Mars and its Mystery

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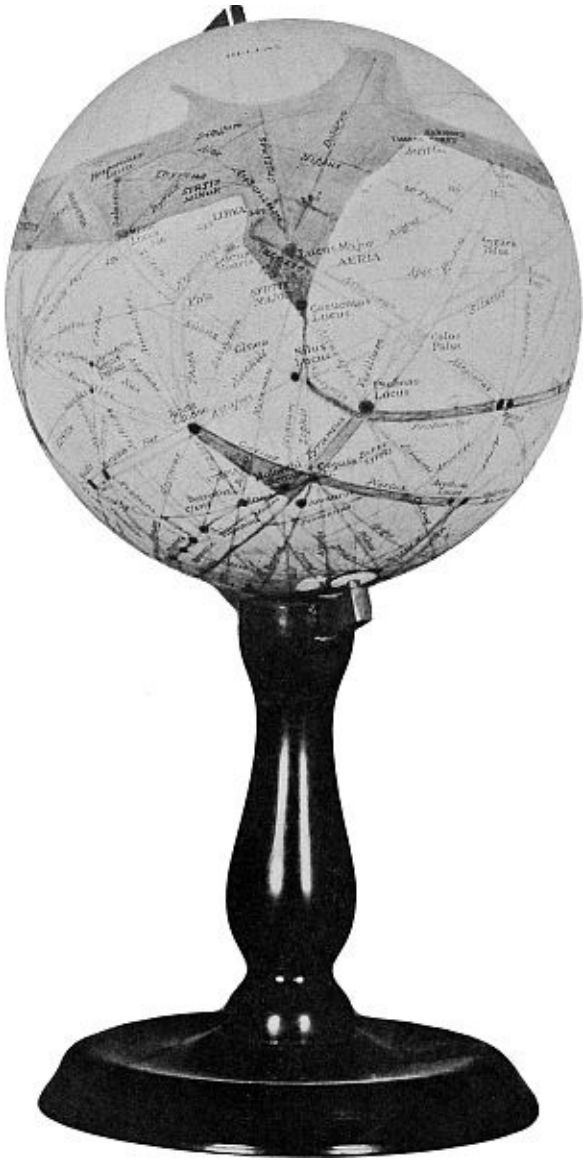

LOWELL'S GLOBE OF MARS, 1903. *Frontispiece*

MARS

AND ITS MYSTERY

BY

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ILLUSTRATED

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To
PERCIVAL LOWELL
WHO HAS BY HIS ENERGY AND SCIENTIFIC SPIRIT
ESTABLISHED A NEW STANDARD FOR
THE STUDY OF MARS
THIS BOOK
IS AFFECTIONATELY INSCRIBED

PREFACE

The following pages have been written for the general reader. The controversies over the interpretation of the curious markings of Mars and the wide divergence of opinion as to their nature first turned my attention to the matter. The question of intelligence in other worlds is of perennial interest to everyone, and that question may possibly be settled by an unprejudiced study of our neighboring planet Mars. Knowing the many analogies between Mars and the Earth, we are justified in asking what conditions really exist in Mars. Instead of flouting at every attempt to interpret the various and complicated markings of its surface, we should soberly consider any rational explanation of these enigmas from the postulate that the two spheres, so near together in space, cannot be so far apart physically, and from the fact that as intelligence is broadly modifying the appearance of the surface of the Earth, a similar intelligence may also be marking the face of Mars.

A student familiar with a general knowledge of the heavens, a fair acquaintance with the surface features of the Earth, with an appreciation of the doctrine of probabilities, and capable of estimating the value of evidence, is quite as well equipped to examine and discuss the nature of the markings of Mars as the astronomer. If, furthermore, he is gifted with imagination and is free from all prejudice in the matter, he may have a slight advantage. Astronomers are probably the most exact of all students as to their facts, and in this discussion there is no attempt to introduce evidence they do not supply, as the frequent quotations from their writings will show.

Having studied Mars through nearly one presentation of the planet with the great refractor at the Lowell Observatory, what I saw with my own eyes, uninfluenced by what others saw, will be presented in a short chapter at the end of this book.

I wish to express my obligations to Professor Percival Lowell for the privileges of his observatory, for many of the illustrations in this book, and for his unbounded hospitality during my visit to Flagstaff. I am also deeply indebted to Mr. Russell Robb for valuable assistance during the preparation of the manuscript.

E. S. M.

SALEM, MASSACHUSETTS,
October, 1906.

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MARS AND ITS MYSTERY

I

INTRODUCTION

Had some one asked, fifty years ago, Is the Sun composed of chemical elements with which we are familiar? Shall we ever know? the question would not have been deemed worthy of a second thought. Realizing what has been accomplished, not only regarding the constitution of the Sun, but of the most remote stars, we are encouraged to ask: Is Mars inhabited? Shall we ever know? To what groups of students are we to appeal for an answer? If we want to know the diameter of Mars, its weight, the form of its orbit, the inclination of its axis, the period of its revolution around the Sun, and its rotation period, its ephemeris and its albedo, we ask the astronomer, for he has the instruments with which to observe and measure, and the mathematical knowledge necessary to reduce the measurements. If Mars were incandescent, we should appeal to the astrophysicist for information regarding its chemical composition. If, however, we want to know the probability of Mars being the abode of life, we should appeal to one who is familiar with the conditions of life upon our own globe. If the question is asked as to the existence of intelligence on the planet, we endeavor to trace evidences of its surface markings, and their character, whether natural or artificial. Knowing how profoundly man has changed the appearance of the surface features of our own globe in the removal of vast forests, in the irrigation of enormous tracts of sterile plain, the filling up of certain areas, like Peking, Tokio, London, with material having a different reflecting surface, we are to scan the surface of Mars for similar modifications, and for an answer ask those who are familiar with physical geography, with meteorology, with geology, including the character of natural cracks or crannies, deep cañon, or range of mountains, or any of the great cataclysms which have scarred the face of the Earth. Taking the great mass of facts as they are presented to us by astronomers, to what class are we to appeal as to the probability of life in other worlds? What class will form the most rational conclusions? Will it be the circle-squarers, perpetual-motion cranks, spiritualists, survivals of a past who believe the world is flat, those who have "anthropomorphic conceptions of the Supreme" and Hebraic conceptions of the origin of things, or will it be those who value observation and experiment, who appreciate the importance of large numbers, and who are endowed with a tithe of imagination? Most certainly the latter class.

In approaching the interpretation of the markings of Mars we should first glance at a brief historical summary of what has already been done. We should examine the testimony of those who have seen and drawn the canals; we are then better prepared to examine the records of the latest observations and the explanation of their nature. In the meantime an inquiry must be made as to whether the mathematical astronomer, after all, is best fitted to judge of the surface features of a planet. Next we should take up in the following order the evidences, which are overwhelming, that a network of lines, geodetic in their character, mark the surface of Mars. It has been claimed that these lines show the result of irrigation, and, therefore, the irrigation features of our own planet should be examined. It has been objected that many astronomers have not been able to see the markings, and consequently their existence has been doubted. It will then be proper to point out that the difficulties of seeing are very great, and that the acutest eyesight, coupled with long practice, is necessary to recognize the markings. It has been objected that the drawings

of the minuter details of Mars vary with different observers. It will be necessary to show that every kind of research employing graphic representation labors under the same difficulty, and none more so than astronomy. It has been objected that there is not sufficient moisture and atmosphere in Mars to sustain life, and this must be answered by those only who are familiar with conditions affecting life on our own planet.

Various theories have been advanced, some of them physical, to explain the markings of Mars, and these must be considered, and, if possible, answered. Comments and criticism are difficult to repress, as the discoveries of Schiaparelli and the additional discoveries and deductions of Lowell have evoked discussions, which, in some instances, have been harsh and unreasonable, and, in one case, positively ridiculous. Schiaparelli has been called an impostor, and Lowell has come in for his full share of vituperation and innuendo. If this portion of the discussion is considered unparliamentary, the attitude and language of certain astronomers have provoked it.

A brief account is presented of what the author was enabled to draw of the Martian details, with a transcript of his notes made at the time of observation, and finally a little imaginary sketch is given as to how the world would look from Mars; and if similar kinds of astronomers existed there, what comments and objections they might offer as to the inhabitability of the Earth.

Such flights of the imagination are justified in that it gives one a chance to appreciate the weakness of some of the arguments urged against the idea of intelligence in Mars.

It will be objected that some of the names herein quoted are not recognized as astronomers. I can only say that in every instance I have found references to the writings and essays of those that might be objected to in the pages of the "Observatory," and other reputable astronomical journals, and in no instances accompanied by adverse comment or criticism. If astronomers—even the distinguished Schiaparelli—quote these names in scientific memoirs, I may venture to do the same in a book written for the general reader. The objection, however, has always presented itself with every controversy; it was conspicuously marked in the passionate discussions over Darwin's "Origin of Species." The intelligent laity recognized the truth of Darwin's proposition long before the zoölogist began to waver. Essays by the unprofessional supporting Darwin's contention were discredited because the writers were not trained naturalists. The history of invention is crowded with instances where devices and processes have been invented by men whose trades or professions were the least likely to enable them to originate such ideas.

II

IMMEASURABLE DISTANCES OF SPACE

It is therefore perfectly reasonable to suppose that beings not only animated but endowed with reason inhabit countless worlds in space.

SIMON NEWCOMB.

Until within recent centuries, man has not only believed that he and his kind were the only intelligent creatures in the universe, but that the little round ball on which he lived was the dominant part thereof. So rooted for ages was this conviction that it became fixed in man's mental structure, and hence the survival of the idea that still lingers in the minds of a few to-day. The conclusion was natural, however, for the behavior of the starry heavens and the Sun and the Moon seemed sufficient evidence that man, and the surface upon which he lived, was the centre of the universe. The stars were bright points of light, the Moon a silver disk, and the Sun a heat and light giving ball of fire, equally diminutive and not far away. Let one realize for a moment the experience of these early people. Everything aerial, with the exception of feathery birds, fluffy bats and flying insects, was composed of the lightest particles—cottony seeds, reluctantly falling snow-flakes, motes in the air, smoke and vaporous cloud, and, in contrast, the rock-foundationed and irregular surface upon which the people dwelt, and flat as far as man had reached. What wonder, then, that man viewed these brilliant points and dazzling disks as objects of no great size and not far away, hauled across the heavens by unseen spirits of some kind. The marvel of it all is, not that they believed as they did, but that any other views of cosmography could have been established. And yet the successive increments of astronomical knowledge, founded apparently on the soundest mathematics, were adopted in their turn. What more convincing than the epicyclic theory of Ptolemy, buttressed by figures so ingenious and convincing, that the theory might have lasted till now except for the truer understanding of planetary movements in relation to that of the Earth? All through this history are found traces of the barriers erected by prejudiced conservatives, of which the attitude of Tycho Brahe is a good example, though in this case it was probably his belief in the Hebraic conception of the universe which excited his opposition to Kepler's views, a conception which, unfortunately for the progress of astronomical research, still lingers among certain observers to-day and places them in precisely the same category with Tycho Brahe.

With the gradual accumulation of knowledge it was found that of all the innumerable illuminated bodies in the heavens, only one,—just one,—the Moon, revolved around the Earth, and that the Earth instead of being all dominant in the affairs of the universe, played a very minor part, and, instead of being master, was a very humble midget revolving around the Sun; that, indeed, with the exception of the Moon, there were visible to the naked eye only three bright points of light in the whole range of the heavens more insignificant in size,—Mercury, Venus, and Mars,—while the other planets were vastly larger, and had many more satellites revolving around them. Then it was found that, with the exception of the few planets, the myriad stars had no connection with the Sun whatsoever, that the Sun was no longer the centre of a great universe. Later it was discovered through spectroscopic analysis that all the myriad of stars were composed of chemical elements similar to our Sun. Here, then, was the startling revelation that our Sun

was simply a star, and that the stars represented a "universe of Suns," and, if we could get near any one star of the millions that sparkle in the heavens telescopically, we should see it as a round ball emitting light and heat. It was perhaps humiliating to find that our Sun was so insignificant in size that from Sirius, for example, it could not be seen with the naked eye, so small indeed that in the close companionship of other stars it would be swallowed up by their greater size and brilliancy.

To assume, then, that our Sun, so identical to the stars in heat and light emitting properties, was the only Sun that had revolving around it a few minute balls, would be as absurd as if one should go on a pebbly beach, extending from Labrador to Florida for example, and picking up a single pebble, should have the hardihood to assert that this pebble was the only one, among the millions of pebbles, upon which would be found the bits of seaweed and little snails which it might support. The overwhelming vastness of the universe is entirely beyond the grasp of the human mind. The mere statement that it requires so many years for the light to reach us from a certain star, the parallax of which has been rudely established, affords one only a faint glimmer of the truth. The swing of our Earth about the Sun gives us a base line of 186,000,000 of miles, and yet, with this enormous base from which to subtend an angle, only a very few of the myriad of stars show the slightest displacement; the others exhibit no more signs of divergence than if while looking at them we had simply moved our heads from one side to the other! Fixed stars they appear to be, and are so called, though we are told they are all drifting in various directions, as our star-Sun is.

Only by reducing all these vast distances and dimensions to a minute scale can the mind realize the futility of ever comprehending the illimitable distances of space.

In order to consider the attitude of the Earth in relation to the Sun and the nearest fixed star, we will reduce the Sun's diameter of 866,000 miles to the dimensions of a ball one inch in diameter; the Earth reduced to the same scale would be a minute speck less than one one-hundredth of an inch in diameter; a perforation in paper made by the finest cambric needle would represent the size of this minute speck, the Earth. Following this scale we should place this speck nine feet from the inch ball, this distance representing 93,000,000 of miles, the Earth's distance from the Sun; Mars would be a still smaller speck a step farther off. Let us now proceed to Boston Common, for example, and on the smooth playground place our inch ball representing the Sun; taking three good steps we should place our minute speck, representing the Earth, upon the ground where it would be immediately lost in the fine gravel; another step and we would place a still smaller particle, representing Mars. How big a circle on the Earth's surface, using the inch ball as a centre, should we have to describe in order to include the nearest fixed star? Such a circle would reach to Detroit, Michigan, and Columbus, Ohio, or Wilmington, North Carolina! To find a circle which would include eight other fixed stars next in distance, and only eight of the thousands which render the heavens so beautiful on a clear winter's night—we should run such a circle through the centre of Hudson Bay, the waters of southern Greenland, Lake Winnipeg, and New Orleans!

In this broad way only can we form a dim conception of the overwhelming distances of space, and, in this absolutely unthinkable space, our little Sun, with its constant rain of meteoric dust, an occasional comet, and its microscopic planets are literally bunched together. To admit, as we must then, that one of these motes has had irrigating canals on various parts of its surface since prehistoric times, and the other mote has nothing of the sort despite the geodetic lines that are seen marking its surface, is simply preposterous. Their disposition, their visibility coincident with the Martian summer, becoming apparent only when the snow caps melt, their convergence towards centres of distribution, all go to prove by the simplest analogy an identity of structure. Certainly the overwhelming force of Lowell's observations and arguments baffles any other reasonable explanation of the character and purpose of these markings. Here are the lines, some following the arcs of great circles, all appearing precisely when they should appear,

and in progressive strength from the north when the vivifying water from the melting snow cap first starts the vegetation. Why certain parallels or doublings are observed in some of the canals is about as puzzling to us as the checkerboard townships of the West would appear to a Martian, where some would be yellow with the ripening grain while others, uncultivated, would appear of a different color.

III

OTHER WORLDS INHABITED

Whether the other fixed stars have similar planetary companions or not is to us a matter of pure conjecture, which may or may not enter into our conception of the universe. But probably every thoughtful person believes with regard to those distant suns that there is in space something besides our system on which they shine.

TYNDALL.

It would be a waste of time to attempt an interpretation of the markings of Mars as a result of intelligent effort, if it could be proved beyond a reasonable doubt that our globe was not only unique among the bodies which probably accompany the innumerable suns, but was the only body, among them all, sustaining creatures of intelligence. If life exists in other planets of a nature with which we are familiar, then the physical conditions must be similar to those of our own planet. Later we shall point out the infinite variety of conditions under which life—even man—exists on this globe, and it will be shown that the question of higher or lower temperature, more or less humidity, higher or lower atmospheric pressure, greater or less force of gravity, can have but little weight in discussing the probability of life in other worlds.

In a planet devoid of atmosphere, or a sphere glowing with its own heat, we may decide without question that life does not exist. Even in a globe in many respects like our own it would be hazardous to conjecture the kinds of organic forms in which it is manifested. Reasoning from analogy, if life exists in Mars, or other spheres in infinite space, it must have originated under much the same conditions as it originated here; at the outset the most primitive bits of protoplasm. But has life appeared in Mars? Tyndall, in graphic words, pictures the rounding of worlds from nebulous haze, and then says, "For eons, the immensity of which overwhelms man's conception, the Earth was unfit to maintain what we call life. It is now covered with visible living things. They are not formed of matter different from that around them. They are, on the contrary, bone of its bone and flesh of its flesh." Mars must come in the same category. It is a part of the original nidus from which our world was condensed, and however life originated in the past, the conditions for its origin, at least, must have been as favorable on the surface of Mars, as on the surface of the Earth, and, so far as we know to the contrary, even more favorable. In the beginning, Mars cooled and hardened with all those behaviors of contraction, condensation of vapor on its surface, erosion, etc., and it is impossible to avoid the conviction that life, as on our Earth, arose under the same physical conditions. Recalling the resemblance which Mars bears to the Earth, and the data which have already been established, we behold a world in many respects like ours, with its sunsets and sunrises, winds that sweep over its surface, the dust storms from the deserts, its snow-storms and snow-drifts, its dazzling fields of white in the north, with an occasional snow-storm that whitens the planet far down in latitude; the seasonal changes, and, most important of all, the melting ice caps, with rivulets and torrents, temporary arctic seas and frozen pools, its great expanses of vegetation and sterile plains. We have in Mars the variety of conditions under which life has assumed its infinite variety of aspects on the Earth, and which, by analogy, should have passed through similar stages in Mars. Life at the outset must have

been protoplasmic; then came contractile tissue, muscular bundles, hardened structures within and without for their support, nerves to animate the muscles, and protection for nerve-trunk, either rigid or flexible. Hard parts might vary under a different force of gravity, though there might appear types of structure that could be classified with our own.

All such conditions, however, are mere surmises, for about such matters we can reason only from analogy. The first proposition to establish is that the conception of the plurality of worlds is not unreasonable, and second, that many of the most eminent astronomers have believed in the inhabitability of other worlds, and this justifies a reasonable man to follow the inquiry. The belief is based upon legitimate analogies which have thus far guided man in every generalization, in the establishment of principles, and are continually appealed to in the details of every day's experience.

From remote times it has been taken for granted by the best minds that other worlds besides ours sustain life. The early belief in the plurality of worlds was based on the idea that since spheres like ours had been fashioned by the Almighty they must have been made for the same purpose for which our globe seemed intended, to sustain life, and Scripture was freely quoted in support of the idea.

Sir David Brewster, in his book "More Worlds Than One," says that the doctrine of the plurality of worlds was maintained by almost all the distinguished astronomers and writers who have flourished since the true figure of the Earth was determined: "Giordano Bruno of Nola, Kepler, and Tycho believed in it; and Cardinal Cusa and Bruno, before the discovery of binary systems among the stars, believed also that the stars were inhabited. Sir Isaac Newton likewise adopted it, and Dr. Bentley, Master of Trinity College, in his eighth sermon on the Confutation of Atheism from the origin and frame of the world, has ably maintained the same doctrine. In our own day we may number among its supporters the distinguished names of Laplace, Sir William and Sir John Herschel, Dr. Chalmers, Isaac Taylor, and M. Arago."

The attitude of the intelligent world to-day is well shown in a recent number of London "Nature," where in a review of a book by Wallace, endeavoring to show that this world alone sustains life, the reviewer ends by saying: "To consider this Earth as the only inhabited body in the stellar universe, a reversion to prehistoric ideas, may or may not be an advance, but it will require very strong arguments before we can be brought to consider that its isolation in the Cosmos is indeed a fact." Until the discovery by Schiaparelli of the network of lines in Mars, laid out with seemingly intelligent precision, the arguments for the inhabitability of other worlds were based entirely upon analogy. Sir Richard Owen, the great comparative anatomist, in supporting the contention that life existed in other planets, said: "The grounds of belief vary with the probability of a proposition; if nothing better than analogy can be had—on analogy will belief be based."

Professor O. M. Mitchell, the first director of the Cincinnati Observatory, in his work on "Popular Astronomy," says, in regard to the doctrine of the plurality of worlds: "It would be most incredible to assert, as some have done, that our planet, so small and insignificant in its proportions when compared with other planets with which it is allied, is the only world in the whole universe filled with sentient, rational and intelligent beings capable of comprehending the grand mysteries of the physical universe."

The eminent French astronomer, M. Flammarion, has, in an eloquent passage in his "Plurality of Worlds," portrayed the vastness of the universe and the utter insignificance of our Earth in the immensity of space: "If advancing with the velocity of light[1] we could traverse from century to century this unlimited number of suns and spheres without ever meeting any limit to this prodigious immensity where God brings forth worlds and beings; looking behind, but no longer knowing in what part of the infinite to find this grain of dust called the Earth, we should stop fascinated and confounded by such a spectacle, and uniting our voice to the concert of universal nature we should say from the depths of our soul, Almighty God!

how senseless we were to believe that there was nothing beyond the Earth, and that our abode alone possessed the privilege of reflecting thy greatness and honor."

Compare these elevating thoughts with the shrunken attitude of one who has the conceit to imagine that he and his kind are not only alone in the universe but superadds to this monstrous conception the idea that the millions of great suns are designedly waltzing around solely for his edification and amusement, unmindful of the heedless way in which the millions of his race regard the overpowering majesty of the heavens. To the thousand millions that live to-day, and the thousand, thousand millions that have perished in the past, the starry heavens have never excited an emotion grateful, reverent, or curious, unless a flaming comet, or an eclipse of the Sun or Moon occurred, and then with superstitious fear have they gone grovelling in the dust.

An astronomer imbued with Hebraic conceptions of the universe is poorly equipped to appreciate the arguments in favor of life in other worlds. He may be keen in perceiving lines in the spectrum, and the significance of their lateral displacement, but possessed with a belief—the result of early training—that a little two-legged human molecule could command the Sun and Moon to stand still, a realization of his own insignificance, or the possibility of intelligence in other worlds, must forever remain beyond his grasp. Emerson said "the dogmas shrivel as dry leaves at the door of the observatory." They never shrivel for such minds, but grow and flourish with a density that obscures by, its rankness every rational conception of the heavens above. As an illustration of the attitude of such mentalities we have to go back fifty years, for few survive to-day. Edward Hitchcock, Professor of Geology and Theology at Amherst, wrote a book just fifty years ago entitled "Plurality of Worlds," in which he denounces the idea; but observe the precise way in which he lays down the law: "The planets had no vital tendencies, they could have had such given only by an additional act or series of acts of creative power. As mere inert globes, they had no settled destiny to be the seats of life; they could have had such a destiny only by the appointment of Him who creates living things and puts them in the places which he chooses for them" (page 352).

It may be objected that it is useless to bring up these old theological conceptions, as the world has happily gone beyond them, and only in an atavistic manner do we find a few still holding them; nevertheless it may be safely asserted that fifty years hence we shall look back upon the attitude of certain astronomers to-day with much the same pity and amusement which excites us when we regard the attitude of a similar class in the middle of the last century.

Tyndall expresses the universal belief of thinkers in whatever line of work, that life is by no means confined to this Earth. He says: "Whether the other fixed stars have similar planetary companions or not is to us a matter of pure conjecture, which may or may not enter into our conception of the universe. But probably every thoughtful man believes, with regard to these distant Suns, that there is, in space, something besides our system on which they shine."

One class of objectors to the idea that other worlds are inhabited endeavors to show that our position in the universe is unique, that the solar system itself is quite unlike anything existing elsewhere, and, to cap the climax, that our own little world has just the right amount of water, air, and gravitational force to enable it to be the abode of intelligent life, and nowhere else in the broad expanse of heaven can such physical habitudes be found as will enable life to originate or to exist!

