at the first I promised (an account of) a world in the Moone. However, I am not so resolute in this, that I may think 'tis necessary there must be one, but my opinion is that 'tis possible there may be, and 'tis probable there is another habitable world in that Planet. Of what kind may be the inhabitants of this other world is uncertain. That 'tis possible for some of our Posterity to find out a conveyance to this other world, and if there be inhabitants to have commune and commerce with them."

CHAPTER VIII

LUNAR WEATHER FORECASTS, AND SUPPOSED INFLUENCE OF THE MOON ON VEGETATION

"Scan well the two horns of the infant Moon
For vesper paints with differing hues,
And variously shapes her horns,
When she is young and three or four days old.
These teach the character of the coming month.
—ARATUS, *The Skies and Weather-Forecasts.*

ARATUS, a physician who lived about 270 B. C., founded his weather forecasts upon his nightly observations of the sky. With his knowledge of astronomy combined with that of meteorology he was able to make shrewd guesses regarding weather changes in connection with the waxing or waning Moon. For instance, he observed that if the horns of the Moon be sharply defined and clear on the third night, the outlook is calm, but a ruddy tint betokens a gale. If, on the contrary, the horns are ill defined and blunted on the third and fourth nights, and the Moon

shines with feeble light, there will be a south wind or coming rain:

Some messages the Moon gives with half orb
Growing or waning; some with all her disc;
If neither of her horns on the third night
Project forward, nor lean back shortened,
But vertical her yard-arms bend their points
A western breeze will blow by the morrow's dawn.
If vertical her cusps on the fourth night
Continue, long the mustering storm shall rage.
Her higher horn pointing forward
Ushers Boreas; backward drawn, the coming South.
If on three nights she show sharp-pointed tips
And a red crescent, look out for great squalls,
The greater, the more fiery red her blush.

Scan too her full orb and her quadratures,
Both waxing from and waning to a horn;
And from her hue infer the following day
Shining quite clear she indicates fair weather;
Ruddy throughout she means careering gales;
And stained with dark spots she announces rain.
Not the same range of prediction have all her phases
Three or four days old she foretells what shall be
Till she has half her size; half-orbed her promise holds
To full moon; her full orb has equal range:
Half-orbed again she prophesies four days,
And four her crescent; the new moon foretells the weather
till her crescent reappear.[1]

[1] Translation from the Greek, by E. Poste, of Oriel College, Oxford.

However, the theory that the divisions of the lunar month denote the epochs of weather change, though it has descended to modern times, does not appear to stand the test of the more exact modern observation.

There is a saying in Scotland, "The bonnie Moon is on her back; mend your shoon and sort your thack," which is expressive, but it is obvious that the Moon is on her back for reasons other than atmospheric. When the Old Moon is visible in the arms of the New, the atmosphere is unusually clear. The probability is that it is in that state of visibility which precedes a wedge-shaped depression, such as is followed frequently by rain. The forecast is therefore fully justified, though not of the "deadly" character indicated in the lines:

> "I saw the new moon, late yestreen,
> With the old moon in her arm,
> And I fear, I fear, my master dear,
> We shall have a deadly storm."

The verse is taken from the famous ballad of Sir Patrick Spens (or Spence). In what age the hero of the ballad lived is not certainly known, but when the fatal expedition took place it must

have been in the days when sailing the wintry seas was considered dangerous. In fact, a law was enacted that no ship should be launched between the feasts of Saints Simon and Jude (October 28th) and Candelmas Day (February 2nd). Apparently on this occasion the law was broken when the King sent Sir Patrick Spence to Norway for the purpose of escorting Margaret, the Maid of Norway, to her own kingdom, Scotland, to which she succeeded on the death of her father. The warning on this occasion was unheeded, though, as the legend goes:

"O our Scots nobles were richt laith
To weet their cork-heild shoone;
But lang owre a' the play were played,
Their hats they swam aboone.

"O lang, lang may the ladies stand,
Wi thair gold kems in their hair,
Waiting for thair ain deir lords,
For they'll se thame na mair.

"Half owre half owre to Aberdour,
It's fiftie fadom deip,
And thair lies guid Sir Patrick Spence,
Wi the Scots lords at his feet."

Regarding warnings given by the appearance of the Moon when it is girdled with haloes:

"A single halo portends wind or calm:
Wind rudely broken; slowly-fading, calm.
Two whorls of halo prophesy a storm;
Three whirls a greater; the most furious blasts
A shattered halo of three dusky whorls.
Such every month the warnings of the Moon."

The halo is often the first warning we get of an approaching change in the weather. Even before the mercury begins to fall the halo may be seen, and when it appears it may be taken as a sure indication of a coming storm. Sometimes a cyclonic disturbance dies mysteriously away, and sometimes it unexpectedly changes its course and weather forecasts are falsified, but after the appearance of a halo these things rarely happen. When the halo appears the cyclone is practically upon us, and though the rain may not come for a day or more, it is there and not likely to be diverted. This is easily understood when we realise that it is just in front of the approaching cyclone, announced by the halo-forming sky, the sure forerunner of an atmospheric disturbance.

This is soon followed by drizzling rain which heralds its approach.

The interval of time between the appearance of the halo and the outburst of the storm is supposed to be indicated by the distance of the rings from the Moon. Thus:

"A near brough, a far-away shower;
A far-away brough, a near shower.

Or, expressed a little differently:

"A near-hand brough is a far-away rough,
And a far-away brough is a near-hand rough.

Still another variant is:

"The larger the brough, the nearer the storm.
The bigger the brough, the bigger the breeze."

Also:

"When round the Moon there is a brough,
The weather will be cold and rough."

In the account of a shipwreck in the story of *Paul and Virginia,* the description begins with the words: *"La lune était levée; on voyait autour d'elle trois grands cercles noirs."*

When, in addition to the halo, the Moon has a pale watery appearance, rain is sure to follow.

It is the vapour in the air condensing before the advancing low pressure of the cyclone comes over the Moon which gives it this appearance. Thus, the observer is warned that a storm is on its way and that the rain clouds will pass overhead before the Moon shines forth again. The cirrus cloud visible at such times is the "Maiden-hair" referred to in the well-known saying:

"Sailor, beware of the Maiden-hair."

This often portends the approach of bad weather, and these attractive-looking clouds sometimes resemble at such times ripples on the sand or foot-prints on the snow. If the clouds become denser at the approach of night, they threaten dangerous weather of which the sailor may well beware. Rapidly drifting cirrus clouds when the Maiden coquettishly shakes her tresses is a certain sign of an approaching storm.

The ring-like halo round the Moon is caused by that orb shining through the cirrus clouds, on which may be seen rainbow-coloured hues, red inside and blue on the outer rim. Just as in the case of a rainbow, these colours are due to light reflected and refracted through the fine ice-crys-

tals of which high stratus or cirrus clouds are composed. Occasionally, a complicated series of beautifully coloured rings is noticeable, caused by the thinness of the high cloud through which the moonlight may be passing. Should these clouds appear parallel to the west horizon and moving from a northerly point, a depression is approaching from the west; but although causing some bad weather, it will probably continue on its way northward. Should the lines appear parallel to the southwest or south-southwest horizon, and be moving from a northwesterly point, the depression sometimes passes over the observer and very bad weather in such cases is often experienced. These are two of many possible prognostics.[1]

Weather-forecasting is much helped by a study of the daily weather charts, but to ensure accuracy a knowledge of local conditions is required. For instance, in an interesting little pamphlet entitled *Is it going to rain?* we are informed that a cyclonic disturbance threatening bad weather may be expected, if it appears on the Irish coast, travelling in a northeasterly direction—the usual direction.

[1] *Clouds*, by Commander D. Wilson-Barker, R. N. R., pp. 29-31.

"The barometer begins to fall, the halo-producing sky and the cirrus clouds appear, and it seems perfectly safe to forecast rainy weather in all the northern districts at least. But unexpectedly the cyclone changes its direction, or it breaks up and disappears, and then the forecasts are all wrong. That sometimes happens, and no amount of meteorological skill can anticipate it, but it is the exception that proves the rule." [1]

To the ancients the sky was an open book, in which they read the signs of approaching bad weather, enabling agriculturists, fishermen, and those who were dependent on such forecasts to prepare for the results of coming atmospheric disturbances. For dwellers in a city who see little of the sky, the Press provides the necessary forecast, but as a precaution it is usually as well to start out with an umbrella and mackintosh so as to be on the safe side, at any rate, in our uncertain climate. Should there be an unexpected downpour, the umbrella is unfurled, the mackintosh donned, and the elements more or less successfully defied; but for the farmer whose crop of hay or

[1] *Is it going to rain?* by Edward Vernon, M. A., Edinburgh, pp. 7-8.

field of vegetables may suffer from the deluge, it is a far more serious matter. However, they are usually adepts—as the result of long and bitter experience—in reading the weather signals, and are indirectly responsible for the science we term meteorology, which dates back to the earliest times when Aristotle and his disciple, Theophrastus, published books on popular weather lore.

