MARS AND HIS MOONS.

We take the following abstract of a paper read before the California Academy of Sciences by Prof. John LeConte, from the *Mining and Scientific Press:*

There is no member of the solar system, with the exception of our moon, which can be studied under such favorable circumstances as the planet Mars; for, although Venus, when in *inferior* conjunction, is nearer to us than Mars in opposition, yet Venus, at this time, turns her darkened hemisphere towards the earth. Moreover, although Mars does not appear so large an object in the telescope as Jupiter, yet he is in reality seen on a much larger scale, not only on account of his much greater proximity to us, but because, being likewise much nearer the sun, his surface is much more brilliantly illuminated, so that a much higher telescopic power can be advantageously employed. Accordingly, ever since the invention of the telescope, Mars has been a favorite object of observation. The largest and most powerful instruments have been employed to scrutinize this planet, and the varied physical details of its surface have been most carefully mapped by many astronomers.

When, therefore, it was announced, a few months ago, that the American astronomer, Hall, had discovered two satellites belonging to Mars, we ought not to be surprised at the astonishment with which the news was received by the scientific world. Moreover, there can be no question that for more than two centuries past astronomers have recognized the probability of the existence of satellites to this planet. In fact analogy would lead us to expect that Mars would be furnished with one or more moons; for, being situated at a greater distance from the sun than the earth, it seems more especially to need such luminaries to cheer its dark nights. Under the influence of these anticipations, the astronomers who have so carefully studied the physical features of Mars, have doubtless been looking for these satellites. In fact, many of them have contended that the failure to discover them is not by any means a conclusive proof of their non-existence; since Mars, being a very small planet, we might expect his moons to be proportionally small, in which case they might escape detection by the telescope. Thus, for example, the second satellite of Jupiter is only about the forty-second part of the diameter of the planet; and a satellite which would only be the forty-second part of the diameter of Mars would be about 100 miles in diameter. At the least distance of the earth from Mars a satellite of this dimension would subtend an angle of less than one-half of a second; so that even in the most favorable position of Mars, powerful telescopes might fail to reveal such an object especially if it do not recede far from the disk of the planet.

This state of doubt and uncertainty in relation to the question of the existence of Martial moons afforded legitimate game for the satirical writers of the last century. Thus, Jonathan Swift (more familiarly known as Dean Swift), in his "Gulliver's Travels," published about 1727, in giving an account of the extraordinary race of abstract philosophers who inhabited the "Floating Island" called Laputa, informs us that "They spend the greater part of their lives in observing the celestial bodies, which they do by the assistance of glasses far excelling ours in goodness. For, although their largest telescopes do not exceed three feet, they magnify much more that those of 100 with us, and show the stars with greater clearness. This advantage has enabled them to extend their discoveries much further than our astronomers in Europe; for they have made a catalogue of 10,000 fixed stars, whereas the largest of ours does not contain above one-third of that number. They have likewise discovered two lesser stars or satellites, which revolve about Mars; whereof the innermost is distant from the center of the primary planet exactly three of its diameters, and the outermost five; the former revolves in the space of 10 hours, and the latter in 21½; so that the squares of their periodical times are very near in the same proportion with the cubes of their distances from the center of Mars; which evidently shows them to be governed by the same law of gravitation that influences the other heavenly bodies."

About 25 years after Swift wrote the foregoing, that is in 1752, the celebrated Voltaire, apparently in imitation of "Gulliver's Travels"), cuttingly ridicules the pretensions of the class of reasoners who found their conclusions upon analogy. In one of his satirical tales Micromegas, an imaginary inhabitant of Sirius, is supposed to make a voyage of discovery through the solar system in company with a denizen of Saturn; they philosophize as they go. Approaching the planet Mars, Micromegas and his companion plainly descried two moons acting as satellites to that body—moons which have certainly escaped the ken of terrestrial astronomers. "I know perfectly well," continues the author of the tale, "that Father Castel (an astronomer of the time) will write, and write sufficiently pleasantly, too, against the existence of these two moons; but I appeal against his decision to logicians, who reason from analogy. These excellent philosophers are perfectly aware how difficult it would be for Mars—a planet so far removed from the sun—to get on with less than two of these satellites." (Œuvres de Voltaire—Micromegas, Chap. 3.) How completely the recent discovery of the American astronomer has "turned the tables" on the renowned satirist of the last century! The previsions of these "excellent philosophers" who founded their conclusions upon analogical reasoning, although slumbering in the domains of the unproven for more than two centuries, have at last been verified by direct observation.

