The Movements of the Moon—I*

A Popular Survey of Their Marvelous Multiplicity and Variations

By Percy Johnson

CERTAINLY, the moon is the most lovely orb of heaven, and richly deserves the title bestowed upon her by the poets—"Queen of the Night." There is no other heavenly body, with the possible, but doubtful, exception of the sun, which is subjected to more observation by "the man in the street," and there can be little doubt that this is chiefly due to her peculiar beauty as she presents her varying phases to our view, and to the pale soft loveliness of a moonlit landscape, which is more entrancing than the warmth and brilliance of one illumined by the glory and splendor of "King Sol" himself. Who has not beheld with pleasure the slender crescent of the young moon in the evening sky, or gazed in rapture on the heaving waters of the ocean glistening under the silvery moonbeams?

The sun may be the grandest, the most important object in the Universe so far as the inhabitants of the earth are concerned, in their dependence upon the beneficence of His Majesty's rays; the great nebula in Orion may be the most awe-inspiring spectacle astronomers have ever looked upon; Saturn, with its wonderful rings, may be the most unique revelation of the telescope; but—upon this, I think, all are agreed—the gentle loveliness of our faithful satellite, the moon, is unequaled in the realms above.

In which of her many changing aspects does the moon most delight the eye of man? Is she most lovely of all when seen in the beautiful western sky at sunset—an exquisite crescent with "the old moon in her arms"—or when serenely "sailing" high in the heavens, amid the fast flying clouds, she shines o'er land and sea, investing every scene with a beauty all her own, or is the great, golden harvest moon of autumn, rising night after night in the north-eastern sky about the time of sunset, the loveliest of all the lunar phases?

Who shall say?

In addition to this wealth of beauty, manifest to the most casual observer of Nature, the moon has many attractions which merit much attention, and which arise mainly from the fact that she is our nearest neighbor, and can be subjected to a closer scrutiny than can any of the other denizens of space.

To the amateur astronomer possessed of a telescope, the moon is certainly the most beautiful of celestial objects, and he can sit for hours at his instrument, reveling in the unsurpassed glories of the lunar landscape. To one who looks at the moon telescopically for the first time, the sight is a never-to-be-forgotten one. The jagged line of mountains, dividing day from night, catching the sunlight on their top-most peaks, looks like a row of snow-white crystals, or shining jewels, and never fails to draw forth exclamations of surprise and admiration. The strong contrasts of light and shadow are a never-ending source of delight and wonder—the shadows streaming across the plains, and revealing in exaggeration the contour of the mountain ranges.

The moon's interest, however, lies not only in her telescopic appearance, a description of which, unfortunately, cannot be included in the present article. With the single exception of the sun's apparent movement athwart the heavens, the moon's varying position among the stars, with the accompanying change in her phase of illumination, is the most obvious and striking of all astronomical phenomena, and one which has attracted the notice of man from times of the remotest antiquity. Although the earliest records extant in this connection are merely the expression of a primitive wonder and simple nature-worship, they are exceedingly interesting, and deserve more than the passing reference here made. They take the form of hieroglyphic inscriptions which the Egyptian races, of probably 6,000 years ago, left on their temple walls, showing us that the sun, moon and stars were then regarded with a seriousness we would do well, to a certain extent, to imitate. At that early period in the history of mankind, about which much might be written, the stage of thought was primarily that of worship, as is shown by the evidence of the deification of the various celestial bodies to be found on every hand in the majestic ruins of the vast and mighty buildings in that strange land on the banks of the Nile.

There is also ample evidence, however, that the utilitarian point of view was not neglected—indeed, it was more important than we are apt to realize in these days of calendars. This is conclusive in the case

of the sun, whose variations were sedulously watched by the priests, both for religious and mundane purposes, and it is certain that the convenient division of time marked by successive lunations would direct an equally scientific attention to those of the moon. In one of the inscriptions referred to, the waxing moon is typified with that charming simplicity which always characterizes these pictorial writings, but which very simplicity often baffles the best brains for an explanation. It is known as "The Square Zodiac" of the chief temple of Denderah, and shows the moon-god at the top of a flight of fourteen steps, which symbolize both the moon's increasing phase, and the number of days between "new moon" and "full moon"! In another representation, the god is divided into fourteen pieces to illustrate the phenomenon of the waning moon!