Undoubtedly, the appearance of the clouds, Moon haloes, and the phases of the Moon, help as a guide in enabling the keen observer to obtain a fairly accurate forecast of the weather. This may be helped by the study of the daily weather charts, though sometimes the predictions do not come true. In this case, the observer may have been mistaken in his calculations, overlooking some detail, such as proximity to the hills or other local conditions, which might alter matters considerably. For instance, there is an old saying: "If the cock's head be to the hills, and there be enough blue sky to make a woman's apron, there is no fear of rain." This is a saying which only holds good in the proximity of the hills, nor must the hills be too far away. It is usually a reliable sign of good weather, and when it is observed the pedes-

trian can safely leave his mackintosh and umbrella at home, despite the threatening aspect of the sky.

From a very remote antiquity, the belief that the weather is affected by the phases of the Moon has been handed down to the present time. "That educated people to whom exact weather records are accessible should still find satisfaction in the fanciful lunar rule, is an interesting case of intellectual survival." [1]

That the belief still lives on, and will not soon die, is clear to anyone who is conversant with current literature and common folk-lore. Even intelligent and well-informed people lend it countenance. In Professor Newcomb's *Popular Astronomy* he makes the statement:

> "Thus far there is no evidence that the Moon directly affects the Earth or its inhabitants in any other way than by her attraction, which is so minute as to be entirely insensible except in the ways we have described. A striking illustration of the fallibility of the human judgment when not disciplined by scientific training is afforded by

[1] *Primitive Culture*, by E. S. Taylor, vol. i, sixth edition, p. 130.

the opinions which have at various times obtained currency respecting a supposed influence of the Moon on the weather. Neither in the reason of the case nor in observations do we find any real support for such a theory. It must, however, be admitted that opinions of this character are not confined to the uneducated." [1]

That a misty Moon is a misfortune is widely supposed. In Scotland there is an agricultural maxim among the canny farmers, that:

"If the moon shows like a silver shield,
You need not be afraid to reap your field;
But if she rises haloed round,
Soon we'll tread on deluged ground."

Others say that a mist is unfavourable only with the New Moon, and not with the Old:

"An old moon in a mist
Is worth gold in a kist (chest)
But a new moon's mist
Will never lack thirst."

In Cornwall they say:

"A fog and a small moon
Bring an easterly wind soon."

[1] *Popular Astronomy*, by Simon Newcomb, LL.D., p. 325.

One thing, however, is a meteorological certainty, and that is a Full Moon *shows* the night is clear, and the cold is in proportion to the clearness of the night. The clouds covering the Earth with no thick blanket, it radiates its heat into space. This has given rise to the theory that the Moon itself reduces the temperature, but according to the native Chinese records it seemingly did more, since we are told that on the 18th day of the 6th Moon, 1590, "snow fell one summer night from the midst of the Moon. The flakes were like fine willow flowers on shreds of gold."[1]

With regard to the widely accepted theory that the turning up of the horns of the New Moon is reckoned a sign of fine weather, since according to the popular idea it retains the water supposed to be within it, which would run out if the horns were turned down, the following extract from *The Life and Correspondence of Robert Southey* is of interest. In a letter dated December 29, 1828, written by Southey from Keswick, he remarks:

"Poor Littledale has this day explained the

[1] *Folk Lore of China*, by N. B. Dennys, Ph.D., p. 118, London and Hong Kong, 1876.

cause of our late rains, which have prevailed for the last six weeks, by a theory which will probably be new to you as it is to me. 'I have observed,' he says, 'that, when the Moon is turned upward, we have fine weather after it, but if it is turned down, then we have a wet season, and the reason is, I think, that when it is turned down it holds no water, like a bason, you know, and then down it all comes.' There, it will be a long while before the march of intellect shall produce a theory as original as this, which I find, upon inquiry to be the popular opinion here." [1]

Not only is the weather supposedly affected by lunar influence, but so also is vegetation. In the *Zend-Avesta* we read, "And when the light of the Moon waxes warmer, golden-hued plants grow up from the Earth during the spring." We find Plutarch writing in his *Philosophie:*

"The Moone showeth her power most evidently in those bodies, which have neither sense nor lively breath; for carpenters reject the timber of trees fallen in the ful-moone,

[1] *The Life and Correspondence of Robert Southey,* edited by his son, p. 341. London, 1850.

as being soft and tender, subject also to the worms and putrifaction, and that quickly by means of excessive moisture; husbandmen, likewise, make haste to gather up their wheat and other grain from the threshing-floore, in the wane of the moone, and toward the end of the month, that being hardened thus with drinesse, the heape in the garner may keep the better from being fustie, and continue the longer; whereas corne which is inned and laied up at the full of the moone, by reason of the softnesse and over-much moisture, of all other, doth most cracke and burst. It is commonly said also, that if a leaven be laied in the ful-moone, the paste will rise and take leaven better." [1]

To this day we are told that the people in Cornwall still gather all their medicinal plants when the Moon is of a certain age, a practice doubtless dating back to druidical superstition. Cucumbers, radishes, turnips, leeks, and other plants are said to increase during the fulness of the Moon; but onions, on the contrary, are much larger and are

[1] *The Philosophie*, 1603, p. 697.

better nourished during the decline.[1] In some parts of England the belief is prevalent that the growth of mushrooms is influenced by the changes of the Moon, and in Essex the following rule is rigidly adhered to:

When the moon is at the full,
Mushrooms you may freely pull;
But when the moon is on the wane,
Wait ere you think to pluck again.

In his *Notes on the Folk-Lore of the Northern Counties of England and the Borders*, William Henderson, the author, says, in referring to the influence of the Moon: "I may, perhaps, mention here, that apples are said to 'shrump up' in Devonshire if picked when the Moon is waning. In the same way, there are popular fallacies with regard to the advantage of cutting timber at certain phases of the Moon, and among our own farmers many continue to observe 'the signs of the Moon' in sowing grain, setting out trees, cutting timber, and other rural occupations." That the Moon has great influence over the crops is a belief common to all nations, and it is said that at a lunar eclipse the Orinoco Indians seize their

[1] Flammarion's *Marvels of the Heavens*, p. 244.

hoes and work with great energy on their growing corn under the impression that the Moon is veiling herself in anger at their habitual laziness. Isis, the Egyptian title of the Moon, literally means moisture, and an ancient myth identified her with the Goddess of Water. In Mexico and Peru the time of the Full Moon was chosen to celebrate the festival of the deities of the water, and the ceremonies were usually connected with the crops which were regulated by her phases.

To come to more modern times, in some countries, such as the north of France or Germany, meteorological records supply evidence of the fact that there is more rain during the time when the Moon is waxing than when it is waning, though in the south of France this law is reversed. The explanation may be that France and western Europe are in a somewhat exceptional position for profiting by the indications of the barometer. According to Abbé Moreux, "The southern regions are much less subject to the influences of the Gulf Stream than those of the north, and conditions such as bring rainy weather in one place do not produce the same effect in other districts." The author then adds, naïvely: "Is there any meteor-

ologist today who can flatter himself that he knows thoroughly the conditions that bring rain? It may very well be that the Moon by its presence above the horizon has some connection with rainfall through chemical action, electric action, or the effect of ionisation, and through slight mechanical action. It is therefore most prudent to hesitate before making any pronouncement, and it is, above all, our duty not to deny the facts under the pretext that we cannot see any explanations for them." [1]

He also informs us regarding a curious belief among the French peasantry, that towards the end of April and during the month of May, when the temperature of the day begins to increase perceptibly, a condition favourable for the rising of sap in plants, these are affected in a peculiar way. If a minimum thermometer is placed a little above the ground, it will be found that even during the nights when the indicator has not gone down to freezing-point, some of the plants have been frost-bitten and the buds affected have turned rust colour. If the Moon is above the horizon, it is accused of "rusting" the plants. Accordingly, the

[1] *A Day in the Moon*, p. 126, Abbé Moreux.

"Rust Moon," as it is called, is dreaded by gardeners and vine-growers, because they attribute its harmful effects to a special chilling effect on the plants produced by its rays.

The following story is related by the great French scientist Arago:

"I am pleased to see you gathered around me," said Louis XVIII one day to the members of a deputation of the Bureau des Longitudes, who had come to present their Almanac and Annual, "for you will explain clearly to me what is the 'Rust Moon,' and how it acts upon the crops."

Laplace, to whom these words were addressed, was mystified and had to acknowledge that he not only knew nothing about the "Rust Moon," but had never even heard of it, though he had written so much about the Moon. He looked around at his colleagues, but as no one seemed inclined to help him out of the difficulty he was compelled to acknowledge his ignorance.