WHY THE DISCOVERY OF THE SATELLITES WAS NOT MADE SOONER.

As the moons of Mars are very small objects, it is only under the most favorable circumstances that they can be seen by the most powerful telescopes. Mars is nearest to us when his opposition occurs when he is near his perihelion; and the greatest possible proximity to us occurs when Mars is in opposition in perihelion and the earth is in aphelion at the same time. The oppositions of Mars near perihelion occur at intervals of 15 and 17 years successively. A very good opposition occurred in 1862; and a great many distinguished astronomers embraced the opportunity of scrutinizing Mars with the aid of excellent instruments. A still more favorable opportunity was presented in the summer of 1877, when Mars was nearer to us than it has been since 1845. It was at this time that Prof. Asaph Hall was fortunate enough, by means of the new 26-inch refractor of the Naval Observatory at Washington, to discover two moons belonging to this planet. It is true that this was probably the first time that so powerful a telescope had ever been directed to the examination of Mars under similar favorable conditions; yet, it is a significant fact, that since the announcement of the discovery the satellites have been detected by means of telescopes of more moderate power. The secret of Prof. Hall's discovery seems to have consisted in devising the means of cutting off, from the field of view of the telescope, the glaring light of Mars. In like manner, M. Henry, of the observatory of Paris, on the 27th of August, 1877, was able to see the satellites when Mars was screened from view. These diminutive moons nestle so closely to the planet that it is difficult to see them in the blaze of light reflected from Mars. Had similar means of screening the planet been employed, it is probable that one or both of these satellites might have been discovered in 1862.

DISTANCES OF SATELLITES FROM CENTER OF MARS.

The distance of the inner satellite from the center of the primary is about 2.73 times the the radius of Mars; that of the outer one about 6.846 times the same radius. Assuming the diameter of Mars to be about 4,200 miles, these distances become, respectively, 5,733 and 14,376 miles from the center of Mars. The nearest satellite of Jupiter is distant about six times the radius of the primary, and the innermost satellite of Saturn is distant a little more than three times the radius of that planet.

PERIODS OF SIDEREAL REVOLUTION OF THE SATELLITES OF MARS.

Prof. Newcomb gives, for the period of revolution of the inner satellite around Mars, about 7.65 hours, or 7h. 39m., and 30.25 hours, or 30h. 15m. as that of the outer moon. Both of them, like our moon, revolve around the primary from west to east. Mars rotates on its axis from west to east in 24.623 hours, or 24h. 37m. 23s.; this is the duration of the Martial day, or the time occupied by a star rising in the east in passing over to the western horizon of the planet. We have seen that the period of revolution of the inner satellite is less, while that of the outer is greater, than a Martial day. It is evident, therefore, that, as seen from the surface of the planet, the apparent motion of the satellites will be in opposite directions, the inner rising in the west and setting in the east, the outer (like our moon), rising in the east and setting in the west. This anomalous condition of things must have greatly perplexed the primitive astronomers of Mars, and probably led them to the invention of cycles and epicycles to account for these appearances.

It follows that the phenomenon of two moons meeting in mid-heavens will be no unusual occurrence to the observers on the surface of Mars. The apparent motion of the fixed stars from east to west, produced by the rotation of the planet upon its axis, is at the rate of 14.62° per hour. The real motion of the inner satellite among the stars from west to east is at the rate of about 47.06° per hour, while that of the outer one is at the rate of 11.90° per hour. Hence it follows that the apparent motion of the inner satellite from west to east across the heavens to an observer on Mars, will be at the rate of about 32.44° per hour, while the apparent motion of the outer moon from east to west will be at the rate of nearly 2.72° per hour.