In parenthesis, it may here be allowable to emphasize the better perspective of awe and wonder which obtained in those far off days, when even the succession of day after night was looked upon with feelings of doubtful confidence, than does with the majority of people to-day. Although it would be foolish to compare the vastly superior knowledge possessed by the public in general, and astronomers in particular, in the twentieth century, with that superstitious regard held by the ancients, it is, at the same time, that very excellence of the learning of to-day which is responsible for the careless indifference of the many to fundamental facts of nature.

These may not be of so recent discovery as, for example, the so-called "canals" on Mars, and may not be so sensational to the popular mind, but they are, nevertheless, among the most impressive things in the universe, fit food for the deepest thought and meditation.

All the heavenly bodies, sun, moon, planets and stars (and comets too, when they happen to be visible) daily perform an apparent revolution round the earth, due to the latter's diurnal rotation on its axis. The general ignorance which prevails respecting this motion of the stars is remarkable, but it will come as a shock to many readers when it is stated that many persons are entirely unacquainted with the moon's regular performance of this apparent daily motion. (The word "apparent" is used to signify that the movement is not real on the part of the moon, but is similar to the apparent motion of objects seen from the window of a traveling train.) The extent of their knowledge seems to be confined at the most to three weeks out of every month. What becomes of our satellite during the remainder of each period, remains with them as great a mystery as the Sphinx, and, it might be added, as far as they are concerned, matters less! Surprising as it may seem the writer has heard the greatest wonder expressed by otherwise intelligent persons at what should be the familiar sight of the moon in her first quarter in the afternoon sky. Such complete indifference to natural phenomena, whether "in heaven above . . . in the earth beneath, or in the waters under the earth," is not justifiable. It is our duty as intelligent creatures inhabiting this planet to take reasonable notice of what is taking place around us.

Let us, therefore, attach our interest to the common but beautiful spectacle of the crescent moon in the evening sky at sunset, watching night by night her progress among the twinkling stars, and try to realize something of the feeling which animated those who carved that simple note on the temple stone at Denderah, which will endure when this printed page, and the material bodies of those who read it, will have passed into oblivion.

In the first place, it is interesting to discover how soon the moon first becomes visible after the time given in calendars as that of "new moon." Previous to this, although the moon is in the immediate vicinity of the sun, she is lost in his superior luster, and we are apt to forget her presence until we are apprised of the fact by her withdrawal to a sufficient distance to permit her illuminated rim to be glimpsed. Theoretically, the completely dark "new moon" should be of brief duration, and quite a degree of enthusiasm may be introduced into monthly searches to secure earlier detection of the exceedingly delicate crescent she presents on her first appearance after emerging from the overwhelming brilliancy of the great luminary. Under the condition of such early observance, she will be disclosed in the evening by the diminution of the sun's

powerful light, but, following the example of her grandparent, she sets almost immediately. Carried by the diurnal rotation of the heavens beneath our feet, she rises soon after the sun the next morning, and will doubtless be apparent in the sky throughout the day. It will be observed that the convex surface of the crescent is presented to that part of the sky in which the sun is situated. It is surprising how many artists spoil what otherwise might be good pictures by neglecting such an observation as this, and erroneously depicting the concave side turned toward the place of sunset, thus betraying their ignorance of the source of the borrowed radiance of the "Lamp of Night."

Once again the sun sinks in the golden west, and the shades of evening commence to fall. As twilight deepens into dusk, the moon, now appreciably advanced in phase, and occupying a position farther to the east than that of the previous evening, though sinking in the heavens, lingers yet awhile, an object of rare beauty and delight, hanging in the vault of heaven like some phosphorescent ball of liquid light set in a silver bowl.

"The old moon in the new moon's arms—" so familiar! so charming!

It may be noted in passing that the bright crescent often seems to belong to a distinctly larger body than the remainder, which accentuates the appearance above referred to especially when the moon is "on her back," to use a popular expression.

This is an optical illusion, due to irradiation, by virtue of which, a light body projected on a dark ground appears to be larger than it is.

In the spring of the year, by reason of the oblique angle at which our satellite's path meets the horizon, the young moon remains in the sky, many hours after sunset; but eventually, whether sooner or later, as our hemisphere of this ponderous earth turns over for its night's repose, the horizon rises up and cuts her off from view, depriving us of her reflected rays, which, although so mild and gentle, have hidden the full glory and splendor of the starry firmament.