"Sire, the 'Rust Moon' has no place in astronomical theory. We are not in a position, therefore, to satisfy the curiosity of Your Majesty."

That evening, the King made merry at the card-table over the perplexity of his Bureau of Longi-

tudes who were unable to answer his query. When Laplace heard of this he hastened to the Observatory to see Arago, asking him if he knew anything about the "Rust Moon," but the great scientist assured him that he had never heard of it before. However, he offered to make enquiries among the gardeners and horticulturists of the Jardin des Plantes, and as a result of his inquiries they told him that the "Rust Moon" is that which is first seen during the month of April, reaching the phase of Full Moon, either at the end of that month or the one following. However, it was found that the gardeners have a sliding scale, for sometimes the plants are affected by the frost, for which the "Rust Moon" is blamed, and at other times the "Rust Moon" fails to affect them harmfully. According to observations made by the gardeners, if the sky is clear and the leaves and buds are exposed to the moonlight they are "rusted," or frost-bitten, although the thermometer exposed to the air remains several degrees above freezing-point; but if, owing to cloudy skies, the lunar rays do not reach the plants, these effects are not observed, although the general temperature of the air remains the same.

At first sight it would seem as though the lunar rays had produced a chilling effect, yet at the time of New Moon, when it is not as yet above the horizon and the sky clears, it is found that the young shoots, especially those of the vine, freeze and "rust" just the same. Therefore, according to competent authorities such as Abbé Moreux, we must come to the conclusion that the Moon has nothing to do with the matter. He also draws attention to an experiment made by the physicist Wilson in 1783:

> "After having placed a thermometer on the snow and noted that it indicated about 22° below zero, while the temperature shown by another 4 feet above the ground was −14°, he saw the lower thermometer suddenly rise some 8° as clouds came over the sky. When the night is fine and clear, therefore, bodies lose their heat by the simple process of radiation. The presence of a screen or cloud, or a covering of canvas or of straw, slight though it may be, at once neutralises this effect. This is an experiment which can readily be tested. On still, cloudless nights

> the grass always has a *lower* temperature than the air 6 feet above the ground. We must not, therefore, judge of the cold that affects a plant during the night merely by the readings of a thermometer hanging in the air."

But to make a successful experiment it is expedient to choose a clear night, for in cloudy weather there is no radiation and the difference of temperature becomes imperceptible. The reason why these nightly frosts take place in spring at the end of April and the beginning of May is due to the fact that the Sun has not had time to warm the Earth, since it is the time of year when winter has not yet ended, while later on the loss of heat by cooling down in the night does not equal the excess of heat stored up during the day.

Among the people of central France there is a strong belief in the influence of the Moon on planting and sowing seeds of trees. For instance, the seed of prune trees should be planted at New Moon, and as a result the growth of the plant will be rapid and vigorous. The theory is, that when the seedlings push through the surface of the ground at the time of Full Moon, the Moon gives

them some of the light they need to absorb carbon and grow, but if the seeds are placed in the ground at the time of New Moon, when the Moon is below the horizon, they are thus deprived of its luminous rays during the night. However that may be, many gardeners pay no attention to the phases of the Moon, planting or sowing at times which from practical experience they have found productive of the best results.

CHAPTER IX

IS THE MOON INHABITED?

"From the moon. A hundred years ago, or else a minute,—for I have no conception how long I have been falling,—I was up there, in that saffron-coloured ball."

—CYRANO DE BERGERAC.

IS THE Moon inhabited? This is a query of general interest on its own account, although the answer is obvious. Life is impossible on a world where there is no atmosphere, no water, nor even moisture in the ground. Changes such as we have here in the form of clouds, storms, the snow of winter, or the spread of vegetation in the spring-time, are all lacking on the Moon. For two centuries and a half the face of the Moon has been scanned with the closest scrutiny, her features have been portrayed on elaborate maps,[1] and many an astronomer has devoted years of his life to the work of examining lunar craters, large and small

[1] The map of the Moon, published in the sixth edition of Webb's *Celestial Objects for Common Telescopes*, made by Mr. Walter Goodacre, required *eight* years for completion!

plains, valleys, and mountain ranges in a vain search for some absolutely definite evidence that the Moon is other than "a dead and useless waste of extinct volcanoes."

With each increase of telescopic power, it was hoped that facts would come to light showing that the Moon was an inhabited world, and that much would be learned of the manners and appearance of the Lunarians. It was only when the elder Herschel's great reflector had been applied in vain to the search, that men began to look on the examination as nearly hopeless. "Herschel himself, who was too well acquainted, however, with the real difficulties of the question to share the hopes of the inexperienced, was strongly of opinion that the moon is inhabited. After describing the relations, physical and seasonal, prevailing on the lunar surface, he adds, 'there only seems wanting, in order to complete the analogy, that it should be inhabited like the Earth.'"[1]

The hope of discovering whether the Moon was an inhabited world or not was renewed when Sir John Herschel conveyed a powerful reflector to Cape Town. Unfortunately, those who were

[1] *The Moon*, by R. A. Proctor, first edition, p. 259.

anxiously awaiting the result of Sir John's observations were imposed upon by an elaborate hoax founded upon the account of a supposed series of discoveries made by the eminent astronomer concerning the inhabitants of the Moon, which was only too readily accepted as genuine. The originator of the celebrated lunar hoax was Mr. Richard Adams Locke of English parentage and education, but American birth. He was a collateral descendant of John Locke, the founder of the modern philosophy of the "Human Understanding." After leaving Cambridge University, he wrote extensively for various journals, finally settling in New York, where, in due course of time, we find him editor of the New York *Sun* in 1835, and the world-renowned author of the *Moon Story*.

In a preface to the series of articles in the *Sun*, entitled "Some Account of the Great Astronomical Discoveries, Lately Made by Sir John Herschel at the Cape of Good Hope," the author solemnly assures his readers that they should be apprised of the fact

> "that the matter in the following pages was arranged for publication in a scientific journal

about to be established; but that, an unforeseen delay having occurred in the appearance of the first number, it has been thought right to publish it separately. A sufficient motive for this determination is that the public mind may no longer be deceived as to the real nature and extent of Sir John Herschel's discoveries, by announcements made in the newspapers and other periodicals, which were wholly unauthorised by the great Astronomer himself, and which must have been derived from sources having but very slender title to a genuine character. The opportunity may be taken of announcing that the appearance of the journal above alluded to will not be long delayed, and that, amongst its other pretensions to public favour, it will contain a regular series of articles to which the title of this volume relates.

"To render our enthusiasm intelligible, we will state at once, that by means of a telescope of vast dimensions, and an entirely new principle, the younger Herschel, at his Observatory in the Southern Hemisphere, has obtained a distinct view of the Moon, and has

affirmatively settled the question whether this satellite be inhabited, and by what order of beings."

After a lengthy preamble, of which the above is merely an introduction, there follows an account of discoveries on the Moon, for which, as Oliver Wendell Holmes states in "The Poet at the Breakfast Table," "the writer had not troubled himself to invent probabilities, but had borrowed his scenery from the *Arabian Nights*, and his lunar inhabitants from *Peter Wilkins*." The proprietors of the New York *Sun*, in which the fictitious narrative first appeared, published an edition of 60,000 copies, and every copy was sold in less than a month.[1]

Possibly no one was more amazed at the credulity of the populace than the writer of the hoax. For instance, in connection with the prodigious lens weighing nearly seven tons, with an estimated magnifying power of 42,000 times—a mere product of his vivid imagination—it was actually

[1] On the occasion of my father's first visit to America in 1873, he succeeded in obtaining a copy of this curious pamphlet. Emerson had called his attention to it as an amazing piece of trickery, of which an account is given in one of the earliest numbers of *Macmillan's Magazine* by De Morgan.

said to have been seen, when it was shipped from England, by a gentleman who avowed he was at the docks when the lens was taken on board.

It seems, according to the story of the hoax told by William N. Griggs, published in 1852, that Mr. Locke was standing at the door of the *Sun* office one morning when he heard an elderly gentleman completely dispel the undecided opinions of the listening crowd around him by asserting his experience in the most convincing manner. He said he was fortunately engaged in commercial business at the East India Docks in London, when the vast lens, of seven tons' weight, and the whole gigantic apparatus of the telescope described in the story, were taken on board an East India ship, for erection at the Cape of Good Hope, and that he himself saw it craned on board. He concluded his corroborative testimony with the remark that although high expectations existed at that time of the success of this enormous instrument, in the hands of an astronomer and optician like Sir John Herschel, yet, for his own part, he had never presumed even to hope that it would be the means of such marvellously minute discoveries as were now proclaimed.

However, apparently the climax of credulity was reached when there was a report to the effect that the great French astronomer, Arago, was entrapped by the hoax. It was said that he circulated all over Paris the wonders related in the Moon pamphlet, until Nicollet—another French astronomer of some repute—wrote to his friend Bouvard, explaining that he had written the Moon-fable for the purpose of raising a little money. So runs the story, but although there may be some truth in De Morgan's supposition that the original work was French, yet there are certain passages in the pamphlet, as published in America, which no astronomer could have written.