In a memoir on the "Evolution of the Solar System," by Professor T. J. J. See, the author, while not denying the possibility of other systems like our own, still considers our system unique. Here are his words: "Therefore, while observation gives us no grounds for denying the existence of other systems like our own, it does not enable us to affirm, or even to render probable, that such systems do exist." Because a number of binary stars have been discovered in which the two stars are nearly equal in mass, and their

orbits highly eccentric, he therefore concludes that the millions of stars that stud the heavens are probably without satellites. The unreasonableness of this attitude is emphasized by realizing that these innumerable suns are similar to our own Sun, as revealed by the spectroscope, and have a similar eruptive energy. Professor Newcomb, however, says: "Evidence is continually increasing that dark and opaque worlds like ours exist and revolve around their primaries." Had Mr. See discovered that every star of the many million was accompanied by another star nearly equal in mass, with its marked eccentric behavior, then only would he be justified in his inference that our solar system was indeed unique. When one realizes that the stars are at such unimaginable distances that the highest powers of the telescope reveal even the nearest of them only as points of light—not as disks—and when one further realizes that the satellites of our Sun, even the largest of them, are diminutive globes compared to the vastness of the Sun, it seems unreasonable if not impossible to entertain the idea that none of these remote stars are accompanied by satellites, and that, therefore, this little Sun of ours stands without parallel in the universe.

Tyndall, in his famous reply to the critics of his Belfast address, in speaking of the origin of life, referred to the Nebular Theory as follows: "According to it our sun and planets were once diffused through space as an impalpable haze out of which by condensation came the solar system. What caused it to condense? Loss of heat. What rounded the sun and planets? That which rounds a tear, molecular force." In these terse and graphic expressions we are made to understand the universality of law. So far as we have sounded the depths of the stellar universe we see the same obedience to gravitational laws, the same flashing lines in the spectrum. We encounter no phenomena that cannot be explained, or at least inferred, by the knowledge we have obtained from our little mote of the Cosmos.

Mr. See thinks it remarkable that "previous investigators have almost invariably approached the problem of cosmogony from the point of view of the planets and satellites, and that no considerable attempt has been made to inquire into the development of the great number of systems observed among the fixed stars." It is true our planetary system has been used as a standard of measurement for the universe, and a very comprehensive standard it has proved to be. The law of universal gravitation was based on terrestrial and lunar observations, spectroscopic analysis was determined in a terrestrial laboratory. As George Iles says, a coal of fire may be raked from a grate and broken up to illustrate the rapid cooling of smaller masses. Even a child's spinning top may be used in an astronomical lecture. The study of our Sun led to the study of the fixed stars, and so our little system has thus far furnished us with examples and illustrations by which we interpret the universe.

In our solar system we have a fair sample of the Cosmos in miniature, though our Sun is so modest in size, compared with the great orbs that appeal to us by their number and brilliancy. So far as our telescopes have sounded the heavens we find nebulous clouds in their structure showing inchoate masses, orbital and spiral arrangements, condensations in their centres. We have the binaries with their extraordinary properties, we have variables with their dark bodies revolving around their primaries. In our little system we also have dark bodies revolving around a luminous primary, from one of which we endeavor to interpret the mysteries of the universe; we have loose masses, as in comets with enormously elongated orbits; we have spheres of insignificant size, with small bodies revolving around them, and these epitomes revolving around a central sun; we have one of these bodies with meteoric rings; and, in the case of our own globe, a satellite of such size that except in the form of its orbit it might well represent a binary in embryo;—and, finally, a host of bodies big enough to reflect the rays of the sun, pursuing their various orbital paths. We are told that the stars are as distant from each other as we are from them. We may regard these systems of nebulæ, variables, doubles, etc., as different kinds or species of heavenly bodies; and to assert that our system is the only individual of the species in the universe seems contrary to all celestial analogy, for do we not have hundreds of binaries, thousands of variables, millions of suns, revealing the same fiery energy and consuming the same elemental fuel?

Professor Newcomb in his "Reminiscences" describes his first sweeping the heavens, at random, with the then new twenty-six inch refractor at the Naval Observatory and discovering a little cluster of stars so small and faint that the individual stars eluded even the great power of this instrument. He says: "I could not help the vain longing which one must sometimes feel under such circumstances, to know what beings might live on planets belonging to what, from an earthly point of view, seemed to be on the border of creation itself." One would suppose that this expression of a longing to ascertain the character of the beings inhabiting planets circling these distant suns would induce one to study a planet analogous to our Earth, and so near in comparison to these unimaginable distances as to be within a hand's grasp, so to speak. The little interest Professor Newcomb has taken in the subject is well expressed in his late book "Astronomy for Everybody." In his chapter on Mars, in which *Everybody* is certainly interested, he says: "The reader will excuse me for saying anything in this chapter about the possible inhabitants of Mars. He knows just as much of the subject as I do, and that is nothing at all." He might at least have given the various pronouncements of Schiaparelli, Lowell, and others as to the probable character of these remarkable markings on Mars, and their supposed significance.

While Professor Newcomb's attitude on the question of the plurality of worlds has been somewhat conservative in the past he has lately, however, expressed himself on the question in no uncertain terms. In a recent article in "Harper's Magazine," entitled "Probability of Life in Other Worlds," he has lent his sanction to the rational idea that other worlds may be the abode of intelligent creatures. His recognition of the principle will do much to offset the influence if it ever had any, of a recent book published in England by Alfred Russel Wallace, in which the distinguished author attempts to show that this world stands alone as the abode of intelligent life. Despite his epoch-making work with Darwin, nearly fifty years ago, which must forever merit our gratitude, and the charm of his various essays on protective coloring, mimicry, theory of birds' nests, etc., he has since those lucid days expressed convictions of such a nature that if a future DeMorgan should write on human paradoxes he would classify Mr. Wallace as chief among them. A profound believer in evolution, he exempts man from the inexorable logic of the principle with about as much reason as if, confessing his belief in the nebular hypothesis, he should insist that the Earth was an exception.

But to return to Professor Newcomb's recent utterances. In the above-mentioned article he says: "Not only does life, but intelligence, flourish on this globe under great variety of conditions as regards temperature and surroundings, and no sound reason can be shown why, under certain conditions which are frequent in the universe, intelligent beings should not acquire the highest development." Again he says: "Life, not wholly unlike that on the Earth, may therefore exist upon Mars, for anything we know to the contrary. More than this we cannot say." In his final summing up Professor Newcomb says: "It is therefore perfectly reasonable to suppose that beings not only animated but endowed with reason inhabit countless worlds in space."

It would seem as if a mind capable of entertaining an idea of our uniqueness in the universe betrays the survival of a mental condition which, centuries ago, regarded the stars as bits of luminous material expressly designed to illuminate this little earth, around which they all pursued their daily paths.

IV

LOWELL'S BOOK ON MARS

This whole arrangement presents an indescribable simplicity and symmetry which cannot be the work of chance.

SCHIAPARELLI, in writing of the canals.

In a discussion of the surface markings of Mars a broad sketch of what has already been accomplished in the study of that planet should be given for the general reader. I know of no better way of doing this than by giving a brief abstract of Percival Lowell's epoch-making work entitled "Mars." In this book he presents in a clear and striking manner the results of his own work covering continuous observations of the planet for many years. The preface is dated from Flagstaff, Arizona, 1895. Since that time he has issued three volumes of Memoirs, in quarto, of the Lowell Observatory, and a number of Bulletins in which he presents many additional facts confirming previous observations, besides new observations; and finally, in a late Bulletin, he has presented photographs of Mars made by his assistant, Mr. Lampland, in which a number of canals plainly show, thus setting forever at rest the question of the subjective character of the markings. The student must, however, follow the advice of an English reviewer and by all means read the book.

"To determine," says Mr. Lowell, "whether a planet be the abode of life in the least resembling that with which we are acquainted, two questions about it must be answered in turn: first, are its physical conditions such as render it, in our general sense, habitable; and secondly, are there any signs of its actual habitation? These problems must be attacked in their order, for unless we can answer the first satisfactorily, it were largely futile to seek for evidence of the second." The reason why Mars in certain years becomes so conspicuous is that its orbit is highly eccentric. Every two years—the period of its revolution about the Sun—brings it nearest to the Sun, and once in fifteen years we find ourselves between it and the Sun at its nearest approach.

Huyghens, in 1659, made a drawing of the dark region on Mars now known as the Syrtis Major, and, through its disappearance and reappearance, he discovered that the planet rotated on its axis, and roughly determined a daily period of twenty-four hours. For the first time it was known that Mars had a day and a night. As some doubts existed as to the correctness of Huyghens's figures, Cassini in 1666 determined anew the rotation period of Mars and found it to be twenty-four hours and forty minutes. From the white polar caps, the study of which we first owe to Maraldi, it was found that the tilt of its axis to the plane of its orbit was very nearly the same as that of the Earth. As this inclination determines the seasons, it was seen that Mars, like the Earth, had its spring, summer, autumn, and winter. A polar flattening was also observed which was slightly in excess of ours.

"To all forms of life of which we have any conception, two things in Nature are vital, air and water." Has it an atmosphere? Without air no change could take place. The Moon without air remains unchanged, except what gravitation accomplishes in pulling down crater walls. "With Mars it is otherwise. Over the surface of that planet changes do occur, changes upon a scale vast enough to be visible from the Earth."

The first sign of change occurs in the polar snow cap. It dwindles in size every two years (the time of a single revolution of Mars around the sun). For nearly two hundred years these white polar caps have been observed to wax and wane. As the Martian winter comes on in the northern hemisphere, for example, the polar cap extends its borders to the temperate zone. As summer comes on the snow cap is seen to dwindle gradually away, till by early autumn it presents but a tiny patch a few hundred miles across. Schiaparelli observed changes in tint which he noticed were correlated with the seasons. In 1894 observations were made continuously from early June till late in November. These dates, in Mars, represent the last of April till the last of August. During this time marked changes took place in the bluish-green areas of the planet. A wave of seasonal change swept down from the pole to the equator. The fact of this occurrence constitutes positive proof of the presence of an atmosphere. In another way the evidence was shown. A series of measurements of the polar and equatorial diameters of Mars were made, and these indicated that a visible layer of twilight atmosphere had been measured. This, Lowell explains by a diagram and other data. It is found, according to Lowell's observations, that the atmosphere is much freer from clouds than had been supposed. He shows conclusively that it is much rarer than that of the Earth. Appearances have been seen, however, which are best explained by assuming them to be clouds.

During the opposition of 1892, Mr. Douglass, at that time an assistant astronomer at the Lowell Observatory, made a special study of the terminator of Mars.[2] A careful study of the terminator for almost every degree of latitude was made, and 733 irregularities were detected. Of this large number, 694 were not only recorded, but measured; and of these, 403 were depressions, and 291 were elevations of the surface. Many of these irregularities were supposed to be clouds, but the arguments to support this attribution are too technical to be presented here. Unmistakable clouds have also been seen moving at a definite rate of speed, as if carried along by the wind.

"To sum up, now, what we know about the atmosphere of Mars: we have proof positive that Mars has an atmosphere; we have reason to believe this atmosphere to be very thin,—thinner at least by half than the air upon the summit of the Himalayas,—and in constitution, not to differ greatly from our own."

As to the existence of water on the planet, one has only to consider the polar snow caps. In the height of the southern winter, the polar cap of snow measures over two thousand miles across, covering fifty-five degrees of latitude, with one unbroken waste of white. As spring advances the snow begins to melt, disappearing rapidly as summer comes on, and, as it melts, a dark band is seen bordering this edge. As the snow recedes the dark band recedes. This band is, therefore, not a permanent marking on the planet, but obviously water, the result of the melting snow—an arctic sea, in fact. This band is irregular, varying in width in different longitudes, as if the water filled up large areas of depression. When finally the snow cap disappears, as it did for the first time on record on the notable occasion of October 13, 1894, the dark band, which had become thinner, disappeared also, leaving only a yellow stretch of surface. An additional proof that this dark band is water, was established by Professor W. H. Pickering, for he discovered that the light reflected from its surface was polarized. The absurdity of the suggestion that these white polar caps are not snow, but congealed carbonic acid gas, is fully shown by Lowell.

The asymmetry of the outline of these snow caps is paralleled by the irregularity of the Earth's polar caps. Glints of brilliant light are seen to flash out from this region, as if produced by sunlight reflected from a sloping surface. On comparing these flashes of light with observations made by Green, in 1877, they were found to be in the same place. Detached fields of snow were also observed below the receding line, an evidence that these regions were at a higher elevation. As before stated, on October 13, 1894, for the first time in the record of polar observations, the southern polar cap disappeared entirely. In this connection it may be of interest to observe that in the United States, in the summer of 1894, the temperature ranged a few degrees above the normal. (For this fact I am indebted to Professor Cleveland

Abbe, E. S. M.)

The large, irregular, dark regions on the planet have been supposed to be bodies of water, or seas, and have been described and named as such by astronomers. Lowell shows, however, that there is every reason to doubt this conclusion. "To begin with, they are of every grade of tint,—a very curious feature for seas to exhibit, unless they were everywhere but a few feet deep; which, again, is a most singular characteristic for seas that cover hundreds of thousands of square miles in extent,—seas, that is, as large as the Bay of Bengal. The Martian surface would have to be amazingly flat for this to be possible. We know it to be relatively flat, but to be as flat as all this would seem to pass the bounds of credible simplicity. Here, also, Professor W. H. Pickering's polariscope investigations come in with effect, for he found the light from the supposed seas to show no trace of polarization. Hence, these were probably not water."

Lowell also shows that if these regions were seas, or water surfaces of the shallowest kind, sunlight would certainly be reflected from some portion of the surface so as to be visible from the Earth. A calculation of the region from which such a beam of light might be reflected has been carefully made, but no light of this nature has ever been seen. These regions change in color, and Schiaparelli suggested that in some way these changes were dependent on the Martian seasons. Lowell, by continuous observations covering many presentations of the planet, has demonstrated that the changes in color are synchronous with the seasons, and they further show that these regions change in expanse as well. The reader must refer to Lowell's book to understand the very minute way in which the author traces out the behavior of these so-called seas as the Martian summer advances and autumn comes on. His evidence is overwhelming that the regions heretofore regarded as seas are vast tracts of vegetation, doubtless on lower levels, or depressions of the surface, old sea bottoms, in fact, where springs and the natural settlings of stray waters might keep the ground sufficiently moist to support a scanty growth. The regions not marked by the dark shading, from their reddish and yellowish tinge, have always been regarded as land, probably desert land, as they remain fixed from year to year, dead and unchangeable as deserts are.

The question naturally arises, if the water of Mars is piled up at the poles as snow, how does it find its way back on its melting? A discovery made by Schiaparelli in 1877 revealed the existence of various lines marking the surface which he called *canali*, or channels.[3] These lines cover the face of the planet like a net, they are laid out with geodetic precision. "The lines start from points on the coast of the blue-green regions, commonly well-marked bays, and proceed directly to what seem centres in the middle of the continent, since, most surprisingly, they meet there other lines that have come to the same spot with apparently a like determinate intent." In other words these lines—fine, straight, dark, as if cut by an engraver, some of them running for hundreds of miles—converge at certain centres. They all start, as Schiaparelli first observed, from definite regions and terminate at definite points. Many of them follow the arcs of great circles. These lines may be thirty or more miles in width, apparently preserving the same width throughout, though slightly wider where they leave the dark bands. They run in every direction, a number often converging at a common centre, and, when they do so, a round, dark area appears which Lowell has called an oasis.

In the clear and steady atmosphere of Flagstaff, Mr. Lowell, by the aid of his superb telescope, has added about four times as many canals as are shown on Schiaparelli's chart. These canals form an intricate network of lines, and no one can contemplate these curious features without being impressed by their artificial character. Schiaparelli, who first discovered them in 1877, continued his observations from year to year despite the fact that no one else could see them. In the course of a few years he discovered a still more remarkable condition, and this was that a number of the canals appeared double. This, indeed, seemed an optical illusion, and by no means strengthened his position, as the single canals

proclaimed by him were supposed to be figments of the imagination. Undeterred by the general scepticism, Schiaparelli established, at each fresh opposition, his previous announcements. For nine years no one was able to confirm his marvellous discoveries. In the year 1886, however, Perrotin, at Nice, with his assistant, Thollon, managed to make out a number of the canals, single and double, which were carefully drawn. Reference to Perrotin's work will be made further on. The reason why so few have seen them is the lack of observers with acute eyesight and patient devotion to the work, coupled with unsteady air. Size of aperture seems to be of little importance. That Schiaparelli, with an 8-1/3 inch glass, discovered the canals, while with the twenty-six inch glass of the Naval Observatory at Washington they have never been seen, is emphatic evidence of what a clear and steady atmosphere means in the study of delicate planetary markings.

The artificiality of the canals is shown by the "supernaturally regular appearance of the system, upon three distinct counts: first, the straightness of the lines; second, their individually uniform width; and, third, their systematic radiation from special points." It was the mathematical shape of the Ohio mounds that first suggested their artificial character. That these lines are artificial and not natural is seen in the fact that at times they are not visible. The lines while temporary in appearance are permanently in place. "Not only do they not change in position during one opposition; they seem not to do so from one opposition to another." "Unchangeable, apparently, in position, the canals are otherwise among the most changeable features of the Martian disk." The order of their appearance synchronizes with the changes of the season, as the snow caps begin to melt the canals begin to appear; in appearance strengthened first at the borders of the polar seas and gradually stretching down towards the equator. In minute detail Lowell presents the successive visibility of the different canals. To account for all these phenomena we have to look at our own Earth for a parallel, and we see it in the great irrigation tracks of the West, and in the vast irrigated regions in India depending upon the melting of the Himalaya snow cap.

The accumulative evidence is overwhelming that here is a dry planet, and an intelligence of some kind that can only survive by utilizing the few remaining sources of water supply. It is to the merit of Professor W. H. Pickering, to whom Professor Lowell gives the credit of having first suggested the idea of irrigation to account for the great width of the canals. What we see, then, is not the canal, which may be a slender stream of water, but a broad band of vegetation irrigated from these narrow channels. These lines penetrate and cross the dark regions in various directions, which again offer additional proof that the so-called seas are not seas but areas of vegetation sparsely scattered, against which the irrigated portions are of sufficient strength and color to show.[4]

Among the most interesting features of the planet's surface are the round, or oval spots which Lowell calls oases; these invariably occur at the junction of the canals. "In spite of the great number of the spots, not one of them stands isolate. There is not a single instance of a spot that is not connected by a canal to the rest of the dark areas." There appears to be no spot that has not two or more canals running to it, and apparently no canal junction is without its spot. The majority of the spots are 120 to 150 miles in diameter. There are many smaller ones. These spots, like the canals, appear and disappear coincidently with seasonal changes. The canals and the oases follow the same method and order in their growth. "Both are affected by one progressive change that sweeps over the face of the planet from the pole to the equator." The reader cannot dwell too strongly on the fact that the visibility of these various markings appears first in northern latitudes, and gradually darkens toward the equator, precisely the reverse of the unfolding of plant life on the Earth. From Mars our Earth would show its tropical vegetation the year round, while in Mars no tropical vegetable coloration would appear until water from the melting polar snow caps animates its growth.

Lowell shows conclusively that the seas are not seas, nor the canals waterways, nor the spots lakes.

Apparently, the spots appear not so much by an increase in size as by a deepening in tint. They start, it would seem, as big as they are to be, but faint in tone; they then proceed to darken throughout. If these spots are areas of vegetation, the explanation of their appearance is at once evident. Even more markedly unnatural is another phenomenon of this phenomenal system, of which almost every one has heard and almost nobody has seen,—the double canals. Upon a part of the disk where, up to that time, a single canal has been visible, of a sudden, some night, in place of the single canal, twin canals are perceived, similar in character and inclination, absolutely parallel, reminding one of the twin rails of a railroad track. The regularity of the thing is startling. In details the doubles vary, chiefly, it would seem, in the distance the twin lines lie apart. Lowell says the widest he has seen is the Ganges, in which six degrees separate the two lines,—in the narrowest, the Phison, four degrees and a quarter. From 120 to 175 miles of clear country is found between the paralleling lines. "One element of mystery may be eliminated at the outset.... It is perceived of a sudden, by the observer, because of some specially favorable night. But it has been for some time developing. So much is apparent from my observations. Suggestions of duality occurred weeks before the thing stood definitely revealed. Furthermore, the gemination may lie concealed from the observer some time after it is quite complete, owing to lack of favorable atmospheric conditions. For it takes emphatically steady air to see it unmistakably." Each canal has its individual behavior of doubling, and the varying widths, and their evident seasonal relations utterly forbid the conception that their appearance is due to optical illusion. Mr. Lowell feels tolerably sure that the doubling, or gemination of the canals, show that the phenomenon is not only seasonal but vegetal. Why it should take this form is one of the most pregnant problems about the planet. For it is the most artificial-looking phenomenon of an artificial-looking disk.

We quote a paragraph from the concluding chapter in his book: "To review, now, the chain of reasoning by which we have been led to regard it probable that upon the surface of Mars we see the effects of local intelligence. We find, in the first place, that the broad physical conditions of the planet are not antagonistic to some form of life; secondly, that there is an apparent dearth of water upon the planet's surface, and, therefore, if beings of sufficient intelligence inhabited it, they would have to resort to irrigation to support life; thirdly, that there turns out to be a network of markings covering the disk, precisely counterparting what a system of irrigation would look like; and, lastly, that there is a set of spots placed where we should expect to find the lands thus artificially fertilized, and behaving as such constructed oases should. All this, of course, may be a set of coincidences, signifying nothing; but the probability points the other way. As to details of explanation, any we may adopt will undoubtedly be found, on closer acquaintance, to vary from the actual Martian state of things; for any Martian life must differ markedly from our own."

* * * * *

In this brief résumé of Lowell's work on Mars but scant justice has been done to the many novel and convincing suggestions in explanation of the varied features marking the surface of Mars. There are many enigmas, however, awaiting solution, if we endeavor to explain them by comparison with the methods pursued by man on this Earth, and Mr. Lowell frankly admits the many difficulties in the way of a clear solution. I have already mentioned how puzzling the checker-board appearance of our Western townships would seem to a Martian, but this comparison does not help us to understand the so-called gemination of the canals, though we might have parallel sets of canals, as we have parallel lines of railways. The enormous distance which the water travels in the Martian canals must presuppose an artificial method of urging it on. Precisely how this operation might be accomplished is a question to be solved by the mechanical and hydraulic engineer.

Beside the doubling, or so-called gemination, of the canals, there are other enigmas in the markings. At certain times there has been observed in the equatorial region of Mars a number of white spots, which have greatly puzzled the student of Mars and for which no explanation has yet been offered. That they are not clouds is seen in the fact that they do not move or drift. Furthermore these white spots are fixed features of the region, as they appear in the same places. It might be suggested that they represent snow-capped elevations or mountain peaks, but this is difficult to believe, as an examination of the terminator of Mars reveals no evidences of high elevations. These white spots appear only in mid-summer, which would argue against the idea of their being snow caps, as in mid-summer they would certainly melt and disappear. The time of their appearance coincides with the time of greatest equatorial heat. For a reasonable suggestion it might be offered that these white spots are due to vegetation of some kind. The cotton belt of the South, if one could imagine the cotton bolls a little larger and more crowded together, would make white areas. Masses of white flowers, such as the whiteweed or daisy, may be seen covering hundreds of acres of meadow land in New England. I have noticed from the tops of mountains in New Hampshire, in July, extensive meadow lands resembling fields of snow from the profusion of white daisies. The blossoming of fruit trees in the Santa Clara valley, California, whitens the surface for miles. Since the appearance of these white spots in Mars corresponds with the period of greatest evaporation, it is conceivable that an intelligence in Mars might utilize the same method which has been recently adopted in Connecticut and Porto Rico in the raising of tobacco; namely, to protect the fields with white cotton cloth; or, as in Florida, where extensive orange groves are covered with white cloth to guard against sudden frost. That this supposition has something to commend it may be seen in the accompanying reproduction of a photograph (Plate I), made in Porto Rico, of tobacco plantations when the fields are covered with white cloth supported on suitable frames. This picture appeared in an article by Eugene P. Lyle, Jr., on Porto Rico, in the January number of "World's Work," to the publishers of which we are indebted for the privilege of using it.

These various guesses may all be wrong, as, after all, we are judging Mars from conditions belonging to our own planet. This, however, we are compelled to do, as we have no other standards of comparison.

PLATE I

TOBACCO CULTIVATION UNDER CLOTH, PORTO RICO

V

TESTIMONY OF ASTRONOMERS

That there may be types of life of some kind on Mars is, I should think, quite likely.