A similar sequence of events takes place during the next twenty-four hours, with the result that the moon is discovered still farther to the east, and more fully illuminated. When she happens to be near a star this motion, which is known to astronomers as "direct" motion because it is the moon's real movement as distinguished from that "apparent" daily rising and setting motion, is easily noticeable in the course of a couple of hours. The distance between the sun and moon is thus steadily increased by this persistent movement to the east, and the illuminated portion of the latter's disk is constantly directed to the former's. When about seven days old, the moon is in her "first quarter" and about the time of sunset is on the meridian—the line which passes through the zenith and the north and south points of the horizon. The gibbous phase is now entered upon, and every night the moon continues her journey to the east, until "full moon" is attained, when she rises at the time of sunset, and is on the meridian at midnight. Of course, when it is said that the moon is farther to the east, it must be understood that it is so at the time of our initial observation, which in this case was sunset, as the daily rising and setting motion due to the Earth's own rotation, carries it through all positions in the course of a day.

The phase now decreases, and it will be seen that the illuminated part has "faced about" and is now directed to the eastern sky. When she has reached her "last quarter" the moon does not rise till about midnight and at sunrise is on the meridian in the morning sky. During the next seven days she approaches closer and closer to the sun until a very fine crescent is attained, when she is seen only in the strong light of dawn in the east. Then she is lost in the sun's rays, to emerge shortly afterward as a brand "new moon" in the west!

This is the monthly cycle of the moon's changes, and although some may smile at such a labored description of what they think is of such common knowledge, the writer is content to let it stand in view of what was remarked in the early part of this article. Very little consideration of the above observations will convince one that the moon's light is not an inherent property, but that she is a dark, globular body reflecting the sun's rays, while the only explanation of the "backward" motion from west to east (which truly is "real" and "direct" motion), which has been distinguished from the daily movement from east to west (which truly is

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only "apparent" and "retrograde"), is that the earth's satellite is revolving round its primary in a period of about four weeks.

According to Professor Newcomb both these facts have been known from the earliest times.

That her light should be so white need occasion no surprise when one thinks of the pure whiteness of the clouds, which at other times, when not reflecting the solar rays, are so dark and forbidding. It has been variously estimated, however, with regard to the intensity of the lunar beams, that from 300,000 to 600,000 "full" moons would be required to produce the degree of illumination experienced by the earth on a bright summer's day!

Let us now consider more closely the period taken by the moon to complete her orbital motion. Subsequently we shall deal with the dimensions of that orbit and certain variations in its form, which, though minute, are of great interest and importance, and were known thousands of years ago.

It has been mentioned that the interval of time between two successive "new" moons is about four weeks. Actually, the average period is $29\frac{1}{2}$ days, but this does not represent the time taken to make a complete circuit of the earth. It is too great, for this reason: The sun, like the moon, has an independent movement apart from the daily rising and setting motion, which carries it from west to east. This is, however, not a "real" motion on the part of the sun, as was the moon's, but an apparent one due to the earth's yearly journey in space and consequent projection of the sun on every part of a great circular belt on the background of stars, known as the Zodiac. That is to say, the sun has a "backward" (direct) movement in the sky like the moon, but a much slower one, which only carries it through in a year what the moon can accomplish in a month. Therefore, when the moon arrives at that point in the great pathway of the stars at which she was last "new" she has circled the earth completely, but the sun has apparently moved farther to the east, and it takes the moon a little over two days to "catch up" and become "new" once more.

The first of these, the true period, because it may be referred to the position of the moon in the stars, which for this purpose may be regarded as forming a changeless background or dial, is termed the "sidereal" month. The second, or interval between two similar phases, is called the "synodical" month. The length of the sidereal month is 27 days, 7 hours, 43 minutes, 11½ seconds, while the synodical month is, as has been mentioned, $29\frac{1}{2}$ days. There are, however, several minute variations which render this statement liable to slight modification, as will afterward appear.

The earth's annual motion round the sun, we have said, causes the latter to appear in various parts of the background of stars which is situated at an infinitely remote distance in comparison to those of both sun and moon. The constellations in which the sun successively appears (or indeed would do so if his light did not hide them) are the well known twelve signs of the Zodiac—Aries, Taurus, Gemini (the Ram, the Bull, the Heavenly Twins) etc., and its actual path which runs through this belt of the Zodiac is called the "Ecliptic." Its position is obviously determined by the direction of a line from the earth to the sun, and continued to the starry dial. As the earth proceeds on its annual voyage round the sun, this imaginary line will sweep round in a plane, which is "the Plane of the Ecliptic," or the plane of the earth's orbit. This plane is marked out then by the sun's path in the sky, which can be accurately marked down on a map of the stars.