"The whole story runs on optical rather than on astronomical considerations; but every astronomer of the least skill is acquainted with the principles on which the construction of optical instruments depends. Arago, a master of the science of optics, could not but have detected optical blunders which would be glaring to the average Cambridge undergraduate."[1] Nevertheless, the readiness with which the story was believed was a sufficient indi-

[1] *Myths and Marvels of Astronomy*, by R. A. Proctor, p. 244.

cation of the prevalence of the opinion that the Moon is inhabited.

Though it is a hopeless task to look on the Moon's surface for the presence of living creatures, or even to look for buildings which may have been constructed by the supposed inhabitants of the Moon—if life at any time existed on its surface—yet it is interesting to consider the conditions which would prevail on its surface owing to the lessened force of gravity which is one-sixth at the Moon's surface than at the Earth's. Therefore the lunar inhabitants, without being cumbrous or unwieldy, might be very much larger than the races subsisting on our Earth; and they might erect with the greatest ease buildings far exceeding in magnitude the noblest works of man.

> "Nor is the argument wholly fanciful. A man of average strength and agility placed on the lunar surface (and supposed to preserve his usual powers under the somewhat inconvenient circumstances in which he would there find himself) could easily spring four or five times his own height, and could lift with ease a mass which, on the Earth, would weigh half

a ton. Thus, it would not only be possible for a race of lunarians, equal in strength to terrestrial races, to erect buildings much larger than those erected by man, but it would be *necessary* to the stability of lunar dwellings that they should be built on a massive and stupendous scale. Further, it would be convenient that the lunarians, by increased dimensions and more solid proportions, should lose a portion of the superabundant agility above indicated. Thus, we have at once the necessity and the power for the erection of edifices far exceeding those erected by man. But having thus shown that lunar structures might very possibly be of such vast dimension as to become visible in our largest telescopes, it remains only to add that no object that could, with the slightest appearance of probability, be ascribed to the labours of intelligent creatures, has ever been detected on the moon's surface."[1]

Failing the discovery of living creatures, or of their work, it was hoped that at least the telescope might reveal the progress of a variety of

[1] *The Moon*, by R. A. Proctor, first edition, p. 261.

changes taking place on the Moon on a large scale, such as an observer on the Moon would note on our planet during the course of the changing seasons. These variations could be easily detected by changes in colour, as, for instance, snow-clad regions in winter-time being transformed to the green hue indicating vast tracts of verdure and vegetation. Undoubtedly, the Moon's surface exhibits distinctly marked varieties of colour, as, for instance, the greenish tint of the Sea of Serenity, vast plains of a bluish steel-grey colour, the pale terra-cotta hue of the Marsh of Sleep, and grey and neutral-tinted regions elsewhere. Nevertheless, although there are undoubtedly varieties of colours, no variation has as yet been detected which could in any way be attributed to the effects of seasonal change (with the exception, perhaps, of those observed by Professor W. H. Pickering).

In the recently revised edition of Young's *Manual of Astronomy*, we find the following with regard to changes on the Moon:

> "It is certain that there are no conspicuous changes; there are no such transformations

as would be presented by the Earth viewed telescopically—no clouds, no storms, no snow of winter, and no spread of vegetation in the spring. At the same time it is confidently maintained by some observers that here and there alterations do take place in details of the lunar surface, while others as stoutly dispute it.

"The difficulty in settling the question arises from the great changes in the appearance of a lunar object under varying illumination. To insure certainty in such delicate observations, comparisons must be made between the appearance of the object in question, as seen at *precisely the same phase of the Moon,* with telescopes (and eyes too) of equal power, and under substantially the same conditions in other respects, such as the height of the Moon above the horizon and the clearness and steadiness of the air. It is, of course, very difficult to secure such identity of conditions. The disputed question, whether short-lived changes, dependent on the phase of illumination, actually occur, is obviously still more difficult to settle. No greater

changes, such as might be caused by volcanic eruptions or landslides, have been detected since the advent of photography. The earlier drawings are not accurate enough to be good evidence." [1]

Failing evidence of the existence of living creatures, or of processes of vegetation, there may be changes caused by volcanic eruptions or earthquakes, such as occur on the Earth.

"Mr. Webb pointed out in 1865 eight noteworthy instances. Several of them may be easily explained as due to well-known effects of difference in telescopic powers, observational skill, keenness of vision, and the like, but there are one or two which seem to deserve a closer scrutiny. On February 8th, 1862, the south-southwest slope of Copernicus was seen to be studded with a number of minute craters not seen in an earlier map made by Beer and Mädler. These seemed to form a continuation of a region crowded with craters between Copernicus and Eratosthenes.

[1] *Astronomy*, by H. N. Russell, R. S. Dugan, J. Q. Stewart, vol. i, pp. 182-183.

> And it is singular that this last-named region exhibits a honeycombed appearance, which appears not to have existed in Schröter's time, since it is not recorded in his maps, and could hardly have escaped his persevering scrutiny." [1]

Another instance of supposed change has been observed in the ring-mountain called Mersenius, which has attracted the attention of observers, in consequence of its *convex* interior—a very uncommon feature. "This bubble-like convexity is represented by Schröter, and also by Beer and Mädler, as perfectly smooth. In 1836, only a year or two after the publication of Beer and Mädler's map, Mr. Webb detected a minute crater on the summit of the bubble within Mersenius; he also saw several delicate markings, resembling long irregular ravines, 'formed by the dropping in of part of an inflated and hollow crust.'" [2]

Yet we are no nearer the answer to the query, Is the Moon inhabited? Therefore, passing the strict boundary of science, whose dictum remains

[1] *The Moon*, by R. A. Proctor, first edition, pp. 266-267.
[2] *Ibid.*, p. 267.

"not proven," we approach the boundless realms of romance wherein such well-known authors as Jules Verne, H. G. Wells, and others have found vast fields of fanciful ideas awaiting their skilful methods of reaping.

For instance, in his book entitled *From the Earth to the Moon* Jules Verne describes the adventures of three members of a gun club who were fired from a canon by means of such a powerful explosive that it should have landed them on the Moon. Then the answer to the query, "Is the Moon inhabited?" might have been answered definitely. Unfortunately, owing to a slight error in their calculations, they did not get within forty miles of its surface and were threatened with the dreary prospect of wandering aimlessly in space, possibly meeting annihilation by crashing into a passing meteor. However, by an ingenious device the danger was averted and they were able to return to planet Earth no wiser than when they started.

H. G. Wells, in his well-known book, *The First Men in the Moon*, overcomes the difficulty with regard to the absence of atmosphere and water on the Moon by describing the inhabitants as large

insects living underground. His reason for making the inhabitants live underground is that there is certainly very little—if any—air on the Moon. Some people say none at all, but Mr. Wells gives it the benefit of the doubt. He considers that there may be none outside, but there may be some in the interior, and for this reason he places the people in dwellings within the cavernous depths of the Moon, where they can have a chance to breathe. But he allows some air for the outside, and he brings it into the story in a very interesting way, all *frozen*. The "first men in the Moon" land in a regular snowdrift of frozen air, due to the fact that they land on a part of the surface on which the Sun is not shining, so that it is bitterly cold—so cold as to freeze the air. Not very long ago no one had ever seen air frozen or even liquid, but now it is well known. A flower dipped in liquid air becomes quite brittle, and it is so intensely cold that if an india-rubber ball is placed in liquid air it is frozen hard and can be shattered to atoms.

The philosopher Fontenelle, in his book, *A Plurality of Worlds*, written in 1686, gives his views regarding the inhabitants of the Moon, in

the course of his conversations with the Marchioness, as follows:

> "'Well, madam,' said I, 'you will not be surprised when you hear that the Moon is an Earth too, and that she is inhabited as ours is.'
>
> "'I confess,' said she, 'I have often heard talk of the world in the Moon, but I always looked upon it as visionary and mere fancy.'
>
> "'And it may be so still,' said I, 'I am in this case as people in a civil war, where the uncertainty of what may happen makes them hold intelligence with the opposite party; for though I verily believe the Moon is inhabited, I live civilly with those who do not believe it; and I am still ready to embrace the prevailing opinion. But till the unbelievers have a more considerable advantage, I am for the people in the Moon.'"