It likewise follows from the preceding calculations that the time elapsing between two successive meridian passages of the inner satellite will be about 11.09 hours, and the time elapsing between two successive conjunctions of the inner with the outer moon will be about 10.24 hours; consequently two conjunctions will occur in less time than it takes for Mars to rotate on its axis, or than a Martial day. This satellite completes more than three orbital revolutions in a Martial day.

As the apparent motion of the outer satellite from east to west is at the rate of only about 2.72° per hour, it is obvious that the time elapsing between two successive meridian passages of this moon will be about 132.35 hours; so that there will be no less than 12 conjunctions with the inner moon in the course of a lunar day. It is likewise evident that the outer satellite will frequently be above the horizon of Mars more than 60 hours, during which period six conjunctions with the inner may occur. Moreover, as the outer moon will go through its cycle of phases in a little more than 30 hours, all of these changes may be accomplished while it is above the horizon of the observer on the surface of Mars.

APPARENT MAGNITUDE OF MARS AS SEEN FROM HIS SATELLITES.

The apparent diameter of Mars, as seen by an observer on the inner satellite would be no less than 41.8′, or about 78½ times the apparent diameter of the sun as seen from the earth; and from the outer moon the diameter of Mars would subtend an angle of 16.7′, or about 31.3 times the apparent diameter of the sun as seen by us. Of course the apparent areas of the disk of Mars, as seen from his two satellites, would be in the ratio of the squares of these numbers. That is, the apparent area of the disk of Mars, as seen from his inner moon, would be 6,167, and from the outer 980 times the apparent area of the solar disk, as seen from the earth.

From the innermost satellite of Saturn, the diameter of the primary would subtend an angle of 35.8′; from the nearest satellite of Jupiter, the diameter of that planet would subtend an angle of 18.6′; and from our moon the earth's diameter would subtend an angle of less than 2°.

APPARENT MAGNITUDE OF HIS SATELLITES AS SEEN FROM MARS.

Astronomers are, as yet, ignorant of the real magnitude of the Martial satellites; but, assuming each of them to be 100 miles in diameter, it is easy to calculate their apparent magnitudes as seen by an observer on Mars. The inner moon being 5,733 miles distant from the center of Mars, would, when in the zenith of the observer, be only 3,633 miles distant from the surface of the planet. Hence it appears that when this satellite is seen in the horizon of the observer on the surface of Mars, its diameter would subtend an angle of about 90m., or nearly twice the apparent diameter which our moon presents to us; but, when it is in the zenith of the observer, it would subtend an angle of 94.3m., or more than three times the apparent diameter presented by our moon. In other terms, in rising from the western horizon to the zenith, the apparent diameter of this moon would be increased nearly in the ratio of two to three; and, of course, its apparent area would be augmented nearly in the ratio of four to nine.

The outer satellite would, under like positions, present apparent diameters respectively, of 24 and 28m., or considerably less than the apparent diameter of our moon. The nearest satellite of Jupiter (having a diameter of 2,310 miles) would, in like positions, present to an observer on the surface of that planet apparent diameters, respectively of 31m. and 37m.

BEARING OF THE DISCOVERY OF MARTIAL SATELLITES ON THE NEBULAR HYPOTHESIS.

As we have seen, the inner satellite of Mars completes three orbital revolutions in less than a Martial day. "This anomalous fact in the planetary system would seem, at first view, to be utterly inconsistent with the nebular hypothesis." According to this hypothesis, the orbital periods of the satellites should be approximately equal to the rotation periods of the primary at the epochs when the satellites were thrown off from it. The acceleration of the rotation period of the primary, in consequence of its subsequent contraction, would necessarily render its time of rotation less than the orbital period of any satellite. As far as yet known, the inner satellite of Mars affords the only instance in which the rotation period of the primary is greater than the orbital period of the secondary.