Now the moon marks out its own track in the sky, and this can also be marked on the chart of stars. It is found on so doing that the moon's path cuts the sun's path or Ecliptic at an angle of five degrees.

Therefore, part of its monthly journey is above the plane in which earth and sun are situated, and the remainder is below that level. That point at which the moon commences to rise above the Ecliptic is called the "ascending node," and that at which it begins to descend below it, the "descending node." It is apparent that once a month when the moon is "new," it must occupy a position somewhere between the earth and the sun, and it is further quite clear that if she were directly between the two, or in the Plane of the Ecliptic, she would "eclipse," or interrupt the sun's light.

We have seen that the moon is in the plane of the earth's orbit at two points only, the nodes, so that when an eclipse occurs, it is certain that one of these nodes lies in a position exactly between the earth and the sun. If this node were fixed in that position, an eclipse would occur regularly every month at "new moon," but as eclipses are not of such regular occurrence, it follows that the moon, when occupying a position intermediate between the sun and earth, it is generally a little too

high above the Plane of the Ecliptic, or a little too low down below it to be in an absolutely straight line between the two and cause an eclipse.

It is perfectly plain, therefore, that the position of the nodes is not constant; in fact, it has been found that these points are gradually changing their positions, and that in about $18\frac{1}{2}$ years they make a complete revolution of the moon's orbit. A good idea of the effect of this on the plane of the moon's orbit can be obtained by spinning a plate on the ground. Just before it is about to collapse flat on the floor it will present a fair representation of what is taking place, each "wobble" corresponding to an $18\frac{1}{2}$ -year revolution of the nodes. Naturally the recurrence of eclipses of the sun and moon depends upon this phenomenon, as an eclipse of either of these bodies can only happen when the moon is at one of its nodes or a certain definite distance thereof, (1) at "new moon" and (2) at "full moon." Taking the case of solar eclipses: If no other circumstance had to be taken into account, an eclipse could happen only once in $9\frac{1}{4}$ years, or the time taken for a node to make half a revolution and occupy the position previously held by the other node. While this backward movement of the nodes, which amounts to $13\frac{5}{5}$ degrees a month, is taking place, however, the sun's position is moving forward (West to East) at the rate of 30 degrees a month, so that at the end of that time the node is removed from the sun's position $31\frac{3}{5}$ degrees, and in $53\frac{5}{5}$ months 180 degrees will separate the two positions. This means to say that the other node will now be in front of the sun, and the conditions for an eclipse again occur, so that two eclipses must occur within six months. We have assumed, however, that the node must be directly between the sun and the earth. This is not quite true, as the sun and moon are not mere points, but have a magnitude, so that if the node is sufficiently near to permit their respective disk edges to overlap a partial eclipse will be visible, while the magnitude of the earth allows an observer to move about to various vantage points and still further increase the frequency of eclipses of the sun. Indeed, eclipses of the sun are of more frequent occurrence than eclipses of the moon, if the observer is always able to be on that part of the earth from which the solar eclipse is visible, but if he is not able to move about in this way the lunar eclipses become the more common, for, while the belt of earth permitting observation of the former is narrow and is continually varying its position, the latter, when visible, is so from every part of a whole hemisphere of the earth. From what has been said it will be seen that, far from an eclipse happening only once in 9.3 years, a regular series of eclipses will be possible under the conditions laid down, but that after 18.6 years this series will start all over again, and the eclipses will all be repeated at successive intervals of time similar to those in the previous series.

The Chinese of two thousand years ago recorded eclipses, but not systematically, whereas the Chaldeans were well acquainted with the period we have been discussing, which they termed the Saros, and were thus able to predict the recurrence of eclipses more or less truly.

(To be continued.)

Tarantism and the Dancing Mania

SOME people, in an effort to explain the modern dancing craze, have attempted to liken it to the remarkable dancing mania of the Middle Ages. Whether this is true or not, it is interesting to recall to mind the extensive outbreak of frenzied dancing which swept over a great part of Europe, particularly during and immediately after the tremendous epidemics of the Black Death. One of the earliest outbreaks to be completely described occurred in Aix-La-Chapelle in 1374. The following strange spectacle was noted: Men and women "formed circles hand in hand, and, appearing to have lost control of their senses, continued dancing, regardless of the bystanders, for hours together in wild delirium, until at length they fell on the ground in a state of exhaustion. During the paroxysms the victims had hallucinations and some asserted that they felt that they had been immersed in a stream of blood, which obliged them to leap so high."