SIR ROBERT BALL.

In the following chapter are presented abstracts from memoirs, communications, etc., of a few among the many astronomers and observers who have recognized the markings on the planet, and, in many cases, have made drawings of them. Before presenting these few brief records, I have compiled, from Camille Flammarion's great work on Mars, the names of those astronomers whose drawings he reproduces in this monograph, for such it is. A brief examination of Flammarion's volume will give one an idea of the extent and variety of work which has already been accomplished in interpreting the surface features of Mars, and the number of astronomers who have made contributions to the subject.

Flammarion divides these observations into three periods; the first, beginning with the rude drawing of Fontana, in 1636, followed by Huyghens, in 1659, Cassini, in 1666, and many others up to Harding, in 1824. In this period the drawings were rude, though a number of the more conspicuous features were established, and above all, the existence of what was interpreted as snow in the white polar caps. Astronomically many points were determined, such as an approximation of the period of revolution, the distance of Mars from the Sun, the diameter of the planet, its mass, the inclination of its axis, the eccentricity of its orbit, its period of rotation, etc.

The second period begins with the remarkable work of Beer and Mäedler, in 1830 and subsequent years. To them belongs the honor of being the first astronomers to make a chart of the planet. An advance standard was set for future studies, and the work which followed revealed details in the surface markings never before suspected. The second period, from 1830 to 1877, includes the observations and drawings of Beer and Mäedler, 1830; Sir John Herschel, 1830; Galle, 1837; Warren de la Rue, 1856; Webb, 1856; Secchi, 1858; Liais, 1860; Schmidt, 1862; Lockyer, 1862; Phillips, 1862; Lassell, 1862; Knott, 1862; Kaiser, 1862; Dawes, 1864; Franzenne, 1864; Williams, 1867; Proctor, 1867; Lahardeley, 1871; Burton, 1871; Wilson, 1871; Gledhill, 1871; Flammarion, 1873; Terby, 1873; Green, 1873; Trouvelot, 1873; Lohse, 1873; Holden, 1875.

The third period extends from 1877 to 1892, when Flammarion published his book. The following drawings are given: Flammarion, 1877–88; Paul and Prosper Henry, 1877; Neisten, 1877–79–81–88; Terby, 1877–79–88; Van Ertborn, 1877; Cruls, 1877; Dreyer, 1877–79; Lohse, 1877–79–83–84; Green, 1877; Schiaparelli, 1877–79; Maunder, 1879; Konkoly, 1879; Boeddicker, 1881–84; Burton, 1882; Trouvelot, 1884; Knoble, 1884; Denning, 1886; Perrotin and Thollon, 1886; Proctor, 1888; Perrotin, 1888; Holden and Keeler, 1888; Wislicenus, 1888–90; W. H. Pickering, 1890; Williams, 1890; Giovannozzi, 1890; Guillaume, 1890.

It is impossible to follow these various drawings of Mars from the earliest ones of the first period,

many of little value, to the slow yet certain advance as seen in the more detailed drawings of the second period, without realizing the gradual improvement of the telescope, coupled with a greater number of observers endowed with better eyesight and impelled by deeper interest in the work. In the third period, culminating with the great work of Schiaparelli, and confirmed by the remarkable observations of Perrotin and Thollon, we see the results of still more arduous devotion to the work; a great advance in telescopes, with better definition, and, in the case of the observations at Nice and Milan, a steadier atmosphere through which to observe. Flammarion brought his work up to 1892.

Lowell's work on Mars, though of a kind with Schiaparelli, is, in every circumstance accompanying it, so remarkable that we may well consider the standard now set by him as the beginning of another period; and this period will fix a standard which will consist in securing observers who, in the language of Sir David Gill, have a special faculty, an inborn capacity, a delight in the exercise of exceptional acuteness of eyesight and natural dexterity, coupled with the gift of imagination as to the true meaning of what they observe. With this standard established, there must also go a perfect telescope for definition, mounted on an elevation a mile and a half or more above the level of the sea, in a region of the clearest and steadiest atmosphere in the world.

One cannot help reflecting on these various drawings presented in Flammarion's work, and wondering what the results would have been if all these astronomers could have had telescopes as incomparable as that at Flagstaff, perched on some high mountain peak with a clear and steady atmosphere continuous for weeks, and, superadded to all these advantages, independent fortunes to enable them to transport their telescopes thousands of miles south when a favorable opposition of Mars occurred at a low altitude.

The astronomers who have advanced certain theories to explain the markings may be counted as admitting their existence, whatever they may be. Among the other astronomers to be referred to are, first, those who admit the markings, and have in all likelihood seen them; second, those who have observed and made drawings of the markings; and, third, those who have drawn them and admit, or at least do not deny, their artificiality.

Miss Agnes M. Clerke, an astronomical writer of great merit, who has written a most lucid and comprehensive "History of Astronomy in the Nineteenth Century," says: "The canals of Mars are an existent and permanent phenomenon." Mr. Thomas Lindsay, of Toronto, read some notes before the Astronomical Society of that city in regard to the phenomenon of the so-called doubling of the canals and the explanation advanced that it was due to errors in focusing. "It had been stated by several English observers that, by racking the eyepiece within or without the focus, all the phenomena might be produced." In the case of Mars, however, he asks: "How is it possible that all the observers had their telescopes unadjusted, and, if any one had, would he not be immediately aware of it?" Mr. Lindsay thought that the theory was too obviously opposed to the simplest kind of common sense to merit a moment's consideration.

Mr. John A. Patterson, in his Presidential address before the Astronomical Society of Toronto, in speaking of Mars, said the discoveries rest on the bed rock of scientific evidence; and, after speaking of the supposed spectroscopic evidence that there was no atmosphere in Mars, refers to the polar snow caps, their melting, and the lines of vegetation that are supposed to mark the margin of the canals, and he asks: "Is it possible that all these may be consistent with no vapor floating above the surface? Is it sound philosophy to conclude that the condition of things on our own little world gauges the possibilities and relations that exist in our sister world? Dame Nature does not turn out all her products in one pattern."

Mr. Denning, in the "Astronomische Nachrichten," No. 3926, gives the result of his observations on

Mars in 1903. He says the canals, without doubt, are objective features; changes in the appearance of these markings he attributes to vaporous condensations. One rotation period of the planet satisfies the observation of all the markings, thus proving them to be definite features of the planet's surface rather than drifting vapors such as are seen when observing Jupiter and Saturn. In spite of these admissions Mr. Denning, in 1905, while repeating his convictions as to the objectivity of the canals, denied their sharp outline. Of the ten canals he drew, eight were discovered by Schiaparelli, and two were discovered by Lowell. Denning observed these lines with a ten inch reflector. Schiaparelli compared them in sharpness to lines of a steel engraving. It rests with the reader to judge who is most likely to be correct in his description of the character of the lines—Mr. Denning with a ten inch reflector, in a poor atmosphere, or Schiaparelli and Lowell, with a twenty-six and a twenty-four inch refractor, respectively, in a far superior atmosphere.

Among the many who have seen and drawn the canals comes first, of course, Professor Schiaparelli, the discoverer of them. It is only necessary to state here that he first detected these enigmatical markings, which he named *canali*, in 1877. In the opposition of 1879, he not only confirmed the discoveries of 1877, but added new *canali*, and for the first time saw the curious process of doubling, or gemination.

Astronomers in various parts of the world searched in vain for these markings, and despite the exalted character and remarkable work of the distinguished Italian in other lines of astronomic research, it was feared that, in this instance, Schiaparelli had been the victim of an hallucination. It is true that from the time of Huyghens, in 1659, a few astronomers, such as Secchi, Schroeter, Kaiser, and Dawes, have detected and drawn a few faint lines which seemed to be identical with the *canali* of Schiaparelli. It was not until 1886, however, that Perrotin and Thollon with a twenty-nine inch refractor of the Nice Observatory, first began to confirm the discoveries of Schiaparelli, and since that time observers in various parts of the world have detected and drawn these remarkable lines. The cumulative testimony of these men as to the veritable existence of these markings cannot be set aside.

It seems strange that nine years should elapse before an astronomer with an interest in the subject, coupled with an acute vision and the patience to observe assiduously, should arise to confirm the existence of these markings, but in another chapter I have called attention to the little interest astronomers have manifested in planetary markings of any kind. It has been shown elsewhere that acute vision, with a clear and, above all, a steady atmosphere, are the chief essentials in making out the markings. It is curious to note the attitude of some astronomers, who, having seen the canals and even drawn them, denied their veritability. Their explanations cover "illusions due to the property of light itself, the inability of the eye to maintain its mechanism of accommodation, the behavior of air waves, temporary alteration of the focus of the eye, undetected astigmatism," etc., etc. But, to return to the astronomers who have drawn them. On the unfavorable opposition of 1888, Schiaparelli declares that "the *canali* had all the distinctness of an engraving on steel, with the magical beauty of a colored engraving." He furthermore says: "As far as we have been able to observe them hitherto, they are certainly fixed configurations upon the planet, the Nilosyrtis has been seen in that place for nearly one hundred years and some of the others for at least thirty years."

In this connection it is interesting to quote from Schiaparelli who, until many years after he discovered the canals of Mars, had no doubt of their natural origin. As late as 1893, he still considered them natural. In speaking of the canals, he says: "It is not necessary to suppose here the work of intelligent beings; and in spite of the almost geometric appearance of their whole system, for the present we incline to believe that they are product of the evolution of a planet, much as on the Earth is the English Channel, or the Channel of Mozambique." This extract may be found in a memoir in "Natura ed Arte," 1893, page 22. On page 24 of the same memoir Schiaparelli illustrates the elasticity of his mind and a thoroughly

unprejudiced attitude by saying: "Their singular aspect, and the fact that they are drawn with absolute geometric precision, as if they were the product of rule and compass, have induced some people to see in them the work of intelligent beings, inhabitants of the planet. *I should be very careful not to combat this supposition, which involves no impossibility.*" (The italics are ours.) His comparison of the Martian lines with the English Channel and the Channel of Mozambique, if he means any resemblance in form and not in the manner of formation, is most unfortunate, for on the whole face of the Earth he could not have mentioned surface features more totally unlike any feature of the Martian surface, as drawn by him, than these two channels: the English Channel, 100 miles wide at its mouth and 200 miles long, tapering to the Straits of Dover; the Mozambique Channel, hour-glass shaped, 1,100 miles long, and, at its narrowest part, 260 miles wide, and at either end nearly 700 miles wide. Had he suggested the Red Sea, 1,200 miles long, or the Straits of Malacca, 350 miles long, a nearer resemblance to the canals of Mars might have been seen, though even here it would be impossible to find their counterparts in Mars. These channels are merging with the ocean, are nearly half the width of their length, and enlarge at both ends, while the *canali* of Mars run for hundreds of miles as straight as ruled lines. How slight the resemblance is may be appreciated by comparing the following figure of the Earth (Fig. 1), upon which the Red Sea, the English and the Mozambique Channels and the Straits of Malacca are indicated.

FIG. 1.

In 1897 Schiaparelli becomes still more convinced of their artificiality. In his Memoir XXV, in the Reale Academia del Lincei, in speaking of the canals, he says: "This whole arrangement presents an indescribable simplicity and symmetry which cannot possibly be the work of chance." In a letter to Mr. Lowell, dated December 4, 1904, he writes: "Your theory of vegetation becomes more and more probable." Mr. A. Stanley Williams, in the "Observatory" for June, 1899, in a paper entitled "Notes on Mars," described the appearance of certain canals, regions, etc., in great detail. He notices that at the crossing of the canals a little dark spot occurs, a feature, he says, which was first elucidated by Professor Lowell in 1894. Mr. Williams also noticed the black streak bordering the northern snow cap, which Mr. Lowell in his book on Mars has interpreted as a body of water resulting from the melting snow.

In the Quarterly Journal of the Astronomical Society of Wales, the Rev. Theo. E. R. Phillips publishes an excellent drawing of Mars in color. In this drawing he shows a large number of regions, a number of canals, and other features which, he says, "came out with the clearness and sharpness of an engraving, and bore no resemblance to the 'diffused streaks' or amorphous smudges one sees for the canals in imperfect seeing." In this drawing the polar snow caps show with remarkable vividness.

Professor W. H. Pickering, in a continuous record of observations on Mars, published in the "Annals of the Lowell Observatory," records under August 20: "The dark north canals are also noticeable, and, had they looked as they now do, could not possibly have been missed on the 16th."

Dr. Phil. Fauth has, with a seven inch objective, drawn and published sixty-three drawings of Mars in which a great many canals are shown, a list of which he presents in his memoir on the subject.

The lamented Perrotin, for some time Director of the Nice Observatory, in company with M. Janssen, at Meudon, observed Mars through the great equatorial (32-2/3 inch), and published the results in the "Comptes Rendues" (Vol. CXXIV, No. 7). He describes the several zones, the northern equatorial zone "being more particularly the zone of the extraordinary canals, the discovery of which we owe to Schiaparelli, and to which we ourselves, by our publication, in 1886, called the attention of the astronomical world."

The London "Nature," March 17, 1904, in noting the death of M. Henry Perrotin, speaks of him as one of the ablest advocates of astronomical science. He devoted much time to Mars. "Aware that he was working at the extreme limit of visibility, and knowing the tendency for self-deception to creep in and impair the value of such delicate observations, he sought opportunities of making similar measures and records with different instruments, and under varied conditions, in order to remove, so far as possible, the evils of bias and partiality from the results of his researches."

Dr. Terby of Louvain, in a memoir entitled "Physical Observations of Mars," a translation of which appeared in the "Astronomical and Astrophysical Journal," No. 106, identifies many of Schiaparelli's *canali* and other details depicted in Schiaparelli's map of Mars. In conclusion Dr. Terby says: "After what we have seen we dare affirm that henceforth the progress of areography will be in the hands of those alone who, freeing themselves from the shackles of doubt, will resolutely engage in the way traced by the celebrated astronomer of Milan. A new era has begun in the study of Mars by the discovery of canals and their doubling, and by the micrometric determination of one hundred and fourteen fundamental points on the map, an era succeeding to that which was inaugurated a half century ago by the construction of the first two hemispheres and by the approximate fixing of fourteen points by Mädler." Dr. Terby further says: "But these results have an incontestable value in the presence of the incredulity with which certain astronomers still consider the beautiful discoveries of Milan. Who would believe it? In spite of the beautiful drawings of M. Perrotin one reads still that the discoveries of M. Schiaparelli have not been confirmed by the largest instruments."

In "Astronomy and Astrophysics," No. 108, is published a series of contributions on Mars by Professors Edward C. Holden, William H. Pickering, C. A. Young, Lewis Swift, George C. Comstock, E. E. Barnard, and H. C. Wilson. All of these men are astronomers and all are connected as directors or observers with various observatories in the United States. Many sent sketches, most of them saw the canals, all saw the polar snow caps and darker regions. To say that these astronomers were sketching details which existed only in their imagination is simply preposterous.

Professor Herbert A. Howe, Director of the Chamberlin Observatory, at Denver, in his "Elements of Descriptive Astronomy" says: "If we have simply to answer the question, 'Would a man, as constituted at present, if transported to Mars find it possible to exist there?' The most probable answer is, 'No.' While one must not be dogmatic, it may be said, with some assurance, that the man would gasp a few times and die. However, it is conceivable that manlike beings might find a home there." Mr. Howe could have said without being dogmatic that a man thus transported would die of what is known as Caisson disease.

Among those who assert that the canals are artificial we have Professor Percival Lowell as pre-eminent. He has erected an observatory in the region of one of the clearest atmospheres in the world, has furnished it with the finest telescope that Clark ever made, and for the chief purpose of studying the surface features of Mars. In his interesting book on Mars he has presented the results of his observations in so lucid and convincing a manner that a reviewer of the English edition of the work, in an English

astronomical journal, is led to write: "We may say at once that we feel bound to accept these observations as sufficient evidence of the real existence of the markings without expressing an opinion as to what they may be." The reviewer ends by saying: "Indeed, there is a subtle deftness in the way Mr. Lowell deals with his observations which gives the impression that he has been there and seen it all, and it is really hard to say why we cannot accept his conclusions. It is probable, because we are shy to receive new facts at a first statement. In time, no doubt, we shall be willing to accept his deductions (or facts) as to the markings. We were about to advance objections, but they seem poor, and really it is a case where each person must read and form his own ideas—but by all means read."

We have already presented a summary of his observations. We may add here, however, an extract from his book on the solar system. In this Mr. Lowell says of Mars: "What we see hints of the existence of beings who are in advance of, not behind us in the journey of life," and again: "Life on Mars must take on a very different guise from what it wears on the Earth. It is certain there can be no man there—that is as certain as anything can be. But this does not preclude a local intelligence equal to, and perhaps easily superior to, our own. We seem to have evidence that something of the sort does exist there at the present moment and has made imprint of its existence far exceeding anything we have left on Mother Earth."

George W. Morehouse, in his "Wilderness of Worlds," says: "Taken all together we must regard Mars as probably an inhabited world and very similar to the Earth."

Mr. Hector Macpherson, Jr., member of the Astronomical Society of France, in his interesting book "Astronomers of To-day," says, in regard to Mr. Lowell's book on Mars: "He does not ask us to believe anything fantastical or extravagant. His hypothesis has been framed to account for all the various Martian features. At present we can only say that it is the most comprehensive and probable theory yet advanced to explain the phenomena of the red planet."

Professor Todd, Director of the Astronomical Observatory at Amherst College, in his book on Stars and Telescopes, in referring to drawings of a region in the southern portion of Mars, known as the Solis Lacus, and a complicated drawing of another region, says: "Whether one views this marvellous and intricate system as a whole, or in some portion of high detail, it is difficult to escape the conviction that the *canali* have, at least in part, been designed and executed with a definite end in view."

There are many who do not deny the existence of some forms of life on the planet, but are not prepared to admit the existence of intelligent creatures. Sir Robert Ball expresses himself as follows: "That there may be types of life of some kind on Mars is, I should think, quite likely."

The number of astronomers above quoted, who have seen and drawn the canals, might be augmented, but a sufficient number have been cited to show that the evidence of the presence of these markings does not rest with a few, furthermore, some of these observers can only interpret the markings as the result of intelligent action. It may be urged that among those quoted are some whose opinion may not have great weight since they are not professional astronomers. One must insist that the study of planetary markings as well as the interpretation of their meanings comes not only within the province of planetary astronomers, but that any broad-minded man, with an acute eye and familiar with the sciences connected with the surface features of the Earth, is quite competent to make observations of his own and to judge of the merits of the question.

VI

THE STUDY OF PLANETARY MARKINGS

Their singular aspect, and the fact that they are drawn with absolute geometric precision as if they were the product of rule and compass, have induced some people to see in them the work of intelligent beings, inhabitants of the planet. I should be careful not to combat this supposition which involves no impossibility.

SCHIAPARELLI.

It is a question whether, after all, the study of planetary markings comes within the province of astronomers. Not more, perhaps, than the study of physical geography and subjects connected with the surface features of the Earth, comes under the cognizance of those whose profession it is to determine the oscillation of the pole, the Earth's movements due to the Moon, etc. Indeed, these lines of research are strictly astronomical. With the study of the surface markings of the Moon, or Mars, features of an entirely different kind are to be interpreted, and quite a different equipment is necessary. It is no wonder, then, that astronomers, the most conservative of all classes of investigators, should view with suspicion the results of the work of Schiaparelli, Lowell and others. Immersed in mathematics, trusting in nothing that cannot be measured and reckoned, as a class holding their imagination in abeyance, is it any surprise that they should present an attitude of indifference and even hostility to the work of those who, differently equipped mentally, have attempted a definition and solution of the riddle of the Martian markings? To appreciate how foreign to the studies of an astronomer is the interpretation of the canals of Mars, one has simply to scan the index of any astronomical publication, or the titles of papers in the transactions of astronomical societies. For example, take volumes XX and XXI of the "Astronomical Journal" and tabulate the papers, memoirs, etc., therein published, numbering two hundred and thirty-eight, and we find of these, seventy-four on the stars; sixty-two on the comets; nineteen on planets and satellites, mostly mathematical; eighteen on the Sun; eighteen on the asteroids; fifteen on Eros; ten on polar motion and latitude; four on Nova Persei; and seventeen miscellaneous, consisting of logarithms, instruments, Gegenschein, etc.; and only one on Mars, and this on the polar snow caps!

As to the question whether it is more important to add another to the thousands of variable stars and binaries, and hundreds of asteroids, already determined, or to consider whether we are alone in the universe and, if so, the significance of it, I think with the intelligent public there can be no doubt.

A fair sample of the subjects which occupy the astronomers' mind, and which are so remote from the study of planetary markings, and have so little interest for the public, may be gathered from the following list selected at random from an astronomical publication. Notes on variable stars; Maxima and minima of long period variables; Micrometrical measurements of the companion of Procyon; The problem of three bodies; Ephemeris of Comet a, 1901; On the eruptive energy of the stars; Eclipse cycles; Determinations of the aberration-constant from right ascension; Theory of a resisting medium upon bodies moving in parabolic orbits; Weights and systematic corrections of meridian observation in right ascension and declination; and other titles equally profound. Many of these memoirs consist of hundreds of pages of

figures, and, as a friend of mine observed, not a column footed up! Take for example a title like the following: "Method of developing the perturbative functions, also precepts for executing their development." This memoir is accompanied by pages of algebraic formulæ which the layman turns over in despair, the only illumination consisting of a few words in English which render the gloom still more apparent,—such words as "hence," "or," "we therefore have," "if we put." Of what we "have," and why we "put," we are left in profound ignorance. Now I venture to believe that the great world of humanity takes but little interest in such pages, or in the kinds of titles above given, though fully realizing that they mean something and represent important steps in astronomic research. It would add greatly to the value of these contributions if a brief summary in plain English could be given at the end of these papers, but it is the rarest event that these collectors of data ever make any generalizations, or form any deductions.

My faith in the appalling character of algebraic formulæ[5] received a rude shock when I learned of an experience of Louise Michel, the anarchist, who was transported for life to New Caledonia (afterwards pardoned). On arriving at the savage island, true to her humanitarian instincts, "she immediately established a school for native children, who by a curious freak of their minds, she noted with rejoicing, took naturally to algebra before they learned arithmetic!"

Hovenden quotes Huxley as saying that mathematics "is that study that knows nothing of observation, nothing of induction, nothing of experiment, nothing of causation." He also quotes the words of Clerk Maxwell, who said, in regard to mathematicians, that it was "doubtful whether the ideas as expressed in symbols had ever quite found their way out of the equations into their minds." They never seem to appeal to the doctrine of probabilities nor do they in any way permit imagination to act as a stimulus to suggestive thought.

Least of all would a layman ridicule or question the painstaking labor involved in astronomic work, though he cannot see a glimmer of light or intelligence in the enigmatical pages. A certain class of astronomers might take a lesson from an intelligent public in ceasing to scoff and ridicule what they are unable to see themselves in the Martian markings. The chief work of these men indicates the cold precise measuring of points of light in the heavens, the determination of orbits, elements and ephemeris of heavenly bodies, the determination of solar parallax, etc., most of the subjects strictly mathematical, a question of careful measurements for which the necessary instruments are at hand, or simply sweeping the heavens for a new variable, binary or asteroid. Parallaxes and orbits are matters of measurement to be reckoned by the figures of anybody else. It is obvious from all this that little or no interest is manifested by astronomers in planetary markings, least of all in those of Mars. The exasperating feature of the matter is that they persistently repudiate the observation of others equally well equipped, and endowed with the same enthusiasm and devotion to their work.

The way in which the gatherers of the raw material arrogate to themselves the science of astronomy, relegating the thinkers and generalizers to the limbo of speculation, is as if the book-keepers of a corporation should assume themselves to be the master-minds of the concern and the banker, or financier, at the head of it, a dreamer not worth regarding.