"M. Schröter, a German astronomer, ventures to assert that our satellite is the abode of living and intellectual beings; he has perceived some indications of an atmosphere which, however, he remarks, cannot exceed two miles in height, and

certain elevations which appear to him to be works of art rather than of nature. He considers that a uniformity of temperature must be produced on her surface by her slow rotation on her axis, by the insensible change from day to night, and the attenuated state of her atmosphere, which is never disturbed by storms, and that light vapours, rising from her valleys, fall in the manner of a gentle and refreshing dew to fertilize her fields." [1]

Dr. H. W. M. Olbers is fully persuaded "that the Moon is inhabited by rational creatures, and that its surface is more or less covered with a vegetation not very dissimilar to that of our own earth." Dr. Gruithuisen maintains that he has descried through his large achromatic telescope "great artificial works in the Moon erected by the lunarians," which he considered to be "a system of fortifications thrown up by the scientific engineers."

The following letter, dated July 25, 1838, from Hanover, where Sir John Herschel had gone with his eldest son on his return from the Cape of Good Hope, is of interest in connection with Dr.

[1] *An Historical Account of Astronomy,* by John Narrien, p. 448. See also Schröter's, "Observations of the Atmosphere of the Moon," *Philosophical Transactions for 1792,* p. 337.

Gruithuisen's suggestion regarding lunar fortifications: "Mrs. Witte presents her compliments to the Baronet Herschel, and begs him to send her for a few minutes Mr. Maedler's sketch of the fortresses which Mr. Gruithuisen pretends having discovered in the Moon. She will send it back directly and only begs to notice her demand if this can be done without any difficulty."

Thus we see how the borderland of science narrowly escapes invasion by the futile attempts of those who would approach it from the domain of myth or folklore, wherein facts are replaced by fanciful imagery or fiction. Hence we find the dark markings on the Moon variously explained, as representing the Man in the Moon, the Woman in the Moon, the dog, the cat, a hare, a toad, or a frog, according to the fancy of the country folk whence the myth originated. Possibly the most poetical variant of such lunar habitation is the Greek story of Endymion, a youth of surpassing beauty who fed his flocks on Mount Latmos. One calm, clear night Selene—the Goddess of the Moon,—looked down and saw him sleeping. Then, as Lewis Morris sings:

"as the full orb poised upon the peak,
There came a lovely vision of a maid,
Who seemed to step as from a golden car
Out of the low-hung Moon."

In the "Faithful Shepherdess," Fletcher continues the story, telling us:

"How she conveyed him softly in a sleep,
His temples bound with poppy, to the steep
Head of old Latmos, where she stoops each night,
Gilding the mountain with her brother's light,
To kiss her sweetest."

CHAPTER X

LUNAR FOLK LORE

"A sycamore boat on a sea of mist,
The moon sails, coasting by isles of amber;
And trembles now, in my cup, I wist,
And now stands poised o'er my leafy chamber.

"The shadows break on the wave, afar,
Cool blows the breeze from the forest, yonder;
And forth convoyed by many a star,
In the open heaven, she goes—a wonder!"

—MONTAKU TENNO, *Sunrise Stories.*

AMONG the Chinese, the Moon is considered the patron of poetry, inspiring such lines as the above, and is described in their legends as Jutho, with a double sphere behind her head and a rabbit at her feet. She is also known as Chang-o, the Fairy Queen:

"Rainbow-winged angels, softly hover over her,
Forming a canopy above the throne;
A host of fairy beings stand before her,
Each robed in light and girt with meteor zone."

On the eighth month of the year the people in

this part of the world have a fête of the Moon, lasting for six days. It begins on the 10th and ends on the 15th with the Full Moon, for it is believed that on that night the Moon is larger than at any other time of the year. This doubtless refers to the Harvest Moon. Young and old alike take part in the fête and presents of all kinds, but shaped like the Moon, are exchanged among friends and relatives. There is a display of fire-works out-of-doors in the evening, while music and dancing in the homes add to the gaiety of the scene, all making merry till midnight. At this hour a great banquet is spread in the courtyard, which everyone attends since it is given in honour of the descent of the Moon-Goddess.

She leaves her celestial abode at times for the purpose of visiting our planet and ascertaining the wishes of mortals. If anyone should meet her while she is thus wandering hither and thither, they can obtain anything they ask for, but so far no one has been so fortunate as to meet her. Nevertheless, there is one exception, for we are told that an old woman once met the beautiful Goddess of the Moon, but was so dazzled by her beauty that she was rendered speechless. Accord-

ing to the legend, when the goddess asked her what she wished for most in the world, the old woman placed her hand over her mouth, indicating her desire to have enough to eat for the rest of her life. Unfortunately, the goddess had mistaken her gesture, for next morning the unfortunate woman was horrified at finding her chin adorned with a full-grown beard. Some of the Chinese legends describe the Moon as a tearful widow, and still others as a goddess inhabiting the lunar palace, where she dwells alone.

In the crude native legend of the Bamboo-cutter's daughter, referred by some authorities to the first half of the ninth century, the goddess is said to have descended on earth, where she hid in the hollow joint of a bamboo cane. An old bamboo-cutter found her and took care of her until she was grown up. By that time her marvellous beauty had attracted suitors from far and wide and some even came from the Imperial City. Not caring for any of them, the Bamboo Maiden set her suitors such impossible tasks—if they would win her—that she placed herself beyond their reach.

For instance, she sent one in search of an old

silver cup of legendary value, with which none other might compare, and hidden where it could not be found—some said at the bottom of a deep well, or in a cave guarded by wild beasts. However that may be, the suitor soon returned with a cup covered with rust which he had purchased from a Buddhist monk, but the sharp-witted maiden soon discerned the fraud. The next suitor was sent to an enchanted island where grew a golden tree bearing jewels for fruit. After a long absence he returned with a golden branch which had been made by a jeweller in Kioto and he presented this to the Bamboo Maiden, but his replies to her queries developed serious flaws in his story. A third suitor, who brought a marvellous blue-fox skin, said to be incombustible, saw his hopes consumed with his gift as it perished in the flames. The fourth—the only suitor who had honestly attempted the task assigned to him—had the worst luck of all; for he fell from a sheer rock that he was trying to climb, presumably in quest of some rare flower, and broke his neck. When the Emperor heard of the wondrous beauty of the Bamboo Maiden, he set out in his august bullock cart to visit her, but she was proof against

love in a palace, and having fulfilled the period of her exile (the reason for which the legend does not state), she returned to her home in the Moon.

According to another Chinese legend, the woman in the Moon is the wife of a celebrated archer of the reign of Hau, named Haou I. He had destroyed nine suns with his terrible bow and was about to destroy the tenth—the only one remaining—when the Sun god begged him to spare it to give light to the world. In return, he would send him a magic draught giving him the power to go and dwell in the Sun. At the same time he told the archer when he must drink the enchanted potion; but unfortunately Haou I told the secret to his wife, who, wishing to prove the truth of her husband's words, drank the draught for him. Next moment she became light as a bird and flew away to the Moon. In "Chin-Chin; or the Chinaman at Home" (translated by R. H. Sherard) it is related that the Emperor Ming Houang, of the Thang dynasty, dreamt that he went to the Moon, where he learned a wonderful melody entitled "Dress of Rainbow and Feathers." On awaking, he remembered the melody, which became the

cause of an insurrection nearly losing him his throne. One of his officers, who had heard a lady of the royal court singing the celestial melody, became infatuated with the fair songstress, which so angered the Emperor that she was dismissed therewith. Only in this way could he preserve his throne. "So true it is," remarks the chronicler, Tcheng-Ki-Tong, "that always and in all things, one must seek the woman, even in the Moon."

In the early Japanese mythology, while the Sun is under the dominion of the Goddess Amaterasu, or the Heaven Shriner, the Moon belongs to her brother, the rough and violent Susa-no-o. Later Japanese legends, however, tell of a maiden in the Moon who came down to earth to do penance among various picturesque scenes. We also read of a great city in the Moon and a cassia tree (*katsura*) whose reddening leaves cause its brighter glow in the autumn.

At the present day the Japanese have borrowed from the Chinese the idea of a hare in the Moon, which keeps pounding away at rice in a mortar to make it into cakes. However, the rice cakes seem to be native, having their origin in a pun, since the word *mochi* means both "full moon" and "rice

cake." The Japanese not only believe that the Moon is inhabited by a hare, but that the Sun is the home of a three-legged crow; hence the expression "the golden crow and the jewelled hare," meaning the Sun and Moon.

There are three great Moon nights in Japan, namely, the twenty-sixth night of the seventh month, when the people in Tokyo visit the tea-houses at Atago-yama, or the seashore of Takanawa, and watch the Moon rise over the water; the fifteenth night of the eighth month, corresponding to our Harvest Moon, but which the Japanese call the "Bean Moon," to which they offer beans, dumplings, and bouquets of eulalie grass and lespedeza blossom; and the thirteenth night of the ninth month, termed the "Chestnut Moon," the recipient of offerings consisting of bouquets, dumplings, and chestnuts.