This extraordinary disease rapidly spread to many parts of Belgium, Holland and Germany, where it was variously known as St. John's or St. Vitus' dance, according to the saint who was supposed to protect those afflicted. The malady was first considered the work of the devil and the clergy were kept busy in their efforts to exorcise the evil one. That the disease was contagious was obvious and the victims were prone to acute recurrences.

In Italy, where the disease later appeared, the learned Nicholas Perotti, in an account of the disorder, points

out that no one had the least doubt that it was caused by the bite of the tarantula, a common ground spider, particularly plentiful in Apulia, a southern district in Italy. It is significant to note this early attempt to explain the malady on natural lines and subordinate the supernatural. From the insect the disease was given the name of *tarantism*. There was a general conviction that by music and dancing the poison of the tarantula was distributed throughout the whole body, and expelled in the sweat induced by the great exercise. Later on it became evident that even those who were not bitten contracted the disease. Inquisitive persons who came to see the unfortunates in their wild dances not infrequently stayed to participate. Relief could only be obtained by dancing until complete exhaustion was produced. The musicians, who in some instances were employed by the municipality for this special purpose, were under no circumstances allowed to stop and substitutes had to be employed to relieve musicians who were themselves literally played out. As time went on it was noted that special kinds of music were very effective in bringing about the speediest cures. Music which permitted quick, lively dancing was most efficacious. A rapid music imported from Turkey soon became the standby and was given the name of *tarantella*, a term still used to describe a rapid whirling dance.

Tarantism was at its greatest height in Italy in the seventeenth century, long after the disease had disappeared in Germany. From this time the disease decreased but has appeared on occasions among special sects, as for example the Convulsionnaires in France, the Holy Jumpers and the Barkers in England, the Holy Rollers in the United States.

Space prohibits a discussion of the disease itself, suffice to say that it is definitely known to be a nervous disorder akin to imitative hysteria. It is doubtful if we shall ever see such widespread affections, but we may expect occasional outbursts of a similar character in connection with fervent revival services and the like. The poor physical and mental condition of the people in the past produced through poverty, plague and other disasters undoubtedly played no small part in preparing their minds for the disorder of the Dancing Mania.—S. M. G. in *Science Conspectus*.

A New Method of Repairing Injured Nerves

DR. L. EDINGER, a well-known neurologist of Frankfurt, Germany, recently gave an address before the *Deutsche Orthopaedische Gesellschaft* on the subject of rebuilding torn and injured nerve tissue. According to Dr. Edinger, nearly all operations on nerves are at present attended by great uncertainty of result, and he ascribes this to a lack of knowledge of the theoretical relations governing nerve growth. Nerve fibers are semi-fluid structures proceeding from the ganglion cells, and in continuation of growth find new material in peripheral assistant cells. Dr. Edinger has been able to produce similar outgrowing structures from silicic acid. The nerve fiber remains throughout its existence dependent upon its original cells; so that when a nerve is divided, as by a shot wound, the portion cut off from the ganglion cell gradually perishes. Only the peripheral assistant cells referred to remain alive. But after such an injury there immediately proceeds from the ganglion cell a fresh putting forth of fiber through the central nerve-end, in an attempt to reach the separated ends. It can be proved that healing will always take place, even after the lapse of years, if these new fiber-ends do not meet with resistance in the blood or in the scar. But extending in every direction into the tissue they often do not conquer this resistance very quickly.

Other attempts which have been made to overcome this difficulty, such as sewing the nerves or transplanting nerves of other tissues between the two separated ends, have left much to be desired. Recently, however, according to the *Naturfissenschaftliche Umschau* (Cöthen), Dr. Edinger has devised an admirable method for promoting growth between the severed ends. He proceeds from the viewpoint that it is important above all to avoid resistance to the forth putting or processive action of the nerves.

Knowing that embryonal nerve-tissue will continue to grow in certain gelatins, even when separated from the parent animal, Dr. Edinger filled animal arteries with such gelatins, and after completely cutting away the scar, inserted the upper and lower ends of the human nerve into the artery filled with the gelatin. The hoped for result promptly ensued. With surprising rapidity the two ends of the separated nerve grew together. An admirable technique of operation has been elaborated by Dr. Ludloff, and it is believed that the new method will largely increase the percentage of recoveries from nerve injuries due to wounds.