An illustration of the conservativeness of astronomers in regard to planetary markings is shown in their cautious attitude concerning the polar snow caps of Mars. Here are white polar caps on Mars, precisely where they ought to be if they *are* snow, they wax and wane at the time they should and at no other time, a dark band appears at their borders as the caps in turn diminish in size, which has been interpreted as water due to the melting snow, and no other substance known could possibly reproduce these varying conditions. Professor C. A. Young, in describing these white areas, says: "The one which happens to be turned toward the Sun continually diminishes in size, while the other increases, the process

being reversed with the seasons of the planet." After these admissions Professor Young cautiously says: "These are believed to be ice caps." Sir John Herschel says: "The variety in the spots may arise from the planet not being destitute of atmosphere and clouds, and what adds greatly to the probability of this is the appearance of brilliant white spots at the poles—one of which appears in our figure—which have been conjectured with some probability to be snow, as they disappear when they have been long exposed to the Sun, and are greatest when just emerging from the long night of the polar winter." Had Michael Faraday been an astronomer, how long would it have taken him to pronounce these white polar caps snow and ice? De la Rive, in his memoir of Faraday, in speaking of his marvellous accomplishments, says: "One may easily understand what must be produced under such circumstances by a life thus wholly consecrated to science, when to a strong and vigorous intellect is joined a most brilliant imagination." Tyndall, in his discourse "On the Scientific use of the Imagination," says: "Bounded and conditioned by co-operant reason, imagination becomes the mightiest instrument of the physical discoverer. Newton's passage from a falling apple to a falling Moon was a leap of the imagination."

That Herbert Hall Turner, Professor of Astronomy in the University of Oxford, does not regard the various contributions on the surface features of Mars as belonging to astronomical science may be inferred from his interesting book lately published, entitled "Astronomical Discovery." This book presents to us the history of the discovery of Uranus and Eros, of Neptune, Bradley's aberration of light, Schwabe and sun-spot period, the variation of latitude, etc., but not a word about the marvellous discoveries of the *canali* of Mars by Schiaparelli, so fully confirmed by the observation and drawings of many others, and the great advances made by Lowell in the discovery of new features with his lucid and rational interpretation of the seeming enigmas.

Astronomy, the oldest and most conservative of all the sciences, has been the last to subdivide. Already one group of men has justified by its work a division of the science known as astrophysics. The lamented Keeler, in explaining the difference between astronomy and astrophysics, said: "Astrophysics seeks to ascertain the nature of the heavenly bodies, rather than their positions and motions in space, *what* they are, rather than *where* they are." This natural division suggests the propriety of making another division equally distinct, which should comprise the study and interpretation of the surface markings of the planets and satellites, under the name of planetology. The study would be the application to these bodies of the science of geology, in its broadest sense, meteorology, physical geography, geodesy, and related sciences.

With the science of planetology established, the student of this science will no longer call to his aid the astronomer, and, least of all, the astrophysicist, nor will he be mindful of their criticism or neglect. He will appeal to the sciences which are involved in the study of the surface features of his own globe, in the interpretation of planetary detail.

VII

DIFFICULTIES OF SEEING

It is contrary to all the analogies of nature to suppose that life began only on a single world.

SIMON NEWCOMB.

For years I had been familiar with different representations of Mars in which the surface features had been strongly depicted in black and white; in other words, photo-reliefs, or engravings incorporated with the printed page. I had unwittingly come to believe that these features were equally distinct when one observed Mars through the telescope. I had not then seen Schiaparelli's original memoir in which his wonderful map presents the canals in light and tenuous lines, which are, however, as clear cut as the lines of a steel engraving, to use his words. For a long time I had hoped for a chance to observe Mars through a large telescope in a clear and steady atmosphere. It seemed reasonable to me—knowing nothing about it—that one who had traced out under the microscope delicate lines and structural features in diaphanous membranes, who had, in fact, used a microscope with high powers for forty years, would find it child's play to make out the canals, oases, regions, etc., of Mars, as represented in the various publications on the subject. Professor Percival Lowell, of Flagstaff, Arizona, finally gave me the opportunity I so much desired, and, through his courtesy and kindness, I was enabled to observe Mars every night for nearly six weeks through his twenty-four inch refractor, the last and probably the best telescope ever made by Clark, mounted in one of the steadiest atmospheres in the world and at an altitude above sea-level of over 7,000 feet. Imagine my surprise and chagrin when I first saw the beautiful disk of Mars through this superb telescope. Not a line! not a marking! The object I saw could only be compared in appearance to the open mouth of a crucible filled with molten gold. Slight discolorations here and there and evanescent areas outlined for the tenth of a second, but not a determinate line or spot to be seen. Had I stopped that night, or even a week later, I might have joined the ranks of certain observers and said "illusion" or something worse. And right here it was that my experience in microscopic work helped me, for, remembering the hours—nay, days—I had worked, in making out structural features in delicate organisms which my unprofessional friends could not see at all, I realized that patient observation would be required if I was to be successful in my efforts. My despair, however, was overwhelming when Professor Lowell and his assistants, looking for a few moments at the same object, would draw on paper the features which had been plainly revealed to them, consisting of definite shaded regions, a number of canals and other markings, of which, with the utmost scrutiny, I could hardly detect a trace. For the first time I realized that observing fixed diaphanous membranes under a microscope with rigid stand, and within four inches of one's nose, was quite a different matter from observing a brilliant disk 4,200 miles in diameter, 52,000,000 miles away, with an oscillating atmosphere of unknown depth between. Night after night I examined this golden, opalescent disk, drawing each time such features as I could convey by memory from the ocular to the drawing table, and, little by little, new features were detected, and to my delight the drawings agreed with those made by the others. Since the drawings made by the four observers coincided, it was evident that we had not been victims of subjective phenomena. Furthermore, as I discovered

afterwards, by comparison, the drawings I made not only agreed with theirs but with those made by other observers, at different times, in other parts of the world. So slow were my acquisitions, however, that it soon became evident that at least months of continuous observation would be necessary before the more delicate markings would be revealed to me. It is interesting to learn that others have had a similar experience. Mr. A. Stanley Williams, of England, in an article entitled "Notes on Mars" ("Observatory," June, 1899), in stating the difficulties of observation, says: "My eye invariably requires at least two months of continuous observation of a planet before it acquires its full sensitiveness to the most minute details."

In this connection it is well to state that Mr. Lowell began the observation of Mars when he was a mere boy. His first telescope, which he still has, was a two and a quarter inch refractor. His observations were made from the roof of his house in Boston, and with this small glass he defined the general shaded regions that Huyghens had detected and drawn in 1659. Since then Mr. Lowell has observed in turn through a six inch, an eighteen inch of Brashear, and, for the last few years, through a twenty-four inch refractor made by Clark especially for this work.

To refute the accumulated observations of Mr. Lowell one must have the same acute eye, and a record of the same continuous and devoted study. Nothing short of that experience will avail. The jealous derision that has gone up from some observers endowed with less acuteness of vision is neither dignified nor just. Were these Martian details based upon the observations of Lowell alone, one might be inclined to say that some vagary of the mind had led him to imagine these markings which were first detected by the great Italian astronomer Schiaparelli. Up to the present time—to mention only a few—observations and drawings have been made by Perrotin, Thollon, and Flammarion, of France; Dr. Phil. Fauth, of Germany; Williams, of England; Lowell, W. H. Pickering, Douglass, Lampland, and Schaeberle, of America, while many others have made drawings of the more conspicuous details. With this record it is impossible to deny the existence of these markings essentially as they are drawn.

The difficulty of seeing the more delicate markings of the planet is unquestionable, and an examination of astronomical literature, from which we shall make numerous quotations, indicates only too plainly the acuteness of vision, and the time and care necessary to make competent observations. Sir Robert Ball says, in one of his recent works: "The detection of the Martian features indicates one of the utmost refinements of astronomical observations." Macpherson, in his "Astronomers of To-day," thus writes of Schiaparelli, "Professor Schiaparelli's observations have been distinguished by his keen-sightedness and care. He has taken every precaution to avoid all disturbances resulting from personal equation, and has found it well to adopt the rule (which he here quotes) 'to abstain from everything which could affect the nervous system, from narcotics and alcohol, and especially from the abuse of coffee, which I found to be exceedingly prejudicial to the accuracy of observation.'" What I might have accomplished in the way of seeing had I followed the wise example of Schiaparelli I do not know. A not too strict abstemiousness in any of these matters, coupled with long daily walks on the Mesa, with its fascinating flora and fauna, found me in the observer's chair every night, somewhat fatigued mentally and physically.

Sir Robert Ball, in his "Popular Guide to the Heavens," in describing the difficulty in making out the more delicate markings of Mars, says: "It should be understood that in the unsteady air of England it is almost hopeless to expect many of the finer details; not even in the most favorable climates are they to be seen always, or all at once, and much training of the eye is required before it is fit to decide for or against the existence of these details on the verge of invisibility." As another illustration, perhaps, of the difficulties of seeing, Sir Robert, in the same book, says: "Observers of Mars are divided into two camps, those who see the canals, and those who do not. The former are in the strong position that they are

perfectly sure that they see what they represent in their drawings."

From the foregoing it must be evident that not only are the finer markings on Mars most difficult to see even under the best conditions but that exceptional acuteness of vision, which few possess, united with long practice, is necessary to make out the tenuous lines which enclose the field of Mars like a net. That Mr. Lowell has had a long and continuous practice, covering years, in observing Mars through the steadiest of atmospheres and with a superb glass, is simply a statement of fact. It may be said without fear of contradiction that he has devoted more time to the observation of Mars than all the other observers combined. Has he then an exceptional acuteness of sight, coupled with indefatigable industry, in the pursuit of this quest to which he is devoting his life and fortune? The following instance will illustrate his marvellous eyesight. We were walking along the shores of a lake some miles from Flagstaff, the expanse of shore left by the rapidly evaporating waters abounding with thousands of very small black spiders running hither and thither at our approach. I told him of one I had just seen in which the abdomen was covered with minute young spiders which the mother was carrying about with her—a well-known habit of certain species. This curious fact I had detected only while stooping close to the ground in search of minute shells. Mr. Lowell, while walking along, immediately began scanning the ground for the trace of a spider with minutely granulated abdomen, and finally exclaimed: "There is one of them!" On stooping down to examine the object it proved to my astonishment to be a female carrying its young in the way already described. This incident revealed a remarkable acuteness of vision to detect, while standing erect and walking, this tiny spider among hundreds of others of its species that were scampering away at our approach.

Not only is acuteness of vision necessary to one who is to study planetary markings, but of importance also is a clear, and above all a steady atmosphere; and, strange as it may appear, telescopes of moderate size seem to be the instruments with which the best work has been done. It is also true in astronomy, as in warfare, that it is not the biggest gun but the man behind the gun that does the most efficient work. As an evidence of the importance of steady atmosphere Professor W. H. Pickering, in his observations on the satellites of Jupiter, says his work had two important bearings: "First, as showing the relative importance of atmosphere *versus* aperture for delicate visual observations of this sort. In the same category would be included studies of planetary detail as distinguished from the examination of very faint objects. In other words, if an observer wishes to study very faint stars he must have a large telescope. If he wishes to study the neighboring planets and brighter satellites he may use a small telescope, but he must have a very good atmosphere."

The importance of a clear and steady atmosphere, for delicate observation, is known to all astronomers. The rarity of such days, even in our clear atmosphere so superior to that of England, is not generally known. Forty years ago Dr. Henry Draper, in an address entitled "Are Other Worlds Inhabited?" in speaking of Mars and the difficulties of seeing, said: "One of the greatest obstacles to distinct vision is our own atmosphere. Its currents and motions tend to confuse the outlines of objects, and, according to my experience, a whole year may pass without the occurrence of more than one good night. The only remedy is to carry the telescope as high up on a mountain as possible, so as to leave below the more injurious portions of the atmosphere. It might be possible to work 15,000 feet above the sea in the neighborhood of the Equator." I quote these words that the general reader may appreciate the advantages Lowell has with his fine telescope south of all European observatories, in the latitude, say of Algiers, at a high altitude, and in the dry and steady atmosphere of Arizona, with uninterrupted seeing for weeks together, and each night far superior to any night which Greenwich could ever be blessed with.

Professor W. H. Pickering attests to the importance of a steady atmosphere in studying the Moon from a station in Jamaica, when he says that, with a five inch refractor, he was able to detect minute details

which were not revealed by the far larger telescopes at Harvard University.

Mr. W. D. Barbour, President of the Leeds Astronomical Society, using his four inch achromatic, says: "In one of those brief intervals of atmospheric steadiness I saw distinctly a number of well-known markings," the names of which he gives. Dr. Phil. Fauth, using a seven inch refractor, made sixty-three drawings of Mars, showing in wonderful detail the canals, oases, etc. Mr. W. J. Lockyer, in London "Nature," testifies that "a keen and patient observer, sitting at the eyepiece of a comparatively small equatorially mounted telescope, if he makes his observations carefully, and with due regard to atmospheric conditions for good seeing, can do more useful and valuable work than one who has a large aperture at his command and employs it indifferently." Mr. E. Ledger, in speaking of Dawes, who made a remarkable map of Mars, says he was justly famed for the remarkable distinctness of his vision; he had detected and drawn a few lines which seemed to be identical to those of Schiaparelli.

In the authorities above quoted we have endeavored to show that a steady atmosphere, a persistent devotion to the work, accompanied by acute vision, and also a talent for observation, are all the factors needed, not only to confirm the remarkable discoveries of Schiaparelli and Lowell, but possibly to detect, at favorable moments, new features which have escaped the eyes of these keen observers.

At this point we cannot resist giving the words of Sir David Gill, Director of the Royal Observatory at the Cape of Good Hope. Professor S. W. Burnham, of the Lick Observatory, in reviewing a memoir entitled "Double Star Observations at the Cape of Good Hope," quotes as follows from the preface: "Sir David Gill, in speaking of the routine character of the work involved in the investigation, says: 'There is no instance, as far as I know, of a long and valuable series of double star discovery and observation made by a mere assistant acting under orders. *It is a special faculty, an inborn capacity, a delight in the exercise of exceptional acuteness of eyesight and natural dexterity, coupled with the gift of imagination as to the true meaning of what he observes, that imparts to the observer the requisite enthusiasm for double star observing.* No amount of training or direction could have created the Struves, a Dawes, or a Dembowski. *The great double star observer is born, not made,* and I believe that no extensive series of double star measurement will ever emanate from a regular observatory, through successive directorates, unless men are specially selected who have previously distinguished themselves in that field of work, and who were originally driven to it from sheer compulsion of inborn taste.'" If the reader will substitute the words *planetary markings* for *double star* in the above quotation from Sir David Gill's report, he will understand why we have ventured to italicise certain lines, and will appreciate their significance. In no stronger or truer words could one have emphasized the conditions involved in a critical study of the surface features of Mars.

In the experience of an astronomer, it is not an unusual occurrence that an object in the heavens, fairly conspicuous, remains unseen until by some lucky chance an observer sweeping the sky picks it up, and, having determined its position, it is promptly found by others. Professor H. H. Turner, in his "Astronomical Discovery of the Nineteenth Century," says: "It is a common experience in astronomy that an observer may fail to notice in a general scrutiny, some phenomenon which he can see perfectly well when his attention is called to it; when a man has made a discovery, and others are told what to look for, they often see it so easily that they are filled with amazement and chagrin that they never saw it before."

In the Rev. T. W. Webb's interesting book on "Celestial Objects for Common Telescopes," a reminiscence of the author is given by a friend in which the following is related as illustrating the varying ability of observers in seeing. "A curious instance of difference of vision was well illustrated one superb evening when Mr. Webb and the writer were observing Saturn with the nine and a half inch refractor at Hardwick. Mr. Webb saw distinctly the division in the outer ring which the writer could not see a trace of, while the writer picked up a faint point of light which afterwards turned out to be Enceladus (a

satellite) which Mr. Webb could not see."

In my brief observation of Mars I probably might have made out many more details if I had permitted Mr. Lowell to tell me what to see, and where to look for them on the disk. This I would not allow him to do, nor did I study any of the numerous drawings in his own work, or the original memoirs of Schiaparelli, or other works containing drawings of Mars in his library. I would not learn the names of any of the regions, or canals, nor with a single exception do I know them now. Only when I had finished my last night's observations, did Mr. Lowell take my drawings and write out a list of the various canals, oases, etc., which I had made out. Thus, unaided, I drew simply what was plainly evident, though many other details flashed out for a second, which were not recorded, simply because I did not see them often enough to be sure of their precise position on the disk.

Mr. Lowell points out one of the reasons why so many observers and astronomers have not seen the canals. In the third volume of the "Annals of the Lowell Observatory" he refers to a certain series of observations of Mars, made in 1894, and says: "Not only was there no sign of a canal, but even the main markings showed disheartingly indefinite." "This vacancy of expression was due to the Martian date." "It was the very nick of time to see nothing, for the part of the planet most presented to the Earth was then at the height of the dead season, and in this fact lies the key to much past undetection and present unbelief in the phenomenon of the canals."

VIII

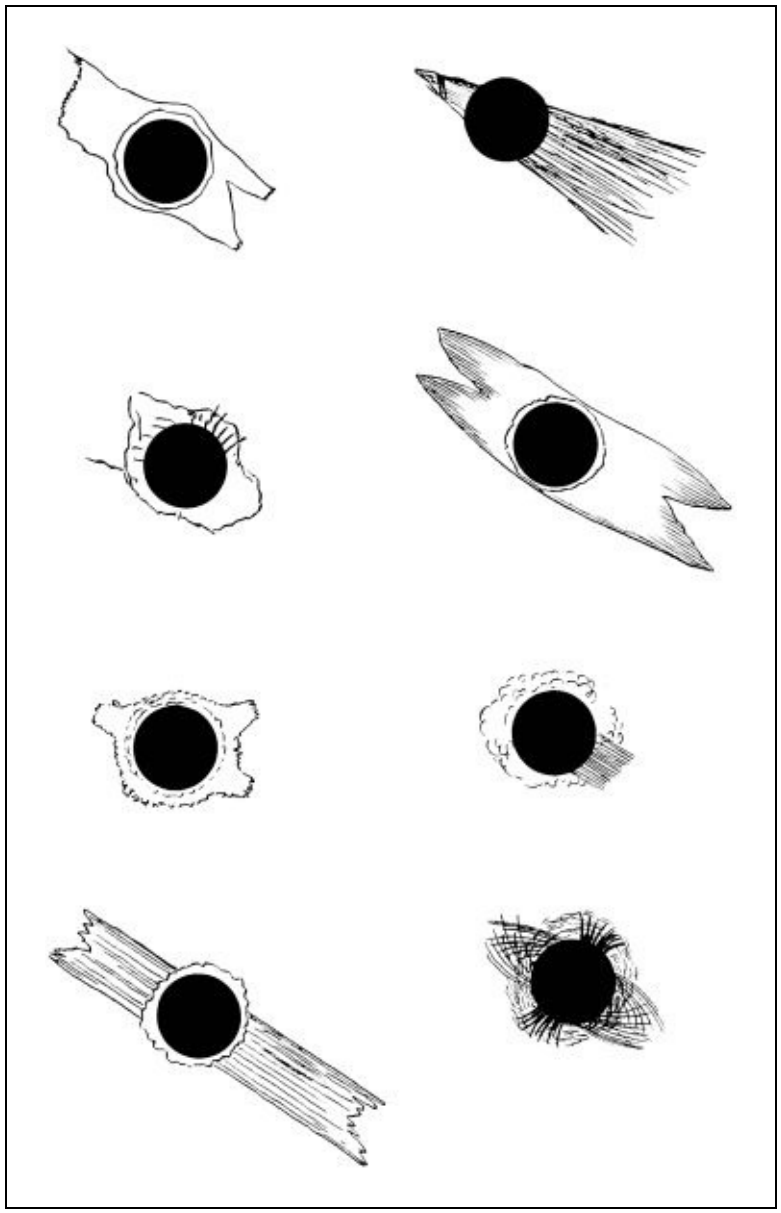
VARIATION IN DRAWING

Let us not cheat ourselves with words. Conservatism sounds finely and covers any amount of ignorance and fear.

PERCIVAL LOWELL.

Much doubt has been expressed as to the existence of the so-called canals in Mars and other surface markings of that planet in consequence of the discrepancy seen in the drawings of the more delicate features by various observers. While in the main a certain general resemblance is seen in the topographical character of the network of lines, and a more close resemblance in the darker markings, notably the Syrtis Major, the disagreement in the minor details has led certain astronomers to deny their existence altogether, or to insist that most of the markings were subjective, or due to poor focusing, or the result of aberration of the eye or lens. Professor Simon Newcomb, in his "New Astronomy for Everybody," in speaking of the work of the observers at the Lick Observatory and the great telescope at their command coupled with favorable situation, says: "It is therefore noteworthy that the markings on the face of Mars as presented by Barnard do not quite correspond to the channels of Schiaparelli and Lowell." Newcomb also reproduces in his book the drawings of a region in Mars known as Solis Lacus, made by Campbell and Hussey, and finds they do not show an exact agreement between them. Now such objections might have some weight if drawings made by different observers of the Solar Corona, for example, or the Nebula of Orion, or the Milky Way had any close resemblance. As a matter of fact, these various drawings depart far more widely from the originals, as shown by photographic reproduction, than do the various drawings of Mars. Mr. Fison, in his "Recent Advances in Astronomy," in speaking of the divergence in the drawings made by different observers, says: "In inspecting sketches of the delicate details of the Corona of the Sun made at the same place by different observers, it is difficult to believe that the same object has been represented." To appreciate how widely divergent such drawings are one has only to refer to the United States Naval Observatory publication on the Total Eclipse of the Sun, July 29, 1878.

PLATE II



DRAWINGS OF THE SOLAR CORONA BY VARIOUS OBSERVERS

As an indication of the dissimilarity of the drawings of the Corona made at the same instant by different observers, many of whom are well-known astronomers, I may say that the various plates resemble in turn the following objects: a skate's egg-case; a circular battery discharging fire from one side while the smoke drifts away in the opposite direction; an ascidian, known as Molgula, with an extra aperture, however; a snowshoe; a radiolarian; a fighting shield of an Igorrote savage; an egg of a hair worm; a crushed spider, and other equally dissimilar objects. I have reproduced a few of these drawings (Plate II), that the reader may realize that my similes are not exaggerated. The many drawings which have been made of the Nebula of Orion, by astronomers of distinction, depart quite as widely from each other as do those of the Solar Corona. In Volume XXV of the "Naval Observatory Observations" is published a monograph of the central parts of the Nebula of Orion, by Professor E. S. Holden. He starts with a drawing made by Huyghens in 1659 and ends with a drawing made by Professor Langley in 1879. In a summary of the work the author says: "I am acquainted with but one drawing of the Nebula which is entirely above criticism, that of the late G. P. Bond. He was a skilled artist," etc. An examination of the

drawings in this Memoir are equally distracting. In looking at them casually they suggest respectively a Japanese stocking pattern; an amoeba; an embryo cuttlefish; a plan of Boston, and other forms equally divergent. Mr. Fison, in his book above quoted, writes as follows of other astronomical subjects: "Drawings of the Milky Way as seen by the naked eye have been recently executed by two independent observers, Mr. Boeddicker and Mr. Eaton, each drawing the result of long and arduous observation, but in comparing them it is the exception rather than the rule to find any approximation in agreement in respect of the more delicate details." The drawings of the surface features of Mars by different observers do vary in respect of the more delicate details, but in every case they represent a map of some kind and do not remind one of a wheelbarrow, baptismal font, or other incongruous objects. These divergent drawings of the same object are not confined to celestial bodies. One has only to examine works on ancient Mexican and Egyptian monuments, or those of classical archæology, to see the astounding caricatures and perversions. The various drawings of the famous Dighton Rock inscription, covering a period of two hundred years, are striking examples of the vagaries of an artist. Moreover, the text accompanying the drawings often states that they were drawn with scrupulous care. The hieroglyphics are pecked out on the face of a rock in rough lines, half an inch wide and a third of an inch in depth. These marks are in enduring rock; it is the observer and his imperfect drawing which is at fault. The Nebula of Orion, the Milky Way, and, for the time being, the Solar Corona are permanent objective realities and have all been photographed, yet behold the drawings! It is unnecessary to state that the ability to draw varies quite as much with man as the ability to sing. A man may be an excellent observer and yet utterly unable to use a pencil, and any attempt on the part of one to draw who has no ability in that direction results in a fiasco. It is noteworthy that an artist with no knowledge of astronomy, or the art of telescopic observation, will make a more accurate drawing than one made by the best astronomer who has no ability as a draughtsman. Concerning the drawings of Mars, if one will turn to the "Annals of the Lowell Observatory," Volume I, Plate XIV, he will there see drawings made on successive nights by Mr. Lowell and his assistants, Mr. Douglass and Mr. Drew, showing a remarkable agreement. After finishing my observations of Mars, which covered nearly a complete presentation of the planet, I made a comparison between my drawings and those made by Professor Lowell and his secretary, Miss Leonard, and a few made by the assistant astronomers, Mr. Lampland and Mr. Slipher, and the agreement was almost absolute, the only difference being that their drawings portrayed additional features which in some cases I had caught a glimpse of but could not fix. I found it exceedingly difficult to draw in the correct positions details within a circle, and particularly when the axis of that circle was inclined some degrees from the vertical, indicated by a spider's thread in the ocular.