In Japanese folk lore a legend is told concerning a Moon maiden who once visited the Earth, making her appearance at Mio-no-Matsubara, the scene of "The Robe of Feathers." Many years ago a fisherman landing on the beach found a robe of feathers hanging from the branches of a tree. He was about to take it home with him when

a beautiful maiden appeared before him and claimed the robe as her own. At first the fisherman was reluctant to part with his treasure, but the maiden assured him that she was a Moon maiden and an attendant of one of the thirty monarchs who rule that orb. She dare not return home without her feather robe. Her tears and entreaties prevailed and the fisherman promised to return it to her if she would dance for him. Then, decking herself in her finery, she danced so lightly on the sunlit beach that her feet scarcely touched the ground. Presently, to the strains of sweet music, she floated upward and away to her home in the Moon.

Even among the inhabitants of the South Pacific islands the most romantic belief exists concerning the Moon, according to the account given by the renowned explorer, Captain Cook. For them the Moon is a beautiful country, ornamented with groves of fruitful trees whose seeds have been carried thence from Otaheite (Tahiti) by white-winged doves, making the Moon a scene of beauty unsurpassed by any region on Earth. They seem to have borrowed their ideas from the ancients, who described the lunar spots as the

forests wherein the fair Diana hunted; or the Moon as the blissful paradise of the Druids.

Among the southern Slavonians the Moon is represented in a Servian song as a beautiful maiden "with arms of silver up to the elbows," sitting on a silver throne which floats on the waves of a beautiful lake. A suitor came to woo her, but she avoided him, shedding tears of sorrow and wailing with anguish as she gradually floated away. He is constantly pursuing her and she is constantly receding from him as he draws nearer to her. According to another legend, the Moon was once king of the night and husband of the Sun. He fell in love with the morning star, and in punishment he was cloven through—hence the phases of the Moon:

"The Moon wedded the Sun.
In the first spring
The Sun rose early.
The Moon departed from her.
The Moon wandered alone,
Courting the morning star.
Perkunas, greatly wroth,
Cleft him with a sword.
'Wherefore dost thou depart from the Sun,
Wandering by night alone
Courting the morning star?'"

There is a resemblance between this myth and the African legend according to which the Moon, having incurred the wrath of the Sun, is carved by its rays, which continues until the whole Moon is cut away and only a small piece remains. The Moon implores the Sun to have pity on him and leave this morsel for his children, and the Sun grants his request, whereupon the Moon grows from this little morsel until it is a Full Moon, when the Sun begins carving again. Thus, evil tongues made mischief between the Sun and the Moon:

"The tender Luna! woman at heart,
Ever she loveth her beautiful lord,
And at evening trembling and pale,
Out she peeps from light cloud curtains,
And looks to the lost one in sorrow.
Fain would she cry in her anguish: 'Come,
Come! the children are longing for thee.'
For vain—the haughty-souled god of fire
Flashes forth at the sight of pale Luna.
For doubly deep purple,
For rage and pain,
And yielding, he hastens him down
To his ocean-chilled and lonely bed.

. . . . . .

"Spirits, whispering evil,
By their power brought pain and destruction

Even to great gods eternal;
And the poor deities high in the heavens,
Travel in sorrow—
Endless, disconsolate journeys;
And they are immortal,
Still bearing with them their brightly-gleaming sorrow."

The Hindus account for the phases of the moon by saying that the Full Moon was created by Bromho, who desired to imitate the beauty of the face of Doorja, the beautiful daughter of Hymaloy and Manoka, who ruled the mountainous region of India in the days of old. When Bromho had completed his task, he was so displeased with the result that he spent the next fifteen days in breaking it to pieces, when he began the task all over again. Vain task, for never can he imitate the beauty of Doorja. Hence the Hindu explanation of the phases of the Moon.

In Hindu mythology, the Moon, Chandra, is a male deity, represented as wearing white garments, holding a mace in one hand and guiding with the other a chariot drawn by ten horses and antelopes. The hare is sacred to Chandra, because, like the Chinese, the Hindus see an imaginary hare in the Moon, thus accounting for its darker spots. How it came there is explained by

the legend told by the people of Ceylon, according to which, Buddha, while living on earth as a hermit, lost his way, one day, in a wood. Wandering for a long time, he finally met a hare who offered to show him the way out of the wood.

"Strike into the path on thy right and I will guide thee out of the wilderness."

Buddha thanked him, but remarked that he was cold and hungry and unable to repay this kindness.

"If thou art hungry," said the hare, "light a fire and kill, roast, and eat me."

Buddha made a fire and the hare immediately jumped in, when Buddha, overcome at the generosity of the hare, showed his divine power by snatching it out of the flames and setting it in the Moon, where it may be seen to this day when the Moon is full. There in the centre is the hare—the same one which, according to Chinese myth, is so industriously pounding away at rice in a mortar.

A Sanscrit legend describes the Moon as a watcher of the sky, who sleeps with her eye open like the hare. The mythical hare, in this instance, seems to be the Moon, and in the first story of the third book of Pantschatantra, the hare

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dwells upon the shore of the lake of the Moon where the king has his palace. In the Vedic hymns the Goddess Rakka, the Full Moon, is supposed to weave the beautiful garments for night and morning with a needle which can never be broken. Thus, she weaves together the roseate hues of morning or the mellow shades of evening in tints of wondrous beauty.

A similar myth is to be found in the folk lore of the natives in Mangaia, the southernmost island of the Hervey cluster. In this instance the woman in the Moon is Ina, who weaves eternally, beautiful cloth, using the white clouds out of which are made the sunset hues of sunset and sunrise. These she blends at dawn with the blue sky of day, and in the evening with the dark sky of night. The people of Samoa still speak of the woman in the Moon. "Yonder is Sina," they say, "and her child, her mallet, and her board." The same legend is told in the Friendly Islands and among the natives of the Tonga group.

A New Zealand myth relates how in days of old Rona went out one night when the Moon was shining, to get water from a well. A cloud passed in front of the Moon so that she could not see

where she was going and as a result she stumbled over a log of wood lying across the path. She cried aloud in her anger, making rude remarks regarding the Moon, who resented the affront. Imagine Rona's dismay when she saw the Moon descending from the sky and rapidly approaching her! She caught hold of a bush and clung to it, but it gave way and with Rona was transported to the Moon. The dark markings are said to denote her outline and that of the bush, and these may be seen any time when the Full Moon is visible.

In Australia the lunar myth prevails that the moon is a mischievous being who goes about the world on evil bent. One day he swallowed the eagle-god—the Sun, and when the wives of the eagle-god asked him what had become of him, the mischievous being protested that he did not know where the eagle-god was to be found. When he asked them where he could find a well, they showed him one and, as he stooped over to drink, they hit him on the head and out flew the eagle—possibly a variation of the many eclipse myths accounting for the disappearance of the Sun. In Norse folk lore the mischievous being is

Sköll, the name of a wolf which pursues the Sun, while Hati is another which follows in the track of the Moon. Sometimes it nearly catches up with the Sun, and when it does there is a total eclipse. The terrified onlookers make a great noise at such times to frighten away the wolf, until finally, as a result of the din, the Sun is released. Great is the rejoicing when it shines forth once more in its pristine glory.

Each country has its own eclipse monster which bears the blame of either stealing the light of the Sun, or else attempting to swallow that luminary. For instance, in India, the culprit is the crafty demon Rahu who slipped in among the gods one day when they were having a banquet and stole a portion of the drink of immortality. He was caught in the act by the mighty Vishnu, who is the enemy of all evil doers and is usually represented as a being with four arms. He carries a club, a shell, a discus, and a lotus and on this occasion he wielded his mighty club and smote off the head of Rahu, who still pursues the Sun and Moon.

According to a story told by Captain Beeckman of an eclipse of the Moon which occurred on November 10, 1714, and was observed by the

natives of the island of Borneo, great alarm was caused, as they imagined that Rahu was pursuing the Moon. "About eight at night, all of a sudden we heard a most terrible outcry, mixed with squealing, halloing, whooping, firing of guns, ringing and clattering of gongs or brass pans, that we were greatly startled, imagining nothing less but that the city was surprised by rebels." On inquiry, the uproar was explained by an old man, who, pointing in terror to the sky, exclaimed: "Look, there! See the devil eating up the Moon!"

The same idea prevails in China, where the devil is replaced by a dragon which is supposed to cause the temporary darkness usual at the time of an eclipse. In order to give the Sun a chance to escape from its clutches, a great clatter is made with kettles and drums. We are told that the eclipse is supposed to be a warning to the Emperor to examine his faults and mend his ways. The astronomer royal is assigned the task of making the necessary calculations as to when an eclipse may occur, since it is essential that the Emperor should be warned of the event in time, so that all may be in readiness at the appointed hour. When it arrives, the Emperor sounds the alarm by striking

on the "drum of thunder" with great vigour. The mandarins let fly their arrows in the direction of the eclipsed Sun and a tremendous clatter follows as the people bang kettles and pans together in an endeavor to intimidate the monster. Their efforts are finally rewarded with success, for the Sun gradually emerges from the jaws of the dragon, soon resuming its usual splendour.