It must be remembered, however, that if we regard the rings of Saturn as composed of clouds of independently-revolving minute satellites, those constituting the innermost portions of the inner ring must revolve in less time than the rotation period of that planet. Under this view, therefore, the case of the inner satellite of Mars is not unique.

There are, however, several methods by which the apparently anomalous fact may be accounted for consistently with the nebular hypothesis.

1. In the first place, it has been suggested that Mars may not have obtained his satellites by means of the usual process of moon formation; but by the appropriation to himself of a couple of the numerous asteroids or planetoids, some of which, in their perihelion excursions, approach comparatively near to Mars in his aphelion positions. Thus, the planetoid called Phocea, when it is at its least distance and Mars at his greatest distance from the sun, would only be about 11,000,000 of miles from each other. It is, therefore, possible that some of the planetoids, moving in orbits of greater eccentricity than any yet discovered, may, at some former period, have approached so near Mars as to have become permanently attached to it as satellites.

2. In the second place, it is possible that these Martial moons may have originally revolved in larger orbits, and therefore in longer periods than at present; but that the retarding influence of a resisting medium on such small masses, might, in the course of myriads of ages, have contracted their orbits and consequently shortened their orbital periods. In this connection it must be borne in mind, that, according to the nebular hypothesis, Mars must be a vastly older planet than the earth; so that this retardation may have been in progress for an incalculable number of centuries before the earth became a separate planet.

3. In the last place, it is possible that Mars may have originally rotated on his axis in five or six hours; but that the tidal rotation-retardation produced by the action of his moons might have brought about its present rotation period. It is evident that the solar tides, on a planet so small and so remote from the sun, must be inappreciable; and, at first sight, the lunar tides produced by such small masses might be supposed to be equally insignificant. But it must be recollected that the tide-generating power of a moon is (other things being equal) inversely proportional to the cube of its distance; so that nearness might more than compensate for smallness of mass. To be more specific: In the mathematical language the tide-generating power is in proportion to the

$$\text{Diameter of Primary} \times \frac{\text{Mass of Satellite}}{(\text{Distance of Satellite.})^3}$$

Thus, for example, let us suppose the diameter of our moon to be 20 times the diameter of the inner satellite of Mars, and both moons to be equally dense; then the mass of our moon would be 8,000 times that of the Martial satellite. Taking the diameter of the earth as equal to twice the diameter of Mars (and it is not so great), and the distance of our moon from the center of the earth to be 41½ times the distance of the inner satellite from the center of Mars; we then have the tide-generating power of our moon acting on the earth, will be to that of the inner satellite acting on Mars as $\frac{2 \times 8000}{(41\frac{1}{2})^3}$ to 1, or as $\frac{16000}{71473}$ to 1, or as $\frac{1}{4\frac{1}{2}}$ to 1, or as 1 to 4½.

Hence, the tide-generating power of this small satellite, would, in consequence of its nearness to Mars, be about 4½ times as great as the tide-generating power of our moon on the earth.

In connection with the idea of the rotation period of Mars having, at some former time, been much shorter than it is at present, it may be noticed that the great compression or ellipticity of this planet is totally inconsistent with its observed rotation period. Most astronomers estimate the ellipticity of Mars at from $\frac{1}{40}$ to $\frac{1}{60}$ (although some of them have failed to detect any sensible difference in his equatorial and polar diameters); the ellipticity of the earth is only $\frac{1}{300}$. Might not this great ellipticity of Mars have been the result of solidification having taken place when his rotation period was much shorter than it is at present? This explanation is not free from serious difficulties. For, if aqueous and aerial agencies were in action after solidification took place, they would have tended to make the shape of the planet conform to its new rotation period.

Berkeley, Dec. 3d, 1877.

SPONTANEOUS GENERATION.

At the last meeting of the San Francisco Microscopical Society, a paper was read by Mr. H. C. Hyde, summarizing briefly the issue as they now stand between the upholders and opponents of the theory of spontaneous generation. Mr. Hyde takes the sides of the opponents, relying on the results gained by Dallinger and Drysdale, of these results he said: In the first place, it is conclusively shown that some form of the monads emitted palpable germs, visible, however, only with the 1-50th inch objective, and when visible of the size of about 1-200,000th of an inch. Others were, exactly speaking, *viriparous*, emitting no germs, but opening to give birth to minute living forms, while another form of monad emitted germs which the highest magnification failed to resolve, but the presence of which was indisputably proven by results.