I think any reasonable man will admit that the divergence seen in the various drawings of Mars by different observers cannot be held as an argument against their existence.

IX

THEORIES REGARDING THE CANALS

In knowledge, that man only is to be condemned and despised who is not in a state of transition.

FARADAY.

Having shown to the satisfaction of any reasonable mind that the delicate lines, known as canals, do exist, it will be interesting to examine some of the theories which have been advanced to explain these markings, as well as some of the absurd deductions drawn from their existence. The late Dr. J. Joly, Professor of Geology in the University of Dublin, in a paper on the Origin of the Canals of Mars ("Trans." Royal Soc., Dublin) came to the conclusion that meteoric bodies, revolving on or near the surface of Mars, produced these lines. In brief, he supposed that Mars at various times in the early stages of his history, when his rotation period was much shorter, attracted small bodies, which, after whirling about the planet, finally came down on the crust and caused these lines. He conceived of satellites twice the diameter of Phobos, or say, seventy-two miles in diameter, flying about Mars at a distance of sixty-three miles, which would at this distance, by its attractive force, exert a stress on the supposed thin crust of Mars of from fifteen to thirty tons per square foot, and thus rend the surface of the planet in a zone two hundred and twenty miles wide, thus forming two parallel ridges which might be visible to us as double canals. This preposterous idea takes no account of the greater attractive force of the Earth, and that it too should have had precisely the same experience, more often repeated. No trace of such behaviors, however, has ever been detected. The Moon, too, should have caught some of these heavy bodies, but while conspicuous cracks are seen on her surface, and delicate ridges are seen radiating from the larger volcanoes, not a trace of these great meteoric furrows has ever been observed. It takes no account of the chances—one in a million—that these cavorting meteors should meet at common centres, and if they did, the impossibility that they should stop abruptly and then start off in opposite directions. It takes no account of many of the lines following the arc of a great circle, or what finally became of three or four hundred of these meteors to tally with the number of the canals, unless it is supposed that some of them went whirling around the planet three or four times, changing their courses instantly and repeatedly. Indeed, the advancement of such absurd ideas shows the desperate despair of a man who tries to escape the admission that the lines in question may be artificial—and hence the result of intelligence working to a definite end—by a conception as crazy as one might possibly get in a disordered dream. To heighten the absurdity of this theory, if that were possible, Mr. J. L. E. Dryer, who signs a notice of this paper, while calling attention to the fact that this hypothesis takes no account of the correlation of changes in the canals with seasonal changes on the planet, otherwise soberly says: "It must be conceded that there is nothing in the new hypothesis contrary to observed facts."

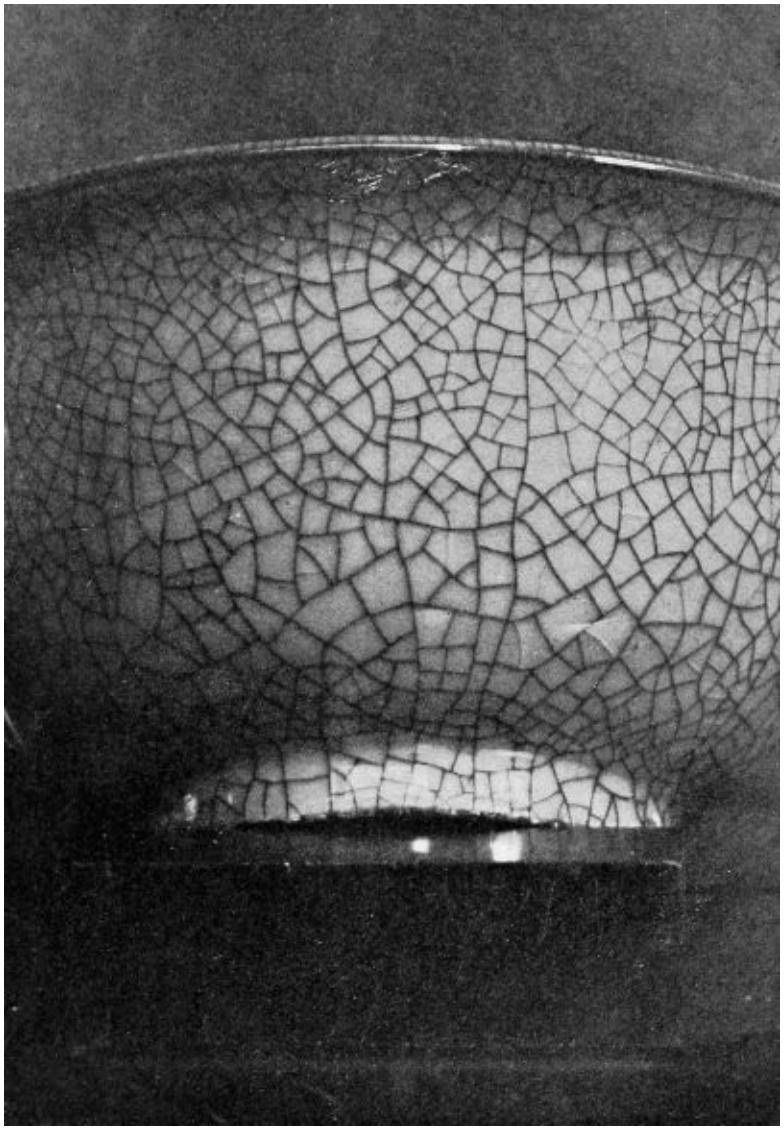
Mr. J. Orr, in the pages of the "British Astronomical Journal," assuming that Schiaparelli believed that the canals were excavated (despite the fact that Schiaparelli called them *canali*, or channels), and compared them to the English Channel and the Channel of Mozambique—for at the outset he had no doubt of their being natural configurations—proceeds to show the impossibility of an idea that was never

entertained. His attempt is as childish and ridiculous as the theory he conjures up. Mr. Orr, taking it for granted that the only explanation offered for these lines is that they are excavated, concludes that a Martian canal, like Tartarus, "should be seventy feet in depth (one might ask, why not five hundred or five thousand?) and that the canals of Mars would contain 1,634,000 of our Suez Canals, and would require an army of two hundred million men, working for one thousand of our years, for their construction," and similar idiocies regarding the population of Mars, which he concludes "must be 409,000,000, thus showing that all the adult males, and a large number of women, must have been engaged in the great work." In connection with this absurd travesty, let us pause for a moment to consider the extraordinary character of the president of this society before which this paper was read. A man who is the senior assistant of the Royal Observatory at Greenwich, instead of rebuking this balderdash as entirely beside the question, stated as the result of an experiment with a lot of charity-school children, that the canals are merely illusions of the brain, and this in the face of the testimony of a number of astronomers, many of whom are highly distinguished, that the markings do exist. This man seriously commented on the paper by saying: "He hoped that Mr. Orr's statistical, but nevertheless amusing and instructive, paper might prove one more nail in the coffin of a very absurd idea which had certainly got most undue currency, namely, that the canals of Mars could possibly be the work of human agents." Equally astounding, too, is it that this nonsense the "Astronomical Journal of the Pacific" republishes without a word of comment. But what could we expect of the mentality of the senior assistant of the Royal Observatory at Greenwich, who, with the great vault of heaven crowded with enigmas awaiting an answer, should waste a particle of gray matter in trying to ascertain precisely where Joshua stood when he commanded the Sun to stand still so that he could have a little more time for his bloody work. Even the day of the month is ascertained; he finds that the date of this murderous affair was about July 22, and that the Sun must have risen exactly at 5 A. M. and set at 7 P. M. The Moon, he concludes, must have been about its third quarter and was within half an hour of setting. He could not fix the year, however! Fancy all this detail without a word of exegetical criticism, or comment on the precise words of Joshua. "And he said in the sight of Israel, Sun, stand thou still upon Gibeon; and thou, Moon, in the valley of Ajalon. And the Sun stood still, and the Moon stayed, until the people had avenged themselves upon their enemies." Not even a pious query as to why the Lord did not shower down a few more meteorites, rather than disarrange the whole solar system. Such an attitude of the mind renders one incapable of appreciating anything in astronomic research beyond that which can be measured and photographed. The above is a fair illustration of the intolerable attitude of many of those who deny the existence of the canals, or, if admitting them as existent, resort to every expedient to disprove their artificial character.

Among the interesting suggestions as to the cause of the lines on Mars is that proposed by Professor W. H. Pickering, who, while admitting that they represent bands of vegetation, believes that they have their counterpart on the Moon, and that both are produced by volcanic forces, the cracking of the surface being the result of internal strain and stress. The fissures thus produced permit the escape of water vapor and carbon dioxide, and thus the natural irrigation of these cracks is effected and growth of vegetation follows. This opinion should have great weight, as Professor Pickering has made a profound study of lunar details, and is one of the foremost authorities on the subject. He has also drawn many of the surface features of Mars, and was at one time connected with the Lowell Observatory. He it was who suggested irrigation to account for the great apparent width of the Martian lines. In the "Annals of the Harvard College Observatory," Vol. LIII, No. 14, Professor Pickering presents a study of a crater on the Moon's surface, known as Eratosthenes, accompanied by drawings and photographs of an area within the crater revealing a few irregular cracks which he thinks correspond to the well-known canals of Mars; indeed, he calls these lines canals though he believes them to be cracks. A few spots, probably craterlets, he compares to the oases of Lowell. That there is no atmosphere on the Moon is admitted by all. Professor

Pickering's keen eye has, however, detected a change in the appearance of these cracks which he attributes to vegetation, animated in its growth by water vapor and carbonic acid gas, as before remarked. In this supposition he may be right, though it seems difficult to believe that so deliquescent an organism as a plant could withstand a variation of temperature from two to three hundred degrees below zero, to one above that of boiling water. One might naturally ask why the greater cracks so conspicuous on the Moon's surface, typical examples of which are found in the Mare Serenitis, Mare Triangulatis, and surroundings, do not emit aqueous vapor and carbon dioxide, and thus show similar features of widening and change of shade. Admitting the correctness of Pickering's views, it seems impossible to see any resemblance between this diminutive agglomeration of lines within a lunar crater, and the great geodetic lines sweeping for hundreds of miles across the face of Mars.

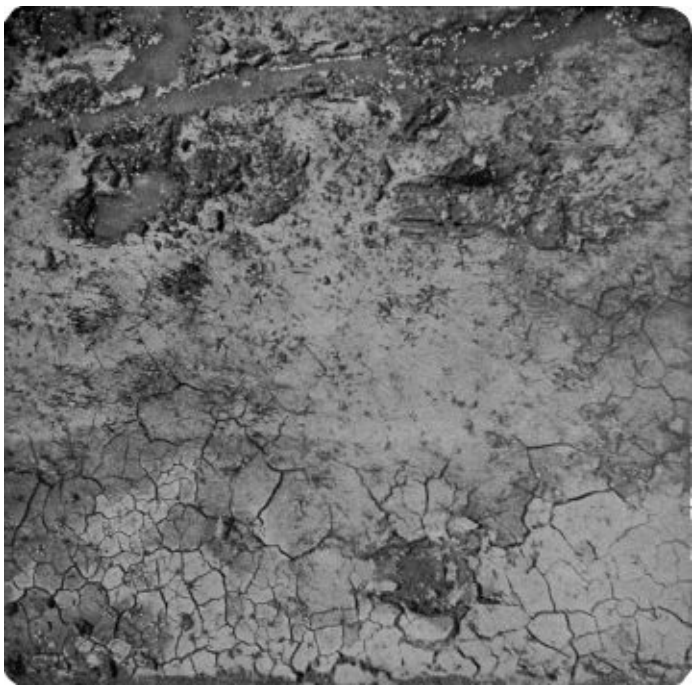
PLATE III



CHINESE BOWL, SHOWING CRACKLE

In the lunar crater, known as Flammarion's Circle, a most typical branching crack is seen. An examination of these lunar cracks, of which I made drawings through the great telescope at the Lowell Observatory, showed them to be cracks of the most unmistakable character, paralleled on the Earth's surface, by sunbaked fissures. If volcanic forces have caused these cracks in the Moon the same kind of energy should have produced the same general results in Mars, and circular craters should equally be in evidence, for many of the lunar craters are sufficiently large to be detected were they on Mars. They would certainly be indicated on the terminator, and yet not a trace of such markings has been found. It is rather extraordinary, too, that such earthquake fissures on any great scale should not have been filled with trap, silicate, or other injected material. Indeed it is strange that such a triangulating arrangement of cracks has not been found on the Earth's surface.

PLATE IV

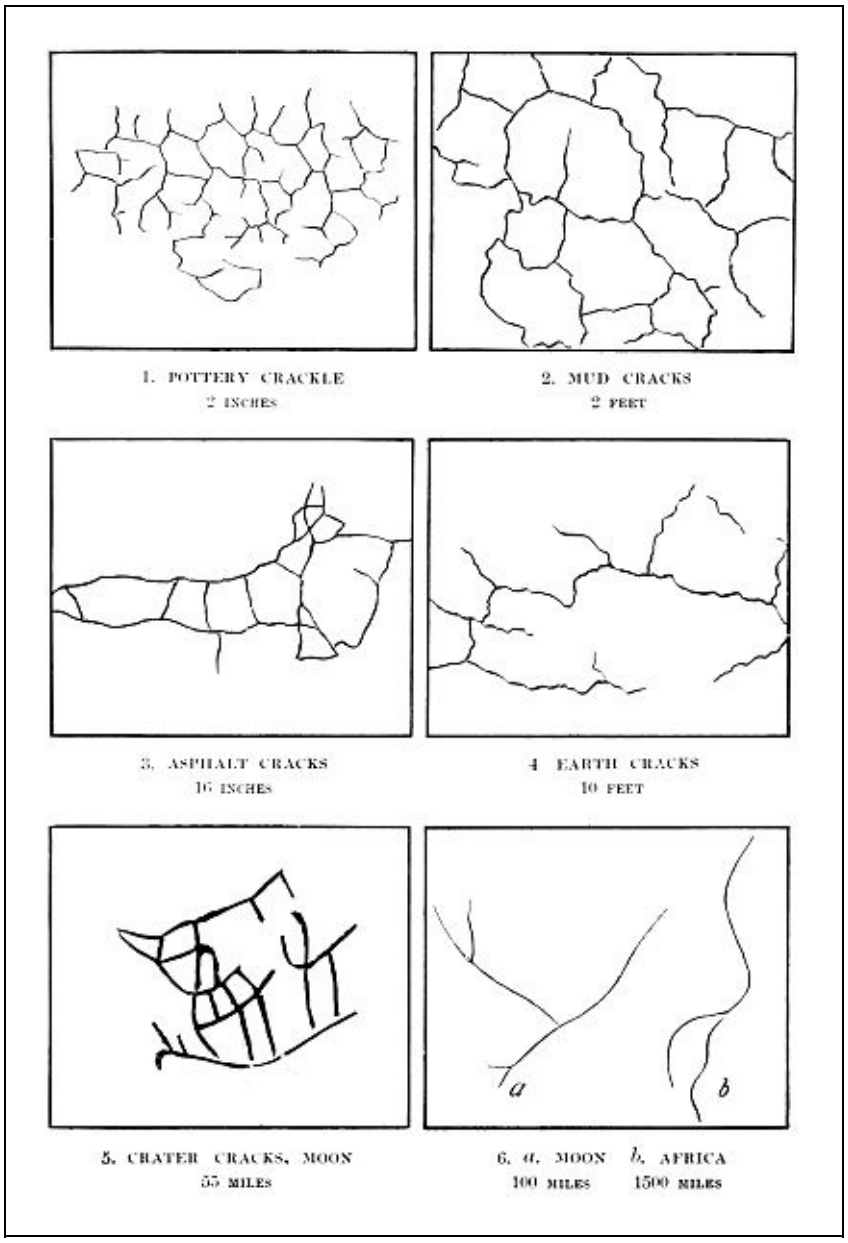


MUD CRACKS ON SHORE OF ROGER'S LAKE, ARIZONA

In order to pronounce the lines on Mars as simply cracks one should study the various kinds of cracks in similar surfaces on the Earth. In such a study he would be amazed at the similarity of cracks. When there is a grain in the substance, as in wood, the cracks follow the grain, though even in this material they are discontinuous. In amorphous material they have essentially the same character; whether in the almost microscopic crackle of old Satsuma pottery, or huge cracks in sun-dried mud, the areas enclosed are generally polygonal. If the material be of impalpable fineness the edges of the cracks are smooth and clean-cut, as in Plate III, from a Chinese bowl; whereas if the material is coarse and pebbly the edges of the cracks are rough and irregular, as in Plate IV, from the muddy shores of a lake. Cracks arising from contraction never converge to a common centre, and when not connected with another crack they taper to a point. They begin at indefinite places and end in an equally indefinite manner. That there should be a common resemblance in cracks due to contraction is evident as they arise from a shrinking of the surface. The most ancient deposits, millions of ages ago, reveal mud cracks differing in no respect from those found to-day. We subjoin a few forms of cracks from various surfaces, to show their essential resemblance. It will be seen that the cracks in the Moon are identical in character to those found on the Mesa at Flagstaff. They start from some indefinite point, are irregular in outline and end as indefinitely. A poor asphalt pavement offers one of the best opportunities for the study of the formation of various kinds of cracks and fissures. On the edge of a sloping sidewalk one may see the cracks due to a sliding, or lateral displacement of the surface; the effects of subsidence show a number of cracks around the area of depression; the growth of a tree crowding the asphalt shows the effect of lateral thrust, and an enlargement of a root below, or the effects of frost show cracks due to elevation. All these various cracks reveal the same features: they are discontinuous, they begin and end without definition. Schiaparelli says in regard to the *canali* of Mars: "None of them have yet been seen cut off in the middle of the continent, remaining without beginning or without end." These lines on the surface of Mars, as a writer in "Nature" says, are almost without exception geodetically straight, supernaturally so, and this in spite of their leading in every possible direction. It is inconceivable that cracks should be laid out with such geodetic precision. We

have seen that cracks have no definite beginning or termination; we have seen that the lines of Mars begin and end at definite places. Cracks are irregular, vary in width and differ entirely from the straight lines depicted by Schiaparelli, Lowell, and others. But if we admit them to be natural cracks in the crust we are compelled to admit that the forces implicated in such cracks must have been active many millions of years ago, as Mars, being a much older planet than the Earth, must have long since ceased to show those activities which the Earth, even to-day, exhibits in such phenomena as earthquakes, subsidences, elevations, and the like. Now cracks made at that early time in the history of the planet must have long since become filled with detritus and obliterated in other ways, and no evidence would show, even on close inspection, of their former existence, much less at a distance of 50,000,000 of miles, more or less.

PLATE V



1. POTTERY CRACKLE
   2 INCHES

2. MUD CRACKS
   2 FEET

3. ASPHALT CRACKS
   16 INCHES

4. EARTH CRACKS
   10 FEET

5. CRATER CRACKS, MOON
   55 MILES

6. *a*. MOON *b*. AFRICA
   100 MILES 1500 MILES

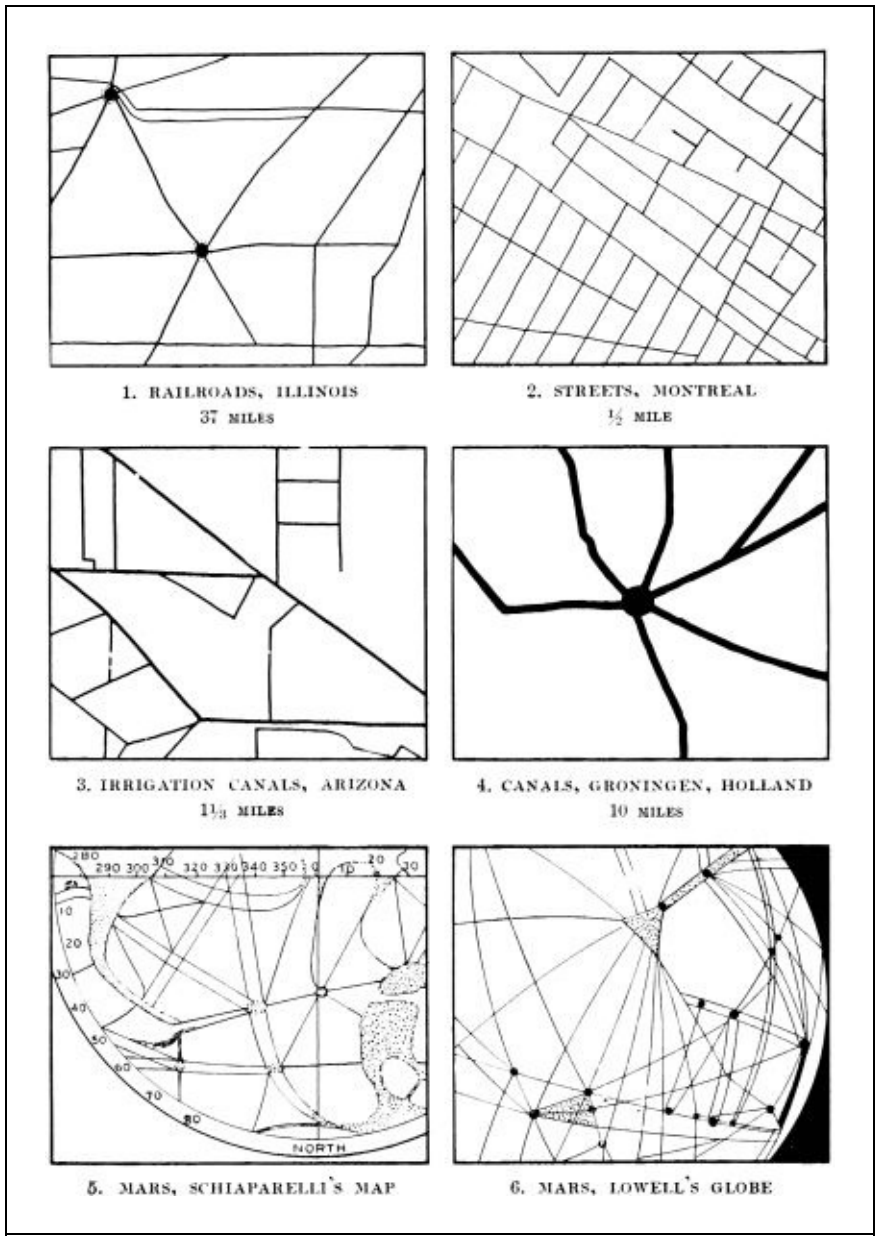
NATURAL LINES

CRACKS, FISSURES, ETC.

In Plate V, page 112, are given six figures representing various cracks and fissures. No. 1 represents the cracks in the glaze of Japanese pottery, magnified. No. 2 shows the mud cracks on the edge of a lake, to the extent of two feet. No. 3 is a series of cracks in an asphalt pavement, covering about two feet. No. 4 shows the form of cracks in the surface of a mesa in Arizona, the result of the summer heat, the length being about ten feet. No. 5 is a tracing from a drawing by Professor W. H. Pickering showing cracks in the

lunar crater Eratosthenes, with an extent of fifty-five miles. The original drawing represented a much greater widening of the lines which Professor Pickering believes to be due to vegetation. I endeavored to trace the centre of each line and Professor Pickering said in regard to my tracing: "In one or two instances you have assumed that a crack went through the middle of a broad space, whereas, for aught we know, it may have gone along either edge, but otherwise the tracing obviously follows the outlines of my drawing." It evidently gives a *cachet* of what appears to be veritable cracks on the surface, and it is interesting to compare this drawing with the cracks in the asphalt. In No. 6 are two drawings; one marked A represents cracks in a region of the Moon known as Flammarion's Circle, the other B represents the great rift in southern Africa, probably the most stupendous phenomenon in geological history. This rift has been traced from the Valley of the Jordan through the Dead Sea, into the Gulf of Akaba, thence into the Red Sea, which it follows the entire length, then turning southwesterly into Africa and branching, one branch takes in Lake Tanganyika, and the other branch Lake Nyassa. A portion north of Nyassa is still problematical. Here is a crack 1,500 miles long, most of it filled with detritus, water, or forest. It would be an interesting question whether such a fracture would be visible even from the Moon. A glance at these various figures will give one a conception of the similarity of cracks, their irregular contour, their indeterminate origin, and ending. Cracks arising from shrinkage vary only in the material in which the crack takes place; the conditions resulting from shrinkage or pulling apart are precisely the same.