In a country where such a belief once existed, eclipses were of vast importance to the Emperor, who was considered to be the Son of Heaven and therefore responsible for the well-being and perfect harmony of the heavenly bodies. In view of the elaborate preparations above referred to, one can well imagine the consternation which prevailed in A.D. 721, when the astronomer Y-hang had the misfortune to predict an eclipse which failed to materialise. As related by the writer in *Legends of the Sun and Moon,* one can see in imagination the Emperor with bâton uplifted to start the performance with his play on the drum and the mandarins with their arrow-tipped bows pointed expectantly at the Sun. Yet there is no sign that the dragon is attempting to bite a piece out of that luminary, nor is its brightness dimmed

in the slightest degree. Peradventure the Emperor glances furtively at the mandarins, whose eyes have wandered from the Sun to the discomfited astronomer. The latter no doubt realises that he has compromised the dignity of the Emperor and the mandarins by his blunder, and possibly he wonders what the result will be. Undoubtedly disgrace or death awaits him, but, being endowed with a nimble tongue and ready wit, he evades both. He assures the Emperor that, while the calculations he had made are absolutely accurate, yet owing to the fact that the high and mighty ruler of China is so perfect that he has no faults to correct, the eclipse has been indefinitely postponed! Who could resist such flattery? It certainly had its effect, for according to the records, Y-hang was pardoned.

At an earlier eclipse, however, which took place some four thousand years ago, the two astronomers royal of the period, Ho and Hi, were taken by surprise when it occurred, and as a result the Emperor and his mandarins were totally unprepared for the usual performance of the ceremonial rites. Ho and Hi, by virtue of their office, should have superintended these rites, but were so deeply

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engrossed in a game of chess that they quite forgot the celestial warfare due to take place between the Sun and the dragon. Some one must have noticed a peculiar greyness over-spreading the sky and a strange lull in the air such as precedes a storm. Then it occurred to one more observant that the light of the Sun was gradually growing dim. Hastening in search of the delinquent astronomers, Ho and Hi, and timidly disturbing their game of chess, the observer suggested that there must be an eclipse, as the Sun was almost hidden by the Moon. It was too late, however, to make the usual prèparations, or warn the Emperor, who was probably having his afternoon siesta. Swiftly spread the alarm, and we can imagine a whisper of dread as the Sun suddenly vanished from sight. This meant that it had been swallowed by the dragon and that it was expedient that it should be released as speedily as possible. Shouting and yelling with all their might and making a deafening uproar by banging kettles and pans together during the period of totality, they apparently succeeded in their purpose, for presently the Sun began to emerge from behind the Moon, soon shining as brightly as ever. As for Hi and Ho,

sad to relate, they were hanged, thus appeasing the wrath of the Emperor, who had been taken unawares. Their fate has been recorded in the following rhyme by some unknown writer:

"Here lie the bodies of Ho and Hi,
Whose fate, though sad, was risible,
Being hanged because they could not spy
Th' eclipse which was invisible."

The Greenlanders carry boxes and kettles to the roofs of their houses and beat them together with all their might until the eclipse is over. Some of the northern tribes of American Indians imagine that the Moon at the time of an eclipse is swallowed by a huge fish. The following is an account given of the terror inspired among the coloured folk at Shelbyville, Kentucky, during an eclipse of the Sun which occurred on August 8, 1870.

"They had come in great numbers to watch some astronomers who were making the necessary arrangements for observing the eclipse. We are told that they asked the price of the 'show,' and on learning that it was free of charge they openly expressed their contempt

for so cheap an entertainment. They crowded the trees surrounding the tents of the observing party and shouted the most sarcastic comments on the inferior interest of the entertainment. The trees were black with darkies and they kept up their noise till totality shut out the light of the Sun. Then they suddenly stopped, and we heard a wail and a noise of tumbling as though the trees had been shaken of their fruit, and the boldest scoffer did not feel safe till he was in his own cabin and under the bed."

Many legends were told by the various tribes, such as the Creek Indians, who believed that the Moon is inhabited by a man with his dog. A quaint tradition exists among the Selish races of Northwest America, which Captain Wilson, a noted traveller, relates as follows: "The expression of 'a Toad in the Moon,' equivalent to our 'Man in the Moon,' is explained by the following story. It appears that a little wolf, being desperately in love with a toad, went a-wooing one night and he prayed that the light of the Moon might shine brightly on his path. The prayer was granted and

by the clear light of the Moon he pursued the fascinating toad and had nearly caught her, when she eluded him by making a desperate leap on the face of the Moon where she is still to be seen to this day."

In the well-known legend of Hiawatha, the black spots on the Moon are accounted for by the story of the warrior:

> ". . . who, very angry,
> Seized his grandmother and threw her
> Up into the sky at midnight,
> Right against the moon he threw her:
> 'Tis her body that you see there."

According to the Iroquois legend, a woman was sent to the Moon because she was always complaining that she could not foretell when the world would come to an end. Presumably she was anxious to know when this event should take place. As a punishment for her curiosity she was sent to the Moon, where she can be seen by those who know where to find her, as a woman seated on a chair with a cat beside her. She is weaving a forehead strap, and once a month she stops long enough to stir a kettle of boiling hominy. Meanwhile, the cat unravels all the work done by the

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woman during the month, so that she has to beg all over again. Thus her task is endless and mu continue till the end of time; for never till the will the forehead strap be finished.

Crossing over to Russia, we find that their lun myth concerns the story of a man who sought tl land where Death is unknown. He took up h abode in the Moon, but after a hundred years or had elapsed, Death came after him. A furio struggle ensued, with victory on the side of tl Moon. The man was caught up in the sky ar now shines "as a star near the Moon." Accordir to a Dutch household myth the Man in the Moc was placed there for stealing cabbages on Chris mas Eve. The neighbours caught him just as l was hurrying away with a good supply, and the "wished" him up in the Moon. He stands ther bearing his load of cabbages, which constantly i creases and decreases, according as the Moon new or old. He is supposed to turn round on every Christmas Eve, although astronomy do not support this theory! In Sylt, the Man in tl Moon was accused of being a sheep-stealer, enti ing the sheep with a tempting morsel of cabbag As an everlasting warning to sheep-stealers he w

placed in the Moon. Alexander Neckham, born in St. Albans in 1157, remarks with regard to the legend of the Man in the Moon, as told in England:

"Do you know what the people call the rustic in the Moon who carries the thorns?"

He was doubtless referring to the legend of the Man in the Moon, as a wood-stealer who stole wood on a Sunday. In punishment, not only for his theft, but his desecration of the Sabbath, he was sent to the Moon, where he carries an axe on his back and a bundle of brushwood in his hand:

"The rustic in the moon
Whose burden weighs him down
This changeless truth reveals:
He profits not who steals."

This version of the popular rhyme is considered as being the earliest allusion we have to the popular legend of the Man in the Moon. In the British Museum there is a manuscript of some English poetry written in the thirteenth century, which contains a song about the Man in the Moon, the opening lines of which are as follows:

"Man in the Moon stand and strit,
On his bot-forke his burden he beareth,

It is much wonder that he do na doun slit,
For doubt lest he fall he shudd'reth and shivareth."

which in plain English means that, shivering with cold, he carries on his fork a load of thorns which tear his coat. He has cut them down and been impounded by the forester in punishment. This song represents him as a large, broad-shouldered man who walks a little and stands a little, but not a word is said about his picking up sticks on the Sabbath. In Wales there is a pictorial representation of the Man in the Moon, in Gyffyn Church, near Conway. The roof of the chancel is divided into four compartments in which the evangelistic symbols are painted. Besides these symbols, an orb of heaven adorns each apartment, the Sun, Moon and two stars being placed at the feet of the Angel, the Bull, the Lion, and the Eagle. The Moon is represented by a disc on which the Man in the Moon is shown with his bundle of sticks, but without the dog.

In my father's book, *Leisure Readings*, there is a chapter on "Nature Myths in Nursery Rhymes," where he refers to the story of Jack and Jill as probably a myth of the Sun and Moon.

"The Sun and Moon (the Moon new, or following the Sun) go up a hill: According to Lazarus Geiger, the Sun was often conceived as a cylinder on a sloping plane, first an ascending then a descending plane. In the story of Jack and Jill the cylinder does not appear, unless it is represented by Jack's pail; but the hill manifestly represents the path, first ascending then descending, followed by the two luminaries. The action of the Sun in raising water is obviously typified by the use of the pail to fetch water. It will be observed that there is only one pail—the myth-maker knew well that the Moon is not able to raise water as some modern meteorologists have mistakenly opined. The Sun, having passed the summit of the hill, descends to the west, his crown of glory being divided when he reaches the horizon. The New Moon follows, but as she is so much less brilliant, the myth says nothing of the loss of a portion of her radiance as she sets. All this is well presented in the nursery rhyme."