In the second place it was conclusively shown that the different adults forms were capable of surviving varying degrees of heat ranging from 61° (142 F.) to 80° (175 F.) C., while the remarkable fact was developed that the sporules or germs were able to survive a temperature of 148.88° C. (300° F.)

From these facts they claim, and justly, I think, that the assumption of Bastian and some others, that the germs of putrefactive organisms must perish in the same conditions that destroy the parent is erroneous.

While this has not been actually shown of bacteria (the sole organism upon which the theory of spontaneous generation has been constructed) it may be strongly inferred that the bacterian germs are too minute to be observed by our present optical appliances, and it must be remembered that the monads are as much putrefactive infusoria as the bacteria.

Bastian, from certain infusions, produced both monads and bacteria. To guard against the introduction of supposed germs, he sealed up his infusions while boiling, and then subjected them to a temperature of about 300° F. Upon opening his sealed flasks, after the lapse of a sufficient interval, he found living monads.

Those he found were absolutely destroyed at a temperature of 140° F.; and upon this result, he regarded the theory of spontaneous generation, or archegenesis, as he terms it, established.

While Tyndall and others have proved negatively that under certain conditions of temperature, and the absolute exclusion of possible germs in the surrounding air, living bacteria were never found, it remained for Dallinger and Drysdale, with the aid of the microscope and a marvellous stock of patience, to actually see that in the case of a closely allied form there was a positive production of germs from living monads, and that these germs, but not the parent forms, absolutely survived a temperature as high as that to which Bastian ever submitted his subjects; and that, after passing through this fiery ordeal, these same germs were seen to develop into the living, parent form, and in one instance, at least, into one of the identical forms described by Bastian, thus illustrating, I claim, beyond the possibility of a doubt, the source of the latter's error, and adding another and most valuable piece of testimony to the general question.

CLEANLINESS.—Dr. N. H. Paaren writes as follows in the *Western Stock Journal:* It is true in all cases known to us, that the finer instincts agree with the conclusions of laborious scientific research. The great laws of nature do not jar, but show a constant harmony; and it is pleasant to see the elucidation of these truths, which may sound too grand to be mentioned in connection with the operation of cleaning a stable. We cannot, however, refrain from admiring this harmony, when we see the busy housewife and clean, industrious maid servant scrubbing at floors and furniture, apparently perfectly clean, and washing and scalding dishes which we would at first sight think might be purified much more simply. Their instincts are true. You come into the room after the furniture has been scrubbed, and you breathe a fresher air, and are in fact a healthier, and therefore a happier and better being. You eat of these dishes—the food tastes better and it digests better; you therefore become, from this cause also, healthier and happier. The reason of this is, that the furniture receives upon its surface the organic matter arising from all living creatures, which after a time is apt to become unpleasant and unwholesome. Every chair, then, and every table, becomes a source of disease; every piece of the wall and the ceiling are the same. This is especially the case with the furniture most in use; every touch of the hand—even the whitest hand—is a source of impurity, and that which is used most has most need of being cleaned. Many porous bodies—and amongst these, cloth—take up these odors in great abundance, and sometimes retain them so much as not to give out any perceptible quantity until they are very much filled. We find this to be the case with carpets, which do not till after sometime become offensive and stifling, but when they are so, are very difficult to clean. The process of cleaning is too often confined to beating. It is to be hoped that washing of carpets will become more general. Until this is the case, we shall never get quite free from the unwholesome mustiness of some of our floors.

THE financial troubles among the fine stock breeders of the Kentucky blue grass region are becoming widespread. The difficulty began some time ago with the failure of B. Groves & Son, with liabilities at over $300,000. The custom among stock men of becoming securities has complicated matters to such an extent that nearly all the leading firms are involved.