PLATE VI



1. RAILROADS, ILLINOIS
   37 MILES

2. STREETS, MONTREAL
   ½ MILE

3. IRRIGATION CANALS,
   ARIZONA
   1-1/3 MILES

4. CANALS, GRONINGEN,
   HOLLAND
   10 MILES

5. MARS, SCHIAPARELLI'S MAP

6. MARS, LOWELL'S GLOBE

ARTIFICIAL LINES

RAILWAYS, STREETS, CANALS, ETC.

Let us now glance at a series of figures on Plate VI, page 113; their artificial character may be recognized at once. They are all designed for channels or thoroughfares for the transportation of men, merchandise, or water. No. 1 represents a tracing from a railroad map of a county in Illinois. The convergence of lines to common centres, and, in one case, parallel lines may be seen. The length of the region represented is thirty-seven miles. No. 2 is a tracing of streets in a district of Montreal, covering an

extent of half a mile. No. 3 is a tracing of a small region near Phœnix, Arizona, showing irrigating canals. The larger ones follow contour lines of the surface; the smaller ones are usually laid out in rectangular form to correspond with the original land sections and sub-sections, the boundary lines of which run north and south, east and west. No. 4 represents the canals converging on Groningen, Holland. No. 5 is a tracing from a hemispherical map of Mars made by Schiaparelli, and No 6 is traced from a photograph of a globe on which Lowell has carefully drawn the canals, oases, etc., of Mars covering a land extent of 7,400 miles. The remarkable artificiality of all these figures must be admitted. The lines on the first four figures are laid out by an intelligence for similar purposes. No. 1 for the conveyance of passengers and freight; No. 2 for the traffic of a city; No. 3 for the conveyance of water; No. 4 for purposes of navigation, and Nos. 5 and 6, according to Lowell's view, for the conveyance of water from melting polar snow caps for irrigation purposes. A simple, rational explanation, as their great width and geodetic precision forbid any other.

Let one contemplate these lines of Mars and compare them with the natural cracks on Plate V and he will appreciate the emphatic words of Lowell when he says: "The mere aspect is enough to cause all theories about glaciation, fissures, or surface cracks to die an instant and natural death." Consider any other possible tracing of lines on the face of the Earth as the result of Nature's forces, such as river beds, cañons, chasms, fissures, faults, rifts, precipitous valleys, fiords, the results of sharp folds in the strata, parallel chains of mountains, and none of these lines would be straight, none of them would be of uniform width, and few of them would have the enormous breadth of the Martian lines, they would begin nowhere and, with the exception of the rivers, end nowhere. This definition holds good as the result of natural forces from the microscopic crackle on a dinner plate, to a crack in the Earth's crust fifteen hundred miles long.

Having briefly alluded to some of the theories advanced to explain the geodetic network of lines encircling Mars—theories in one case so puerile, and in another case an interpretation so monstrous, though endorsed by astronomers of standing—we turn to the suggestion that these various lines are artificial, that they were designed for a definite purpose, namely, to conduct water from those regions alone where water is found for the purposes of irrigation. We shall call attention to a parallel case where the great ice caps and glaciers of the Himalaya Mountains supply water, by their melting, for thousands of miles of irrigating canals. Let us ask ourselves whether if the snows of the Himalayas gradually failed, the crowded millions of India would not if necessary reach out to the farthest North for this precious fluid? Our great centres of population at the present time are reaching out in every direction for water supply. How long would it take New York City to decide in case of water famine to tap the Great Lakes to the north, or to establish pipe lines to the north pole, if it were necessary to go that distance for water?

From the foregoing it is seen that the question of water supply has engaged the energies of man from pre-historic times. These great irrigating works are found, however, in regions of sterility, or light rainfall, from the rude irrigating canals of ancient Peru and Arizona to the marvellous accomplishments of the hydraulic engineer in India and Egypt. This demand for more water is not, however, confined to regions of sterility, the reaching out of cities for supplies of water for potable purposes and for the wasteful disposal of sewage was inevitable. What shall we say, however, of the notes of warning in regions of rain?

England is considered a land of humidity and copious rains, and yet the alarm is already sounded that in the no distant future an appalling catastrophe may threaten her in the failure of her water supply. In a special despatch to the "New York Herald," Mr. Bently, president of the Royal Meteorological Society, is quoted as saying at its Annual Meeting, "So enormous now is the drain upon the country's available supplies, so much have the growth of cities, the disappearance of forested areas, the extent of street

surface impervious to moisture, and the diversion of the rivers, lakes, and other natural fresh water reservoirs from their natural function of irrigators and distributors of the all essential moisture to the land interfered in England with nature's arrangements, that English engineers and meteorologists at no distant date may find a task of almost insuperable difficulty awaiting their endeavors."

Dr. Mill, a rainfall expert, on being consulted by a "Daily Mail" correspondent regarding this alarming statement, was of the opinion that the question would require early consideration. We quote his words as follows: "Legislation is needed in the immediate future for the regulation of the rivers. The great question is how to store the water which at present runs to waste on the coasts."

"The planting of trees on the high water-sheds is one of the first solutions of the problem. The chief difficulty lies in the scarcity of suitable land available for building large reservoirs, and at some future date the services of engineers will be required to reform the present arrangement of reservoirs."

"In Austria the government issues an annual report on the condition of the Danube and detailed statistics of the rainfall, with a view to storing all the available water supplies. The work done by the Austrian government I am doing in regard to the British Isles on my own responsibility, but the rainfall and the river conditions are only a portion of a much larger problem."

The above quotations indicate that even now an alarm is felt in countries of fair rainfall regarding the possible failure of the water supply in the near future and is perhaps a premonition as to what may be absorbing our energies in centuries to come. Such possibilities as here suggested may offer an additional clew to an interpretation of the Martian markings.

The unnatural straightness of these interlacing lines on Mars, many of them following the arcs of great circles, their uniform width throughout, their always starting from definite areas, their convergence to common centres, and their varying visibility synchronizing with the Martian seasons finds no parallel in natural phenomena.

If in the mind's eye we were to survey the Earth from Mars the only feature we should find at all paralleling the lines in Mars would be found in the level regions of the West, where, for thousands of miles, the land extends in vast level stretches. In these regions would be found lines of railroads running in straight courses, starting from definite places, converging to common centres, their sides, in certain seasons, conspicuous with ripening grain fields, or again the work of the United States Reclamation Bureau running its irrigating canals in various directions through that great region. Both these kinds of lines would be artificial and both designed for purposes of conveyance—in the one case, merchandise and passengers, in the other case, water.

If the Martian lines are not artificial some other theories must be offered than those thus far advanced to explain their origin and purpose.

The phenomenon of the extraordinary doubling of the canals when first announced was immediately disbelieved; when, however, other observers confirmed Schiaparelli's discoveries, and it became evident that these double lines had a veritable existence, the phenomenon was regarded as an evidence that profound physical changes were going on in the planet. Thus in 1887 Mr. Stanislaus Maunier, in "La Nature,"[6] in alluding to the remarkable discovery of the doubling of the canals, says: "Mars at this moment is the theatre of phenomena of stupendous grandeur which will be adequate in a few years to impress profound changes in its aspect." This was written in 1887, and continuous observations of the planet since that time have shown no profound changes, or changes of any kind beyond those which periodically occur with the seasons. Since Mars is a much older planet than the Earth, it seems reasonable to believe that it is more stable, that volcanoes and earthquakes have long ceased to manifest their activities, that erosive

action by water is no longer in evidence, subsidence and elevation of continental areas no longer occur. From this condition of the planet it is impossible to believe that the curious phenomenon of the doubling or gemination of the canals can be due to any physical changes now taking place.

Schiaparelli said that many of the ingenious suppositions advanced to account for this doubling of the canals would not have been proposed had their authors been able to examine the gemination with their own eyes; he further says: "It is far easier to explain the gemination if we are willing to introduce the forces pertaining to organic nature; here the field of plausible supposition is immense," and in this field of suppositions he suggests "changes of vegetation over vast areas." Let any intelligent mind soberly consider this rational suggestion of Schiaparelli's and compare it with other theories that have been advanced, and he will be compelled to admit that vegetation alone gives us at least a clew to the extraordinary behavior of these parallel lines. To understand the symmetry, the suddenness, and the vast extent of this phenomenon, the further explanation of vegetation superinduced by artificial methods will alone complete the answer.

Sir Robert Ball cannot conceive how Mars, a much older planet, should develop synchronously with the Earth creatures of intelligence, an event which he insists should have occurred ages earlier in its history. In this supposition he is quite right, for if there are creatures of intelligence in Mars these should have appeared much earlier, and that is probably what has happened. The problem is one parallel to that urged by Sir Boyd Dawkins in regard to the evidences of man in the Tertiary rocks. Dawkins argued that since the mammals in the Tertiary had changed so profoundly, many types becoming extinct, if man had lived at that time he also should have been affected by the same influences, and should have changed accordingly. It has been clearly pointed out by Cope and others that the moment intelligence became a factor in natural selection it was seized upon to the relative exclusion of physical characteristics, hence but little change, otherwise than an intellectual one, has taken place in man since his progenitors took to the trees and made up by agility, cunning, and alertness what they lacked in physical strength. In the same way, if, in the past history of Mars, an intelligent creature appeared he must have survived under precisely similar conditions, and long after favorable environments had passed that were implicated in making him what he was.

Admitting that there is an intelligent creature of some kind in Mars, is it reasonably conceivable that he should have caused such changes in the surface features of that planet as to be visible from the Earth? Professor Newcomb concludes, in a recent article in "Harper's Magazine," that "we cannot expect to see any signs of the works of inhabitants in Mars, if such exist." Let us, however, reverse the proposition and ask ourselves if man has been implicated in any changes in the surface appearance of the Earth that would be visible from Mars? And I think the question can be answered in only one way. The vast cities such as Pekin, Tokio, London, and New York, with their great expanse of tiled and slated roofs, and sterile streets, would certainly have a different albedo from the grass and trees in the immediate outskirts of such places. The tracts of land reclaimed from the sea, and still more the enormous areas which have been rendered green by irrigation, must, of all contrasts, be markedly conspicuous. To realize the extent of this work, it is only necessary to state that in Egypt 6,000,000 acres depend upon irrigation, and this area to be vastly increased in a short time; the Western states of America with 10,000,000 acres, and this area being rapidly augmented by the work of the United States Reclamation Bureau; in India 25,000,000 acres under irrigation, and this being continually added to; above all, however, the vast extent of territory from which the dark forests have been removed in this country, and more particularly in China, must make a visible landmark. If one can recall the appearance of forests in the southern and middle part of Maine, say from Bethel or Bangor, fifty years ago, he will remember that from the top of any hill a stretch of dark blue forest was to be seen as far as the eye could reach, and now from the same elevations one can see only an occasional clump of blue forest, while the remaining surface is, according to the season, either bright

green, yellow with ripening vegetation, or white with snow, out of which the dark clumps of forest growth are most conspicuous. Considering the contrasting colors in one year covering hundreds of thousands of square miles in various portions of the country, the question naturally arises which of these contrasts would be most conspicuous,—the colors just mentioned of solid land surfaces of vegetation, snow, and desert, or diaphanous clouds with their gray shadows. We are told that Jupiter, with the mean distance at opposition of nearly 400,000,000 miles, shows its clouds, its red spot, and the shadow transits of its satellites. Surely if these conditions are seen from the Earth, the changes in the Earth's appearance above described might be seen from Mars, which at its nearest opposition is only 35,000,000 miles away, and, conversely, any change of similar character in Mars would certainly be visible from the Earth.

X

COMMENTS AND CRITICISM

Nothing is more difficult and requires more caution than philosophical deduction, nor is there anything more adverse to its accuracy than fixity of opinion.

FARADAY.

It will be of interest to examine the writings of certain astronomers, and writers on astronomy, to appreciate the unreasonable conservatism, not to say narrow-mindedness, which color their opinions. It ill becomes students of science to ridicule the honest and persistent labors of such men as Schiaparelli, Lowell, Perrotin, and others, unless they can show an equal devotion to the work. They do not recall the deluge of essays, reviews, and sober treatises which followed Darwin's great work, viewing the evidences of Darwin not thoughtfully, nor based upon any knowledge of the subject, but with contempt, and, in many instances, with vituperation. So rapid, however, was the recognition of Darwin's interpretation of Nature's facts that most of these writers lived long enough to see their protests entirely discredited, or to become enthusiastic advocates of the theory.

In their own domain of astronomy these writers are equally forgetful of the earnest and even bitter controversies regarding the demonstration by Chandler of the oscillation of the poles, and consequent variation of latitude, and the final establishment of Chandler's views, in the teeth of opposition, by the greatest astronomers.

The character of this irrelevant and adverse criticism may be appreciated by subjoining a few examples. The most amazing of all these expressions is to be found in the report of the British Astronomical Association, for 1892. It seems that a committee had been appointed by the Association to report on the surface features of Mars. E. Walter Maunder was made Director of the Committee. Twenty-six observers, of whom twenty-one were inhabitants of Great Britain, sent in the result of their work accompanied by drawings. A summary of this work was published in the form of memoranda accompanied by a Mercator projection map of Mars, individual planisphere drawings, as well as colored plates; these together represented twenty-eight single canals, five double canals, nine oases, as well as the dark regions so long familiar to astronomers. This was a somewhat remarkable contribution considering the complaints from the different observers in regard to the weather, and the prejudiced, and negligent part played by the man at the helm. That I am not unjust in these statements may be understood by quoting from the report showing the conditions under which the English observers labored, the delinquent part which Mr. Maunder, the Director, played in the matter, and the conclusions which Mr. Maunder arrived at after this unsatisfactory performance. He says: "The opposition of 1892 proved on the whole a very disappointing one. Although Mars at opposition was almost at its nearest approach to the Earth, it was far from being well placed for observation by European astronomers owing to its great southerly declination, and consequent low altitude.[7] The weather during the autumn of 1892 was for the most part very unfavorable for observation of so difficult an object, and several members who joined the section at the

beginning were unable to contribute either drawings or report."

Now I beg the reader to carefully note the part the Director played in this important work. Here are his words; there is no need of italicizing them. "None of the few evenings which the Director was able to give to the examination of the planet was really suitable for the purpose, and as the pressure of other duties rendered it impossible for him to supply any detailed help to the members, the section was at a very serious disadvantage." He certainly is frank enough to state the disadvantages the section was under with such a man at the head. Realizing the conditions of seeing in the fog and soot-begrimed atmosphere of England, the low altitude of Mars, and the loss to the committee of the assistance which a Director might have given to the work had he been able to approach the subject in a broad and unprejudiced manner, one is naturally led to ask what this committee would have accomplished if each member in turn had had an opportunity of observing Mars at a high altitude with a twenty-four inch refractor of remarkable definition, at an elevation of 7,000 feet above the sea-level, in an atmosphere so clear and steady that stars of the third and fourth magnitude may be seen to set at the horizon line.

Mr. Maunder in speaking of the nomenclature used in his report says, "The term 'canal' has also been retained, though 'canals' in the sense of being artificial productions, the markings of Mars which bear that name, are certainly not. It is difficult, indeed, to understand how so preposterous an idea obtained currency for a moment even by the most ignorant." It is impossible to repress one's amazement at these expressions after the confessions he makes as to his official functions on the committee, and I appeal to any honest and unprejudiced mind if a more incompetent person of the class to which he belongs could have been found in England for the Directorship of such a body. In this connection we cannot refrain from giving a few paragraphs from a paper entitled "Can Organic Life Exist in the Planetary System?" by C. A. Stetefeldt. The author says: "We must, however, acknowledge that if other suns in the universe have planets—and there is no reason why they should not—many of them may present physical conditions identical with, or similar to, those existing on the Earth, and that therefore their organic life may be similar to our own. Further, I am far from denying that, under favorable circumstances, creatures may be evolved upon planets which revolve around other suns, whose mental capacity is as much superior to man's as that of the latter is to the lowest form of vertebrates." Having made these liberal admissions in regard to the universe at large he attempts to show that none of the planets outside the Earth could sustain life, and finally closes in this extraordinary manner: "In concluding this investigation we cannot help admiring the inductive acumen of the theologians who considered the Earth the most important of the planets, and the centre of creation. Although their opinions were not based upon scientific facts, they *arrived at the truth nevertheless*." (Italics ours.) Familiar as every one is with the attitude of theologians for the last several centuries concerning astronomical discovery I think it may be safely said that this is the first instance on record where they have been credited with an induction not based on observed facts worth quoting in an astronomical paper. And this contribution also appeared in the publications of the "Astronomical Society of the Pacific," Volume VI, No. 25, without a word of comment! How different was the behavior of the "Journal" when a report of Percival Lowell's lecture on Mars, written by Dr. Edward Everett Hale, was reproduced in its pages. The following comments were made by Edward S. Holden, then Director of the Lick Observatory: "Something is seen, no doubt, but I may add that nothing has been observed at the Lick Observatory during the years 1888–1895, so far as I know, which goes to confirm the very striking conclusions here described." It may be added that during the years 1888–1892 nothing was seen of the fifth moon of Jupiter. The discovery of this satellite with the Lick telescope was not due to any special efforts on the part of the Director.

The Rev. E. Ledger, "Nineteenth Century Magazine," Volume LIII, 1903, p. 773, in an article entitled "The Canals of Mars—Are they Real?" presents an excellent account of the successive observers of Mars, and the results of their work, and the objections of those who could not see the canals, or saw them

imperfectly. He recalls Maunder's childish experiments, and is greatly impressed by them. He then says: "Astronomers are no doubt very well acquainted with the laws of optics as applied to the eye. They have made, and may yet make, many experiments connected with their action. They are accustomed to allow for individual peculiarities in observation, as, for instance, when what is termed personal equation affects the rapidity with which different observers touch a key to record what they see. They may therefore skilfully judge of the effect produced in observations of Mars by such processes of the eye, or of the brain, or nervous system as I have referred to." He strongly thinks it would be well "if some skilful nerve specialist and oculist could work in conjunction with some of these practised observers who have seen the canals. They might both assist in observing, and at the same time carry out careful researches into the optical delusions which brain or eye may experience in connection with telescopic observation." This is certainly a happy thought of the reverend author, only it would seem in this case that a larger and more diversified corps of specialists, including alienists, is needed to attend to that class of astronomers who are suffering with mental strabismus. It might be advisable to call in the services of a bacteriologist to make cultures of new forms of microbes which may be involved in rendering a man incapable of estimating the value of evidence.

It is the exception rather than the rule in astronomical science that one finds such unfounded and prejudiced utterances as those above commented upon. The glamour of astrology still lingers, in the public eye in its respect and awe for the astronomer's work. Every eclipse seems in the nature of a prophecy. The public contributes liberally for the support of eclipse expeditions, observatories, and the like, and these contributions would be still more liberal if the public could realize the profound significance of the researches now being carried on by Director Pickering at Harvard, Director Campbell at Lick, Director Hale at the Solar Observatory, Mount Wilson, and many others. Their observations are received without question. The thoughtful man would only ask that like credence should be given to the work of every earnest student unless disproved, even though the field of investigation covers regions hitherto but little explored, and yet of the very greatest interest to the human race.

XI

ATMOSPHERE AND MOISTURE

If in any planet we could detect the traces of vegetable life it would at once be a strong argument for the existence of animals there and vice versa.

HENRY DRAPER.

Schiaparelli points out that "the polar snows of Mars prove in an incontrovertible manner that the planet, like the Earth, is surrounded by an atmosphere capable of transporting vapor from one place to another." Mr. E. E. Barnard, in the "Astrophysical Journal," Volume XVII, No. 4, in speaking of the polar caps, says: "There seems no definite proof that they are not as much ice and snow as that which we have to deal with in our own terrestrial winters. So much is at least suggested by the great seasonal changes they undergo from winter to summer. There seems to be a general belief now that Mars certainly has an atmosphere. This atmosphere seems to be very much less than our own, and yet it is of sufficient density to produce the phenomena of the polar caps by condensation and evaporation and also to produce, though rarely, some form of clouds."

Among those who have claimed to have established the existence of water vapor in Mars by the spectroscope are Rutherford, Secchi, Huggins, Janssen, and Vogel; and these declare the existence of a Martian atmosphere similar to our own in composition. Mr. Campbell can find no spectroscopic indication of an atmosphere charged with water vapor. Lewis E. Jewell says: "The spectroscopic proof of the presence of a fair amount of water in the atmosphere of Mars must be regarded as unattainable." Professor Lowell, despite the aid the admission of water vapor in Mars would give to his position, also doubts whether the spectroscope is able to detect the evidence through our own moisture-laden atmosphere.

After a minute and exhaustive study of the polar snow caps by the combined observations of Lowell, Douglass and W. H. Pickering, Mr. Lowell says: "It is interesting that the cap should so simply tell us of these three important things: the presence of air, the presence of water, and the presence of a temperature, not incomparable with that of the Earth."

Seasonal changes on Mars have long been recognized and admitted by astronomers, and these changes are on so vast a scale as to be distinctly visible from the earth. Without an atmosphere the surface of Mars would be inert. Schiaparelli was the first to notice that at successive oppositions the same regions showed different degrees of darkness and accounted for these variations by seasonal change. Mr. Denning believes that certain changes in the appearance of the markings to be due to vaporous condensations. Sir Norman Lockyer believed he saw the obscuration of a large region by clouds, this obscuration continuing for some hours. A bright spot on the terminator of Mars, discovered by Douglass at the Lowell Observatory, and which led to the newspaper excitement that signals were being made, was seen to move and finally disappear and its appearance, drift and disappearance is interpreted by Lowell as a cloud illuminated by the Sun and carried along by the wind. The presence of clouds, judging from my own brief experience, was certainly suggested at times by the peculiar way in which a large region known

as Syrtis Major disappeared and flashed out again. This behavior might be expected of the tenuous lines as a result of refraction and other disturbances in our own atmosphere; when, however, a large, dark region at one time stands out firm, clear and sharp-cut as the stroke of a Japanese brush, then gradually fades out and remains obscure for some time we are inclined to believe that Sir Norman Lockyer's interpretation is true and that in such a case drifting clouds or sudden vaporous condensation produced the obscuration.

From an article on Mars by Sir Robert Ball, republished in the "Annual Report of the Smithsonian Institution" for 1900, we quote the following: "The discussion we have just given will prepare us to believe that a planet with the size and mass of Mars may be expected to be encompassed with an atmosphere. Our telescopic observations completely bear this out. It is perfectly certain that there is a certain shell of gaseous material investing Mars. This is shown in various ways. We note the gradual obscuration of objects on the planet as they approach the edge of the disk, where they are necessarily viewed through a greatly increased thickness of Martian atmosphere. We also observe the clearness with which objects are exhibited at the centre of the disk of Mars, and though this may be in some measure due to the absence of distortion from the effects of foreshortening, it undoubtedly arises to some extent from the fact that objects in this position are viewed through a comparatively small thickness of the atmosphere enveloping the planet. Clouds are also sometimes seen apparently floating in the upper region of Mars. This, of course, is possible only on the supposition that there must be an atmosphere which formed the vehicle by which clouds were borne along. It is, however, quite obvious that the extent of the Martian atmosphere must be quite insignificant when compared with that by which our Earth is enveloped. It is a rare circumstance for any of the main topographical features, such as the outlines of its so-called continents, or the coasts of its so-called seas, to be obscured by clouds to an extent which is appreciable except by very refined observations."

Professor W. H. Pickering made seven photographs of Mars on April 9, and within twenty-four hours made seven additional photographs of the same region. The second series of photographs showed an area of white extending from the polar snow cap far down toward the equator, covering a surface which he estimated to be as large as the United States. It afterwards slowly disappeared. How shall we account for this sudden apparition of a vast area of white which the photographs of twenty-four hours before did not reveal. A boy of ten, as well as the philosopher would simply say a snow-storm had taken place in Mars. Is it, then, unreasonable to picture whirling snowflakes, snow-drifts, and dazzling whiteness from the Sun's rays, and in the rapid melting of the snow, broad rivers and turbulent brooks with water areas frozen at night? But why should we be compelled to imagine as naked the surface through which these waters find their way? Soil there must be from the continual erosion of running water. The character of the rock exposures we cannot guess at, but a picture of bare rock and lifeless ground is unthinkable. Such wide-spread storms without an atmosphere could not occur. The seasonal appearance of these snows and their slow disappearance not only indicates an atmosphere, but an atmosphere disturbed by established currents which convey the moisture-laden air to regions of congelation.