There is a curious resemblance between this

English nursery rhyme of "Jack and Jill" and the Scandinavian myth of Bil and Hjieki, who, it is said, were taken up to the sky by Mani. According to the legend the children were on their way to the well of Byrgir, bearing on their shoulders the bucket Soeg and the pole Simul, when they were seen by the Man in the Moon:

"How they pleased me! How they tempt me!
Shall I snatch them up to-night?
Snatch them, set them here forever
In the middle of my light?
Children, aye, and children's children,
Should behold my babes on high;
And my babes should smile forever,
Calling others to the sky.

"Thus, the philosophic Moon-man
Muttered many years ago;
Set the babes, with pole and bucket,
To delight the folks below.
Never is the bucket empty,
Never are the children old;
Ever when the moon is shining
We the children may behold."

CHAPTER XI

ANCIENT MOON WORSHIP

"Moonèd Ashtaroth
Heaven's queen and mother both."
—MILTON, *Ode.*

NO FORM of idolatry is older than the worship of the Moon. For the Hebrews the Moon was Astarte, Queen of Heaven, and she is mentioned in the Book of Genesis, as Ashtaroth-Karnaim, or Ashtaroth of the two horns. Symbolised by a figure with a heifer's head whose horns resembled the crescent moon, she was worshipped as the chief local deity of Sidon. In the Book of Isaiah we read that the daughters of Zion ornamented themselves with networks and crescents, or "round tires" like the Moon. The Book of Ezekiel records that the gate of the inner court of the Sanctuary that looketh toward the east shall be opened on the day of the New Moon.

If there were no sacred meaning in the observance of these lunar phases, why did the writer of

the Epistle to the Colossians say, "Let no man judge you in respect of the new moon," showing an association between the Hebrew religion and the changes of the Moon. To connect the annual festivals with the New Moon, and to commemorate them in the evening by greeting the Moon with sounds of joy, was a primitive custom in the circle of nations from which Israel was formed. Reference to the quaint practice of kissing the hand as an act of adoration on seeing the Moon, is to be found in the Book of Job.

At the entreaty of Samuel, the children of Israel renounced the worship of Ashtaroth, but her idolatry was resumed in the reign of Solomon though repressed for a time by Josiah. In the reproaches of Jeremiah, we read of Ashtaroth or Astarte as the Queen of Heaven to whom the women of Israel poured out drink offerings and burnt incense and offered cakes. She was regarded as the cause of national prosperity, and her cult spread to Phœnicia and Arabia, where she was looked upon as a beneficent goddess.

The monuments found in Sinai contain information which points to the existence of Moon worship at a remote historical period. These

monuments consist of rock tablets which were engraved by the Pharaohs from the First Dynasty onwards, over the mines which they worked at Maghara, and of remains of various kinds discovered in the temple ruins of the neighbouring Serabit. Maghara more especially was associated with the Moon-god, and was presumably the site of a shrine during the Babylonian or Arabic influence which preceded the invasion of the peninsula by the Egyptians. It has been suggested that the name of Mount Sinai was actually related to Sin, one of the Semitic names of the Moon, to which it was probably dedicated; and all the surrounding region was called Sinon, or Moonland. Sin was also a name of the Moon God in ancient Babylonia, where the constant recurring phases of the Moon caused it to be accepted as the ruler of times and seasons by huntsmen and herdsmen generally.

Ur of Chaldea, from which Abraham migrated to Canaan about 2100 B.C., was a centre of Moon cult. In the Chaldean mythology the moon ranks higher than the Sun, the preference probably being due to the fact that the nights are more pleasant than the days in hot countries, and the soft light

of the Moon is welcome after the intense glare of sunshine. Not only were the Chaldeans Moon worshippers, but the ancient capital of Chaldea was Ur or Hur, their name for the Moon-god. (In the Armenian language, the name for the Moon is Khaldi, possibly the origin of the word Chaldea, as indicating Moon worshippers.) During the recent excavations at Ur, under the direction of the trustees of the British Museum, who joined forces with the Museum of the University of Pennsylvania, many interesting discoveries were made in connection with the temple of the Moon-god. The temple of E-nun-mah, dedicated to Moon worship was found to be divided into three main periods. The first of these extends from an unknown date in prehistoric days to the close of the seventh century B.C.; the second period is that of Nebuchadnezzar, who remodelled the temple, changing its ancient characteristics; the third is that of Cyrus, who preserved the main lines of Nebuchadnezzar's work, but so altered it in detail as to modify the original plan.

Another name for the Moon-god was Ea or Yah, who was accounted the oldest Semitic god in

Babylonia, to which his devotees were held to have brought the cultivation of the date palm, an event that marked a notable step in civilisation. The emblem of Ea was the Full Moon, who, in the Assyrian Creation story, is described as: "Ea, the god of the illustrious face." On Babylonian seal cylinders, Ea is shown standing up as a bull, seen front face, with his devotee Eabani, who wears the horns and hide of a bull. (Such tablets can be seen in the British Museum.)

The Egyptians had two Moon gods, Khons, or Khonsu, and Tet, or Thoth. M. Renouf, the well-known Egyptologist, tells us that Khonsu was one of the triad of Theban gods, and was the moon, one of his attributes being the reckoner of time. "In the tombs the Moon-god is represented seated on a bark, and holding the sceptre of benign power to whom two Cynocephali are doing homage, followed by the Crescent and Nuter god. Lastly, the same god is found in a standing posture, worshipped by two souls and two Cynocephali." [1]

There were shrines to the Moon-god at

[1] *Egypt's Place in Universal History,* by C. J. Bunsen, trans. by C. H. Cottrell, vol. i, p. 395.

Hierakonpolis and at Abydos in Upper Egypt; and in both these places he was worshipped under the semblance of a baboon. At Hermopolis in Lower Egypt he was represented as ibis-headed. The figure of the baboon found in the temples at Abydos was deemed a suitable offering to the sacred shrine at Serabit in Sinai, because of the nearness of this shrine to the centre of Moon worship of that country. If the figure was carried to Sinai at the time when similar figures were offered in Egypt, the establishment of the Moon cult in the peninsula dates back to the pre-dynastic days of Egypt, according to M. Renouf (Hibbert Lectures for 1879).

Of the kindred of the Pharaohs, Plutarch observes: "The sun and moon were described by the Egyptians as sailing round the world in boats, intimating that these bodies owe their power of moving, as well as their support and nourishment, to the principle of humidity." This statement is confirmed by the sculptured representation of the Moon-god Khons, who bears in his hand either a palm branch, or the "Nilometer" used for ascertaining the rise and fall of the waters of the Nile.

Regarding the Cynocephali or dog-headed worshippers of the Moon, it is interesting to note the association of the dedication of the cat to Pasht, another name for the Moon-god, and the veneration of the Egyptians for this animal. The origin of this association seems to have been of prehistoric date, and not invented by the Egyptians. Herodotus describes seeing the mummies of cats at Bubastis, and thereon Henty wrote a most thrilling story, entitled *The Cat of Bubastis*, giving an account of the veneration in which that animal was held and the narrow escape from an untimely fate of one who accidentally killed one of these "sacred" animals. Why the cat was likened to the Moon, and lifted to the lofty pinnacle it once attained, is difficult to define, but possibly the fact that the pupil of its eye is singularly changeable, dilating from a narrow line in the daytime to a luminous orb in the dark, may have impressed the Egyptians with the idea that feline eyes shine at night with what seemed to them a supernatural lustre.

According to Plutarch, a cat placed in a lustrum denoted the Moon, illustrating the mutual symbol.

He supposes that this is because the pupils of a cat's eyes dilate and increase with the Moon. On the other hand, Renouf says: "It is not improbable that the cat, whose name in Egyptian was Mäu, became the symbol of the Sun-god, or Day, because the word Mäu also means light; but though the cat may also have been adopted in Egypt as a symbol of the Moon-god, yet its native land is certainly Persia, some etymologists assigning *pers* as the origin of *puss*."

These are only a few instances of ancient Moon worship, traces of which may be found among widely scattered places, such as far-away Peru, where, according to Prescott, in his interesting *History of the Conquest of Peru* (page 130), he tells us, after describing the magnificent Temple of the Sun at Cuzeo, where everything within the temple is made of gold, that there is an adjoining Temple of the Moon, where this goddess is held in reverence as the mother of the Incas. Her effigy was delineated in the same manner as that of the Sun, on a vast plate that nearly covered one side of the apartment. This plate, and all the interior decorations of the building, were of silver,

as suited to the pale, silvery light of the beautiful satellite."[1]

"While rocks and floods reflect the quivering gleam
The whole air whitens with a boundless tide
Of silver radiance, trembling round the world."

[1] *History of the Conquest of Peru,* by W. H. Prescott, p. 47.

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