A number of observers who have detected clouds in Mars described them as being yellowish in color. What more probable than that these yellowish masses are simply dust-storms such as one may often see whirling along over our American deserts? When the gusts of wind are fitful like squalls at sea, the obscuration would be fitful, to clear up again. The vast areas of desert land in Mars renders this supposition very probable.

Since the above was written, my attention has been called to an early "Bulletin of the Lowell Observatory," in which Mr. Lowell, in discussing the appearance of a certain large projection on the terminator of Mars, says: "Finally, its color leads me to believe it not a cloud of water-vapor, but a cloud

of dust. Other phenomena of the planet bear out this supposition."

XII

NOTES ON IRRIGATION

Your theory of vegetation becomes more and more probable.
SCHIAPARELLI in a letter to Lowell.

Let one stand on some peak of the Verd Mountains, northeast from Phoenix, Arizona, overlooking the Gila River as it follows its course across the desert, and after the river is lost to view he will notice that the foliage along its banks marks its course. If one takes this view in winter time, the uniform gray of the plains, unbroken by a single shade of color blends with the light blue of the distant Plomas and Castle Dome Mountains on the southwest horizon. In the early spring when the water is first let into the irrigating channels with their innumerable divergent ditches, a shade of green may be seen emerging from the monotonous yellow-gray of the hot and sterile plain, first conspicuous near the source of the water supply, and then following along to Phoenix, Tempe, and other regions till in full efflorescence these cities stand out like great green carpets spread upon the Earth. From this mountain top not a trace of an irrigating ditch, large or small, would be discerned, except here and there a glint of reflected sunlight, but the effects of the life-giving waters can be traced in broad bands to the remotest limits of the water channels, when they would end as abruptly as they had begun.

If we examine railroad maps, the lines of which represent the road-beds utilized to convey passengers and freight to various places, we shall observe that in mountainous regions the lines run very irregularly, often paralleling mountain chains, or following rivers. On level areas such as Iowa, Texas, and other states, the railroads run for hundreds of miles in straight lines, at times converging towards large centres of population. Their occasional parallelism and radiation from centres, all present a certain *cachet* in angles of approach and alignment that reminds one strongly of similar features in the markings of Mars. If each railroad were bordered by a wide growth of trees with sterile desert between, these broad bands as seen from Mars would be identical with the appearance of similar lines in Mars as seen from the Earth. In Mars, however, there are no high elevations since the terminator of Mars stands out clear cut and not jagged as in the Moon. The planet being devoid of hill ranges, and large oceans, the canals can run in straight lines for hundreds of miles. If it were possible to conceive by analogy a creature on Mars furnished with a telescope, he would undoubtedly correlate the irrigating regions of Arizona as similar in nature to his own canals. The irregularity of the rivers running through such regions would puzzle him quite as much as we are puzzled by the absolute straightness of the Martian canals. He would, of course, observe that in our winter the irrigating areas became invisible, to appear again as our summer advanced. His own experience of vegetation arising from irrigation alone and starting from the north when the first water from the melting snow cap animated the growth of plant life, and proceeding slowly towards the equator would prevent him from understanding the reverse condition on our planet, with the shade of green being perennial at the equator and spreading slowly north with the advance of summer.

The marvels of irrigation are impossible to conceive of without first seeing a parched land before the water channels are dug and the exuberant vegetation springing with the water's advent. The illimitable

stretches of arid plain, no green, rarely an evidence of life, and then usually in hideous shapes like the hissing and purple-mouthed Gila monster; hot pale dust; blinding sunlight; ragged clumps of gray sagebrush, rebuking by their hopeless color and dishevelled appearance, the intolerable condition of their existence; angular cacti, surviving because of their vicious needles, and then literally a step only from this sterile waste, and one finds himself wading through rich, soft alfalfa, under the deep shade of cottonwood trees, glistening threads of water when the overhanging vegetation does not hide the channels, brilliant flowers, singing birds, fat cattle and vociferous children.

In this apparently irreclaimable desert of Arizona, have sprung up prosperous cities, great farms and fruit orchards. About Phoenix, more than one hundred and twenty-five thousand acres are under the richest and most profitable cultivation, and all due to a little narrow canal which conveys the water from Salado River, and distributes it by narrow ditches, so narrow, indeed, as to be invisible except on the nearest approach. There have already been constructed in the Gila Valley alone, two hundred and fifty miles of ditches, and four hundred miles of parallels. Mr. Ray Stannard Baker, in the "Century" for July, 1902, presents in a graphic way, the marvels of irrigation. Major J. W. Powell, during the later years of his life devoted his whole time and energy to urging the reclamation of desert lands in the West by irrigation. In his reports on the subject he estimated that a region equal in size to New England, New York, Pennsylvania, and West Virginia could be recovered from the desert sands of Arizona and other regions in the West. In India, millions of pounds have been spent for irrigating canals and ditches. A single canal with its tributaries drawing water from the Ganges measures 3,910 miles in length, bringing into cultivation one million acres of land at an expense of fifteen millions of dollars. The idea of irrigation is not due to the advanced intellect of man; it has been the result of dire necessity and is of great antiquity. Mr. Frank Hamilton Cushing discovered evidences of the most extensive irrigating canals among the ancient Pueblo Indians of Arizona.

Sir C. Scott Moncrief, in his address as president of the engineering section of the British Association for the Advancement of Science, describes the various forms of irrigation. The primitive method consists in raising water by human labor. Early Egyptian sculpture depicts laborers raising water by means of buckets, and along the banks of the Nile the same method may be seen to-day. Other methods of raising water are by pumps driven by windmills. In certain regions Artesian wells furnish water for irrigation. The importance of irrigation is best shown in the fact, that, while the rainfall in Cairo is, on an average, one and four tenths inches a year, yet in the immediate neighborhood land brings $750 per acre; this value being due to irrigation alone. In speaking of water storage for supplying the irrigating canals the author says: "When there is no moderating lake, a river fed by a glacier has a precious source of supply. The hotter the weather the more rapidly will the ice melt, and this is just when irrigation is most wanted." (Judging from this dictum, the condition in Mars is ideal.) In speaking of the great Assouan Reservoir in Egypt, he says: "The sale value of land irrigated by its waters will be increased by about $125,000,000. The increase in irrigation areas in our Western States may be appreciated by the following figures. In 1889 it amounted to 3,564,416 acres; in 1900, to 7,539,545 acres. Now it is at least 10,000,000 acres. Without irrigation this land sold for four or five dollars per acre; with irrigation it brings forty dollars per acre.

XIII

VARIETY OF CONDITIONS UNDER WHICH LIFE EXISTS

Not only does life but intelligence flourish on this globe under a great variety of conditions, as regards temperature and surroundings, and no sound reason can be shown why under certain conditions which are frequent in the universe, intelligent beings should not acquire the highest development.

SIMON NEWCOMB.

The argument most often urged against the idea that life exists in Mars is that there is no atmosphere in that planet, or if there is one it is so rarefied that it could not sustain life as we know it. According to Proctor, we have heretofore been led to consider the planet's physical condition as adapted to the wants of creatures which exist upon our own Earth rather than to ascertain the conditions which might obtain to enable life to exist on the surface of other planets. It is highly probable that if an air-breathing animal of our earth were instantly immersed in an atmosphere as rare as that of Mars, it would perish in a short time. Precisely what a species through thousands of generations of selection and survival might adapt itself to, is an open question. Leaving this contention for a moment, let us consider the almost infinite variety of conditions under which life exists on our globe, and we shall find that any and all conditions which the surface of Mars may offer, if experienced gradually through successive generations, would not be inimical to terrestrial life from the lowest to the highest, including even man.

Mr. Garrett P. Serviss, in discussing the question of life, in his book "Other Worlds," said: "Would it not be unreasonable to assume that vital phenomena on other planets must be subject to exactly the same limitations that we find circumscribing them in our world? That kind of assumption has more than once led us far astray even in dealing with terrestrial conditions. It is not so long ago, for instance, since life in the depths of the sea was deemed to be demonstrably impossible. The bottom of the ocean, we were assured, was a region of eternal darkness and of frightful pressure, wherein no living creatures could exist. Yet the first dip of the deep-sea trawl brought up animals of marvellous delicacy of organization, which, although curiously and wonderfully adapted to live in a compressed liquid, collapsed when lifted into a lighter medium."

One has only to make himself familiar with the wide range of conditions under which life in various forms exists on the Earth, to realize that the introduction of Martian conditions here would not be such an overwhelming calamity, and if these conditions could be introduced by minute increments covering thousands of centuries, it is not unreasonable to believe that myriads of forms would survive the change, and among those that survive would be precisely the kinds that thrive under the most diverse conditions here—namely, man and the higher hymenoptera, the ants.

To enumerate, in the broadest way, the variety of conditions under which life exists here, one has only to enumerate creatures living in the deepest abysses of the ocean; high up on the slopes of the Himalayas; swarming in arctic seas; withstanding the hot glare of a tropical sun; living deep in the ground; breeding in the darkest caves; flourishing in desert regions; thriving in water below freezing, and again in water

nearly at the boiling point. Professor Jeffries Wyman, in a memoir on "Living Organisms in Heated Water," has collected data showing that fishes are found living in water ranging from 104° to 135° Fahrenheit. He also found that low forms of plant life exist in water of various temperatures as high as:

168° F. observed by Dr. Hooker in Sorujkund;
174° F. observed by Capt. Strachey in Thibet;
185° F. observed by Humboldt in LaTrinchera;
199° F. observed by Dr. Brewer in California;
208° F. observed by Descloizeaux in Iceland.

If we consider man alone, we find him at Aden, on the Red Sea, at a temperature of 130° in the shade, and in Siberia at 70° below zero; grovelling in mines deep in the Earth, and living in great communities ten thousand feet above sea-level; fighting battles on the slopes of the Himalayas, at an altitude of 19,000 feet; nomadic on sterile tracts; sweltering under the glaring sun of the equator, and existing in regions of perpetual snow and ice, and without sunlight for six months of the year. Such are a few of the varied conditions to which man has become accustomed since he emerged from his tropical and arboreal relatives.

The question finally comes down to the effect of the rarefaction of air on life. An inquiry as to how far man can stand changes of atmospheric pressure is of interest in this connection, for we know that sudden changes are accompanied by mountain sickness, at great elevations, and caisson disease under great pressure. Large birds soar among the high peaks of the Andes and drop at once to sea-level. I have dredged delicate mollusks at a depth of one hundred and fifty fathoms of water and kept them alive for weeks in an aquarium. Man, while showing a sensitiveness to changes in barometric pressure when experienced suddenly, can nevertheless get accustomed to great ranges of pressure. The cities of Bogota and Quito are 10,000 feet above the level of the sea and yet in Quito when De Saussure, the naturalist, became so ill from the rarefaction that he could hardly find energy enough to read his instruments, and his servants, digging holes in the snow, fainted from the exertion, the natives were pursuing their various activities, and bull-fights were going on! One has only to read the accounts of the English expedition to Thibet to learn that troops fought in skirmishes at the height of 19,000 feet.

Mr. Douglas W. Freshfield (in "Scot. Geo. Mag.," April, 1905) gives an account of mountain sickness in the Sikkim Himalaya. He says the effect of high altitude was different in different individuals; some men were entirely free from it, and among them a Goorkha, who ran back in a pass at an altitude of 20,000 feet to hurry up some loiterers. Another member of the party, an Englishman, actually gained in weight, and had an increased appetite. Here, then, are a few men among a small number, without previous experience in rarefied air, feeling no disturbance, and, in one case, actually benefited by it!

The question arises as to what natural selection would do among a hundred million say, who, through many centuries, might be subject to a gradual attenuation of the air. The result of rarefaction of the atmosphere and the absence of moisture is associated with marked hygienic influences. The Hadley Climatological Laboratory of the University of New Mexico has made special investigations as to the increased lung capacity of those living at high altitudes, the relation of dry soil to health, etc. Important work has been done by Drs. John Weinzirl, C. Edw. Magnusson, F. S. Maltby, and Mrs. W. C. Hadley, and their investigations go to prove that high altitudes and absence of moisture are favorable to the health of man on this world, and by analogy would not be inimical to the survival of certain forms of life in Mars.

Dr. S. E. Solby (in "Medical Climatology," p. 43, 1897), in describing the effects of rarefaction of the air says: "The amount of air taken in at each breath becomes greater, and the air-cells, many of which are at lower altitudes often unused, are dilated."

If we consider the atmospheric pressure under which a man can work and live, we find equal

adaptability.

Mr. Gardner D. Hiscox, in his work on "Compressed Air, Its Production, Uses, and Applications," says: "Experience has taught that the ill effects are in proportion to the rapidity with which the transmission is made from compressed air to the normal atmosphere. That while the pressure remains stationary all subjective phenomena disappear." He speaks of pressure of forty or fifty pounds to the square inch, and says that, at these pressures, taste, smell, and the sense of touch lose their acuteness.

In the "Engineering Record" for January 23, 1904, there is an interesting article on "Caisson Disease." It says that twenty pounds pressure per square inch is common on foundation work in New York, and that bridge piers have been built when pressures of nearly fifty pounds were required. The deepest pneumatic work in New York was done in the East River gas tunnel, when the maximum pressure was about forty-seven to fifty pounds per square inch above atmospheric. In the gas tunnel four men died from the effects of heavy pressure, while none died from that reason under bridge work. The article further says that ordinarily "strong young men in proper condition do not suffer from working two four-hour shifts daily, under pressure up to twenty-five or thirty pounds; above that limit injurious effects may be felt," etc.

Let any reasonable man consider the meaning of these data. Without any selective action on the race, without even a graded increase of pressure from boyhood up, these workmen perform hard labor of stone excavation at these pressures, and in the same way, without previous experience, men are fighting battles at 19,000 feet altitude, and in one instance growing fat at 20,000 feet. Eminent German and French scientists have studied the effects of pneumatic pressure by numerous experiments on men and animals. One experimenter subjected a great number of dogs, cats, rabbits, guinea-pigs, and other animals to repeated pressures up to one hundred pounds, and carefully observed the effects of the varying conditions, some of which were fatal, while others were apparently harmless. The experiments showed that sudden release from heavy pressures was fatal, but that if three or four hours were occupied in reducing a pressure of one hundred pounds, it was harmless.

With these facts one cannot help wondering whether even man himself could not exist on Mars if allowed time to get accustomed to the rare atmosphere through thousands of generations of minute increments of adaptation.

As a matter of fact we use but a small portion of our lung capacity. Let any one experiment with himself and observe that after he has inspired the accustomed quantity of air he can continue for some time to inspire more air, and also when he has expired the accustomed quantity of air in normal breathing, he can continue to expire a great deal more air. Professor Jeffries Wyman, the famous lecturer on comparative anatomy at Harvard, used to tell us that we ordinarily inspired about twenty cubic inches of air but we could inspire one hundred cubic inches more by an effort; also that having expired the ordinary quantity we could expire a hundred cubic inches more and when the lungs were removed from the body, an extra hundred cubic inches could be forced from them. A surgeon friend tells me that many men live and work with the greater portion of both lungs diseased, and unable to perform their functions.

It would be an interesting inquiry to ascertain what other species of the animal kingdom has so wide a range as man. The dog evidently follows him in all altitudes and at all temperatures.

The group of insects to which the bees, wasps, and ants belong, have always been recognized as standing highest in intelligence among the invertebrates. In the great work of Dr. and Mrs. Peckham on wasps are shown manifestations of intelligence among the wasps that are simply startling, and the remarkable work of Miss Adele M. Fielde on the ants adds greatly to the evidences of their unique intelligence. The ant stands among the invertebrates much as man does among the vertebrates. One has

only to state concretely that ants practise a division of labor; distinguish certain colors; estimate numbers; recognize friends and enemies; harvest seeds, and, it is said, raise them, hence are called agricultural ants; have insect cows and milk them; collect leaves which they chop up for the purpose of raising a kind of fungus upon which they live; organize raids and fight battles in masses; enslave other species; build covered ways and tunnels; and perform other acts of a similar nature.

Bearing these statements in mind it is an interesting fact that at altitudes in Arizona, where man finds it impossible to live except by fetching water from regions below, the ant, equally dependent on water, has survived on these high tablelands, and manages to raise huge colonies. In wandering over the mesa at Flagstaff, at an elevation of over 7,000 feet, the extreme dryness of the ground is indicated by long cracks which appear on the surface. Here, where hardly any insect is found except an occasional roaming butterfly, the ant has survived and is met with in great numbers. Even a rare solitary insect known as the velvet ant, and consequently without communal aid, is found chirping merrily amidst these arid surroundings.

In this connection, it is interesting to observe that creatures endowed with the highest intelligence, both vertebrate and invertebrate, manage to survive in considerable numbers in regions devoid of water. One conveys it to his habitations from lower levels, the other digs wells or manages to utilize the moisture from the roots of trees.

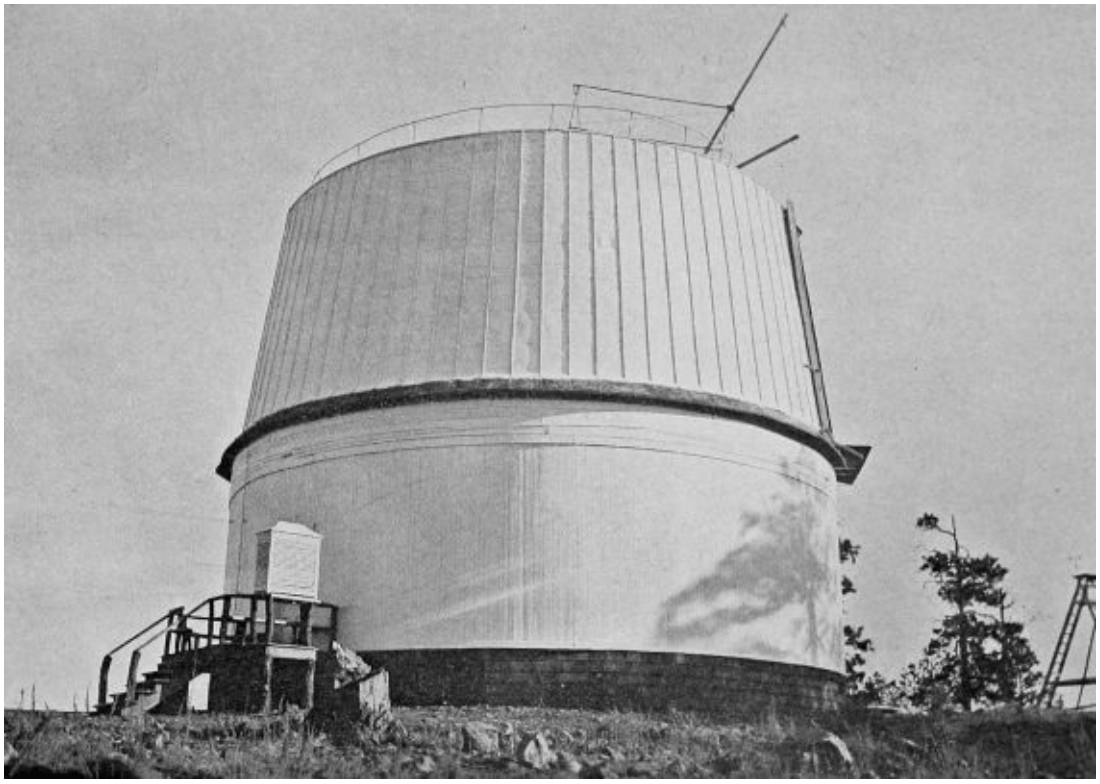
XIV

MY OWN WORK

> *Snow caps of solid carbonic acid gas, a planet cracked in a positively monomaniacal manner meteors ploughing tracks across its surface with such mathematical precision that they must have been educated to the performance, and so forth and so on, in hypotheses each more astounding than its predecessor, commend themselves to man, if only by such means he may escape the admission of anything approaching his kind.*
>
> PERCIVAL LOWELL.

I am led to present these few brief memoranda of my own work in order to meet questions which would naturally be asked as to whether I had ever seen Mars through a telescope, and if so did I make out any markings or canals.

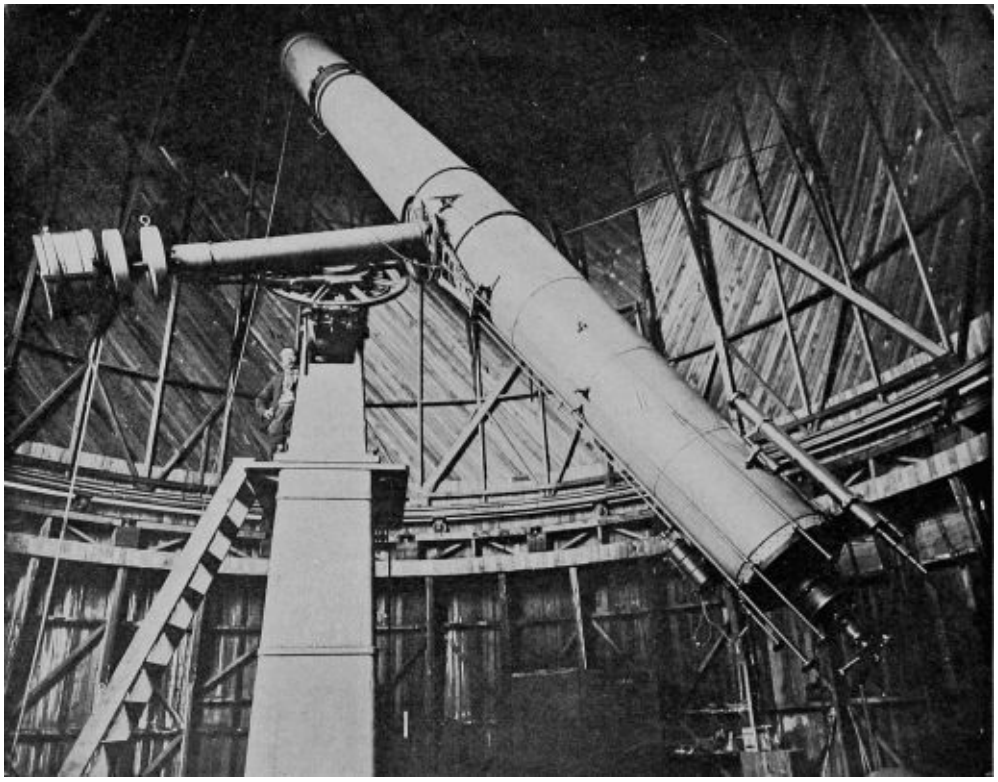
PLATE VII



DOME OF THE LOWELL OBSERVATORY, FLAGSTAFF, ARIZONA

It was my good fortune to have the privilege of observing Mars every night at the Lowell Observatory (see Plate VII) for thirty-four days, covering an almost complete presentation of the planet. A few nights were cloudy and no observations were made. With these exceptions I was in the observer's chair several times each evening. The twenty-four inch refractor of which I had the use was the last telescope Clark ever made, and he pronounced it his best one. This instrument (Plate VIII) is mounted on a mesa near the town of Flagstaff, Arizona, at a height of over 7,000 feet above sea-level, in an atmosphere of remarkable clarity and steadiness. I have already stated on page 80 my first experiences in observing and will only present the brief notes I made at the time of observation. Better results would have accompanied these efforts had I followed the custom of Michael Faraday and asked what was I to look at, what was I expected to see? I had been somewhat prejudiced as to the existence of the canals by the comments of sporadic observers, many of whom, by the way, had never been able to see them, and denying that any one else ever had, straightway proceeded to suggest a theory to explain their presence! Careful to avoid any bias in the matter I rigidly refused to allow either Professor Lowell or his assistants to suggest where I might find a canal or a marking on the disk. The night before I left the Observatory for home I asked Mr. Lowell for the first time, to indicate the position of some conspicuous canal which I had not seen. This he did and examining the region which I supposed he had indicated on the disk I searched in vain for the line. In doing so another line was detected and drawn, and on confessing my failure to see the line he had described, showed him my drawing, when he exclaimed, "Why, you have got it," and sure enough when he showed me his drawing and repeated the directions he had given me, I found that I had been looking at the wrong pole of the planet.

PLATE VIII



TWENTY-FOUR INCH TELESCOPE OF THE LOWELL OBSERVATORY, FLAGSTAFF, ARIZONA

In one stage of great discouragement I came across a statement made by Mr. A. Stanley Williams which has already been quoted, namely, that he had to observe continually for two months before sufficient sensitiveness enabled him to make out the more delicate markings. That I might have seen more had I been acclimated, and had been accustomed to telescopic observation there is no doubt. The record is poor enough and yet under the conditions mentioned the results may be of interest to the reader.

May 14. Midnight. Saw planet for the first time. A beautiful luminous disk with shades of tone dimly visible. Southern pole cap white and seen.

May 15. Certain details sufficiently distinct to make out dark areas, and at times a line or two.

May 16. Occasional flashes of a few lines, while broad darkened area and cuniform area on right visible, and, in one flash, a line supporting the wedge as well as basal line. With no better seeing conditions than last night, more details came out, and for the first time I am encouraged to believe that each day an improvement will take place. I saw enough to make my first drawing.

May 17. Bad seeing. I made out only the broad southern band, the line at the northern pole and the wedge-shaped area to the right below, also a slight discoloration in the middle.

May 18. Not very good seeing. Could make out but little more than I did last night.

May 19. Seeing about the same, perhaps slightly less. Saw rift in southern dark band and north pole appeared luminous.

May 20. Mr. Lowell informed me this morning that the luminous appearance around the north pole that I saw last night was the result of a snowstorm. Seeing fair. Considerable vibration o

planet. Saw new snow field of the northern pole distinctly outlined and much confused markings. Looked in vain for spots but could not discern them.

May 21. Seeing clearer, and for the first time I made out distinctly two spots, or oases. Mr. Lowel informed me that Schiaparelli had never seen them. The snow which fell on May 19 was still conspicuous.

May 22. With a headache and a seedy condition from not being acclimated, I yet found an improvement in my seeing capacities. I made out a promontory in the southern dark belt, also a canal running down from the Trivium.

May 23. Bad seeing. Could not define snow cap though dark southern band showed. Made no drawing.

May 24. Am in despair of seeing anything when the others see so much. I must have an old and worn-out retina. In looking, lines flash out at times but it is impossible to locate them. I can certainly see more than Huyghens did, but not much more.

May 25. Heavens very cloudy and Mars obscured.

May 26. Poor seeing—saw but a few markings.

May 27. Snow and hail storm in the afternoon. Temperature 35° at night. Seeing zero, and consequently no observation.

May 30. To-night markings and more particularly shades seemed abundant yet so evanescent that only an intimate knowledge by long study could define them. I gave up in despair.

May 31. Saw a little more than I saw last night but did not see a trace of things that Mr. Lowell and his assistants apparently saw without effort. I realize that it requires a special training to observe the flickering evanescent markings on Mars.

June 1. Though the best night yet for steady atmosphere I saw but little more and have come to th conclusion that it will take months of continuous observation before I can see anything.

June 2. I went to the Observatory to-night in despair of ever seeing anything more. Got into the observing chair and immediately saw a number of markings I had not seen before, as my drawings show. I have purposely refrained from studying the maps, and so do not know the names of the lines detected.

June 3. Atmosphere so unsteady that it was impossible to make anything out of Mars, so after struggling awhile gave it up in disgust.

June 4. Seeing about 4, yet manage to see a few planetary details.

June 5. I find a slow advance in my ability to see the markings though it is exasperating that the janitor of the Observatory talks about plainly seeing certain details which he indicates to me by a sketch, and looking at the region I can see no trace of a canal or anything else.

June 7. Seeing very good and in my observations tonight added another canal. It is a most difficult matter to catch the fleeting lines as they appear with startling distinctness to instantly vanish again.

June 9. Seeing fairly good. Could make out but little more. Color of regions very strong and vivid.

June 10. Seeing a little better than last night. Added three new canals, and these canals flashed ou three or four times before I was willing to record them, and then I did not believe them till Mr. Lowell showed me a drawing he had made just before, and the two drawings corresponded.

June 11. Looked at eight o'clock and the markings of larger features came out strong and dark and yet the seeing was not estimated high.

June 12. Rather poor seeing though some of the dark regions came out with remarkable distinctness. Every day I notice a very slight improvement in detecting lines. Markings formerly made out with great difficulty are now instantly recognized.

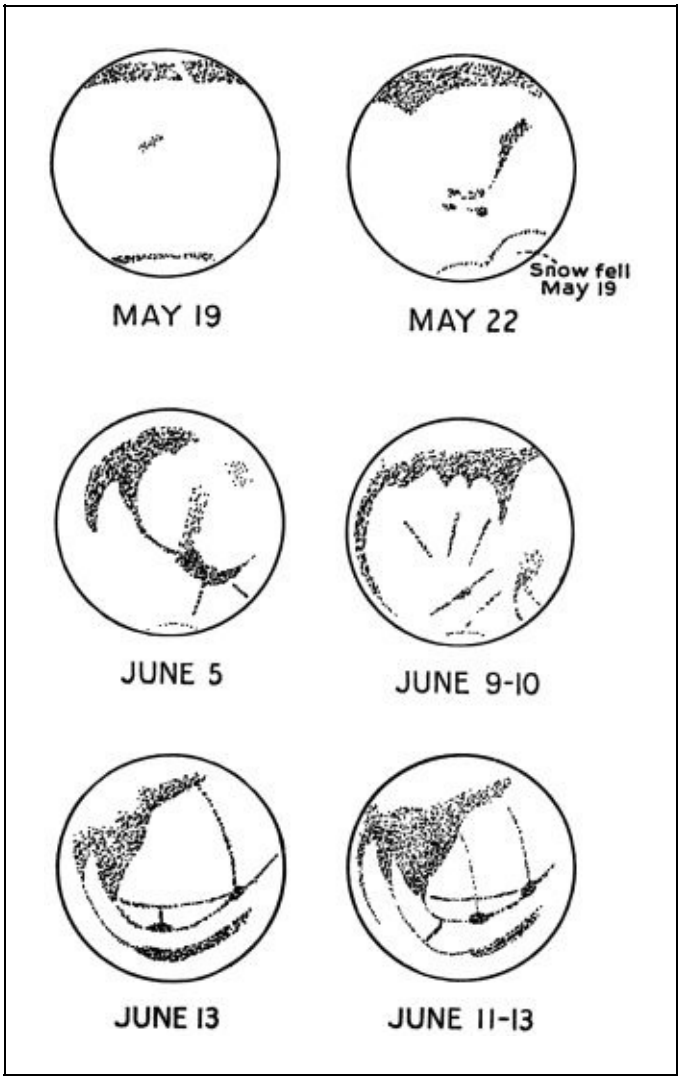
June 13. In my observations to-night added one new canal and completed another, and was able to detect one that Mr. Lowell had not seen during the evening—a well-known one he says. I simply shows that one must continually observe as the lines flash out for a single instant.

June 14. Made out still another canal to-night. The markings show very clear, in fact some parts were vivid in distinctness and the lower part of Syrtis Major dark blue.

June 15. Poor seeing, yet I was able to see a few of the prominent features and defined the wedge-shaped region below.

On Plate IX I give a few of my drawings of Mars in which are indicated the lines I saw many times and was able to fix. Other lines flashed out for an instant but these were not recorded, simply because I could not definitely locate them.

PLATE IX



MAY 19

MAY 22
Snow fell May 19

JUNE 5

JUNE 9–10

JUNE 13

JUNE 11–13

DRAWINGS OF CANALS OF MARS BY THE AUTHOR

The expression "poor seeing" in the above notes must be taken in a comparative sense with relation to the usual conditions of the atmosphere of Flagstaff. Poor seeing, therefore, at Flagstaff would be equal, if not superior, to the best seeing at much lower levels. An astronomer who resigned his position in a western observatory for duties at Mount Wilson, California, told me that for thirty consecutive nights the seeing was superior to the best nights he had observed in at his former post.

XV

WHAT THE MARTIANS MIGHT SAY OF US

O wad some power the giftie gie us,
To see oursels as others see us!

ROBERT BURNS.

For every single perplexity of interpretation we encounter in our study of the surface markings of Mars, the Martian would encounter a dozen perplexities in interpreting the various features on the surface of the Earth.

Admitting the conclusions of Lowell of the existence of intelligence in Mars, and that that intelligence has been associated for ages with a planet having only slight elevations of land, a tenuous atmosphere, a scarcity of water which has been utilized for ages through artificial channels, as we have done in various parts of the world since prehistoric times, having vast tracts of sterile plains, and, within these sterile tracts large oases fed by irrigating canals, regions of sparse vegetation, and no large bodies of water; with these conditions going beyond the history of these intelligences, what must be the Martian interpretation of the surface features of this world? It is a perfectly fair inquiry, for by such means we may appreciate the attitude of some of our interpreters of Mars.

In examining the Earth, then, as we have examined Mars, the Martian would find large yellow and reddish areas, extensive greenish areas, and, besides, large regions of varying shades of blue, possibly, occupying three-fourths of the Earth's surface. The yellow areas he would interpret as desert land, the greenish areas he might consider vegetation, but what would he make out of the larger regions of blue? This would certainly puzzle him, because, unfamiliar with oceans, he could not believe that such vast tracts could really be water. He would easily interpret the polar snow caps, and the waters at their edges, but the oceans would be impossible to solve. The suggestion, by some audacious interpreter, that this vast blue area was water, would be answered by showing that these so-called bodies of water bordered vast tracts of sandy deserts with no canals running into them for irrigation or navigation purposes. Even the polar snow caps would be doubted, because they seemed to extend far down into temperate latitudes; and on their recedence in summer, there would be seen no dark, bordering seas as the result of their melting. The vegetation, instead of unfolding at the north and gradually extending southward, would unfold in a contrary direction, appearing first in south temperate latitudes and developing northward. The perennial character of the vegetation in the tropics would puzzle him. Even if he recognized oases in the deserts of America and Africa, the results of Artesian wells or springs, he could not believe them to be vegetation; for he would detect no irrigating canals running into them. He would come to the conclusion that no creature could possibly exist on the Earth, as the tremendous force of gravitation with great atmospheric pressure would forbid the existence of any organic forms. The immense clouds veiling the surface must at times suffer condensation, and the impact of raindrops would, from their velocity and weight, smash everything in the way of life. Life, if it existed in forms supported by appendages, must have legs of iron to sustain its weight, and a crust like a turtle to be impervious to raindrops, and this would be contrary to

all Martian analogy. The courses of rivers, if detected, would puzzle him from their irregularity, unless he dared to suggest that these long sinuous channels extending for thousands of miles were identical to the little rivulets he had studied near his own poles.

In fact, about the only feature outside the polar snow caps that he would instantly recognize, would be the great ice cap of the Himalayas. India, that vast region extending from latitude 35° nearly to the equator, with its great plains and sterile regions, with its overpowering heat, and a dense population, depends for the sustenance of many of its millions upon the thousands of miles of irrigating canals, fed from the melting snow caps of the Himalayas. India has no great lakes, but in the northern plains great rivers course their way to the sea. The Ganges and the Indus and their tributaries derive their waters from the melting glaciers, and from these, a most extensive irrigating system of canals and reservoirs draw their waters. As the heat increases the ice melts more rapidly, and so more water is supplied at just the time when it is most needed. The whole scheme is on so vast a scale that a Martian would recognize its meaning, though he would wonder at the tortuous outlines of the larger canals.

Flammarion has, in a similar manner, presented the arguments of Martian astronomers as to whether life exists anywhere but upon the planet Mars. He says, among other fancies, that the sapient Martian argues that houses could not be built on the Earth, on account of the violence with which building materials, such as bricks, blocks, etc., would drop, and thus endanger life. Believing that Mars is rightly balanced as to temperature, the Earth being so much nearer the Sun, would be too hot for life to exist. The Martian conceives himself to be supremely complete "even to the point that artists wishing to represent God in our sanctuaries have figured Him in the image of a Martian man." The Martian considers our year too short. In his reflections he says: "During the period in which one of us attains the middle age of fifty years those on Earth have become decrepit old men of ninety-four, if, indeed, they are not already dead."

Seriously, if there is an intelligence in Mars, it must have evolved along the same general lines as intelligence has developed on the Earth. Being an older planet, it must have outgrown many of the vagaries and illusions which still hamper man in his progress here. In the dim past, however, we can imagine some Martian astronomer with the enigma of our Earth before him, and the great vault of heaven with its thousands of riddles unanswered, consulting records and covering pages with mathematical formulæ to ascertain the precise spot upon which grew the bean stalk by which a Martian Jack ascended to encounter the giant. Indeed, the imagination can conjure up an infinite number of parallels. If Mars is an older sphere, we trust it has long outgrown the superstitions which still hamper man in his interpretation of the inexorable phenomena of Nature on this little planet. We may hope that they have finally reached that stage when a dictum similar to that of Huxley forms an engraved tablet in their temples of worship. These are his words: "Science is teaching the world that the ultimate court of appeal is observation and experiment, and not authority. She is teaching it to estimate the value of evidence; she is creating a firm and living faith in the existence of immutable moral and physical laws, perfect obedience to which is the highest possible aim of an intelligent being."

XVI

SCHIAPARELLI, LOWELL, PERROTIN, THOLLON

Every age has its problem, by solving which humanity is helped forward.
HEINRICH HEINE.

In previous pages allusion has been made to the distinguished character of the astronomers who have contributed to a knowledge of the surface markings of Mars. Testimony from astronomical sources has been quoted as to their keen-sightedness in this work which, as Sir Robert Ball has said, "indicates one of the utmost refinements of astronomical observation." That the reader may better understand the eminence of some of those whose names will forever be associated with the investigation of the surface features of Mars the following brief records are given.

GIOVANNI VIRGINIO SCHIAPARELLI

The two astronomers most widely known in connection with the study of Mars are Professor Giovanni Schiaparelli and Professor Percival Lowell. Lowell had just graduated from Harvard, at the age of twenty-one, when Schiaparelli, at the age of forty-two, made his first great discovery of the *canali* of Mars. Macpherson, in his valuable history of the "Astronomers of To-day," says of Schiaparelli: "His studies of meteoric astronomy, of Mars, Venus, and Mercury, of double stars and of stellar distribution, have given him a place second to none among living students of the heavens." From the same interesting book we gather the following facts: Schiaparelli was born in Sabigliano, in Piedmont, in 1835. He attended the usual schools in his native town and then entered the University of Turin as a student of mathematics and architecture. Before he was twenty years old he decided to devote himself to the study of astronomy. At the age of twenty-four he was an assistant in the celebrated Observatory of Pulkova. When the kingdom of Italy was organized he became an assistant in the Brera Observatory, Milan. He became suddenly famous at the age of twenty-seven by the discovery of a new asteroid. In 1862 he became Director of the Observatory. Schiaparelli's first great discovery was the relationship between comets and meteoric showers. In 1872 he was accorded the gold medal of the Royal Astronomical Society for his various astronomical discoveries. Professor Simon Newcomb gives him high praise when he says: "Among the individual observers Schiaparelli may be assigned the first place in view of his long continued study of the planets under a fine Italian sky, the conscientious minuteness of his examinations, and his eminence as an investigator." Schiaparelli's researches into the relation of comets and meteors "were developed in 1873, in his remarkable work 'Le Stelle Cardenti,' which is, according to Sir Norman Lockyer, one of the greatest contributions to astronomical literature which the nineteenth century has

produced." Macpherson closes his interesting memoir of Schiaparelli by saying: "His devotion to astronomy, his singularly accurate observations and his wonderful discoveries have secured for him an exalted position among the greatest astronomers of modern times." For a further appreciation of the work of Schiaparelli the reader is referred to Macpherson's "Astronomers of To-day." In this brief sketch the reader may judge of the eminent character of one who insists that the lines in Mars are a persistent feature of its surface, whatever one's interpretation of them may be.

PERCIVAL LOWELL

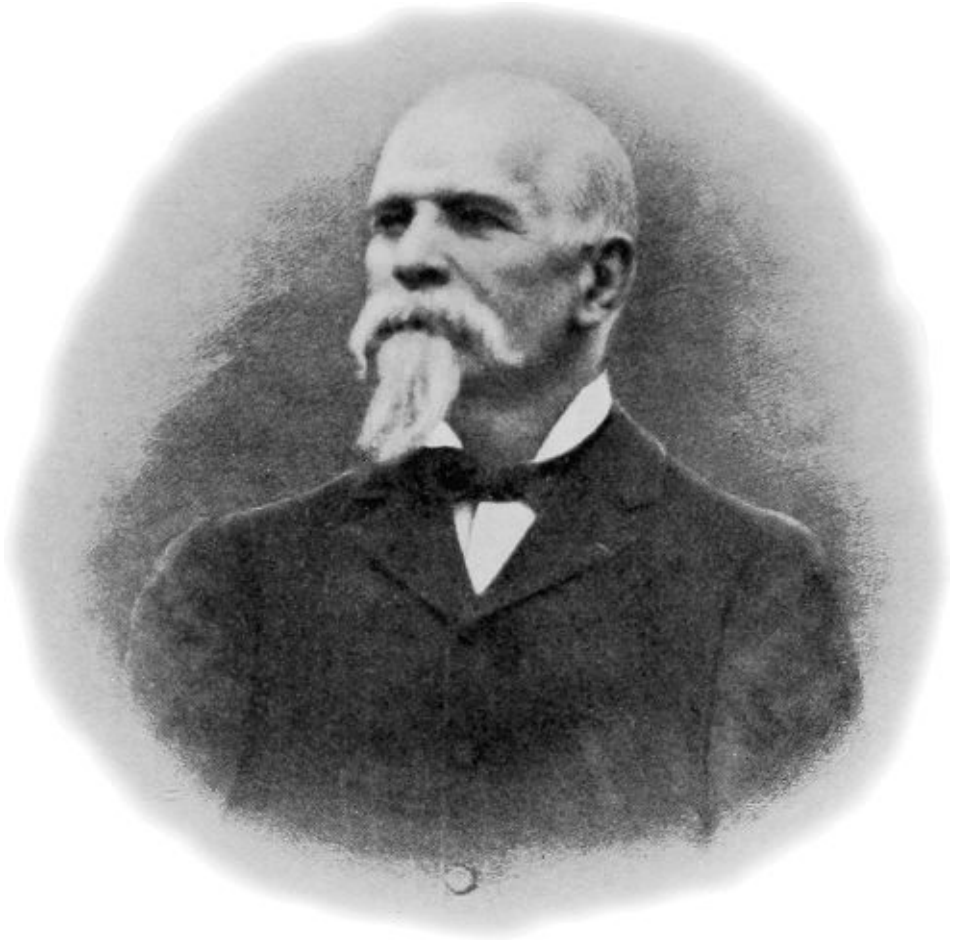
Percival Lowell was born in Boston in 1855. He was graduated from Harvard in 1876, and prepared for his graduating thesis an essay on the Nebular Hypothesis. Lowell is a many-sided man. Early interested in mathematics, he became one of the founders of the Mathematical and Physical Society of Boston. A visit to Japan, where he lived a number of years, resulted in the writing of three interesting books: "The Soul of the Far East," 1886; "Noto," 1891; and "Occult Japan," 1894. During his residence in Japan he was chosen foreign Secretary and adviser to the Korean Special Commission, then about to visit the United States, which he accompanied. On his return to Korea he was the guest of the Korean Government, and this experience prompted him to write "A Korean Coup d' État," 1894, and his well-known volume, "Choson, the Land of the Morning Calm," 1885. On his return to America he undertook an eclipse expedition to Tripoli with Professor Todd. His early interest in astronomical subjects was now fully awakened, and the red planet, which he had observed in boyhood with a small telescope from the roof of his father's house, aroused his interest on account of the heated discussions over Schiaparelli's discoveries. With an impetuosity and enthusiasm which characterizes all his work, he set about to secure a proper region and a sufficient elevation for an observatory site. This was found in northern Arizona at an elevation of over 7,000 feet. Here, then, was established the Lowell Observatory with a twenty-four inch refractor made by Clark especially for this Observatory, the last, and, according to the maker's words, the best telescope he had ever made. Lowell insisted that the location of an observatory was a much more important factor than the size of the instrument, and says: "When this is recognized, as it eventually will be, it will become the fashion to put up observatories where they may see rather than be

seen." It may be said with truth that, for the first time in the history of astronomy, an observatory has been erected and fitted for the special purpose of studying the surface features of Mars. During unfavorable oppositions Lowell has turned his attention to the other planets, notably Mercury and Venus, with the result of adding many new and interesting details concerning these bodies. Three volumes of quarto memoirs and many bulletins from the Lowell Observatory attest to his industry. He has been fortunate in securing talented assistants, and their contributions may be found in the various publications of the Observatory. The character and importance of Lowell's work may be understood by stating that the "British Nautical Almanac" is to adopt for the future the value of the position of the axis of Mars, and the tilt of the planet's equator to its ecliptic, which was furnished by Professor Lowell in compliance with a request.

Mr. Lowell is a Fellow of the American Academy of Arts and Sciences; Member of the Royal Asiatic Society of Great Britain; American Philosophical Society; Société Astronomique de France; American Astronomical and Astrophysical Society; Astronomische Gesellschaft; Société Belge d'Astronomie; Fellow of the American Geographical Society; Honorary Member Sociedad Astronomica de Mexico; and others.

In 1904 he was awarded the Janssen medal of the Astronomical Society of France for his researches on Mars.

Mr. Macpherson, in his memoir on Lowell, says that "Mr. Lowell, by his unwearied devotion to astronomy, has already gained for himself an enduring reputation."



HENRI PERROTIN

M. Henry Perrotin and his assistant, M. Thollon, have been quoted in previous pages as having markedly confirmed the discoveries of Schiaparelli. Through the courtesy of Professor Lowell I am enabled to present the likenesses of these two astronomers. I am indebted to the exhaustive work of Miss Agnes M. Clerke, entitled the "History of Astronomy during the Nineteenth Century," for the following memoranda of some of the work accomplished by these men. Perrotin made a series of observations on Venus fully confirming Schiaparelli's inference of synchronous rotation and revolution: "A remarkable collection of drawings made by Mr. Lowell in 1896 appeared decisive in favor of the views of Schiaparelli." In other words, Venus, like the Moon, presents the same face to the Sun in its revolution about that luminary. Perrotin has made important observations on the rings of Saturn; his double-star measurements are also considered work of the highest character.

M. THOLLON

Thollon has made many spectroscopic studies, among which were delicate experiments showing the lateral displacement of lines in the solar spectrum arising from the Sun's rotation. In the Annals of the Nice Observatory he published a great atlas consisting of thirty-three maps, exhibiting in quadruplicate a subdivision of the solar spectrum under varied conditions of weather and zenith distance. He also studied the spectrum of the great comet of 1882, and by the displacement of its lines estimated that the comet was receding from the Earth at the rate of from sixty-one to seventy-six kilometers per second. The Leland prize was awarded to Thollon for a hand drawing he made of the prismatic spectrum obtained with bisulphide of carbon prisms of high dispersive power.

The character and reputation of these men, as well as others who have been quoted in these pages, must be weighed against the few who, not content with denying the existence of the *canali* in Mars, have in strong language abused those who accept them as veritable markings on the planet's surface.

XVII

LAST WORDS

The uniformity of the course of Nature will appear as the ultimate major premise of all inductions.

JOHN STUART MILL.

The final question is, do the lines as depicted and described by various observers exist on the surface of Mars? Those who have made the greatest addition to our knowledge of the character of these lines, and have constructed maps based on Martian latitude and longitude are accredited on other grounds as being endowed with remarkable acuteness of vision coupled with persistence and painstaking care in observation. The most successful work has been accomplished with instruments of fine definition in regions of steady atmosphere and high altitude, or at intervals of clarity and steadiness in regions otherwise unfavorable. Finally, and most convincing of all, Mr. Lowell's assistant, Mr. Lampland, after many attempts has succeeded in photographing the more conspicuous linear markings. *The lines do exist essentially as figured by Schiaparelli and Lowell.* It now rests with the objectors to suggest any better interpretation of the markings of Mars than that they are the results of intelligent effort.

The mediæval attitude of some astronomers regarding this question recalls the story of Scheiner, a Jesuit brother, who, independently of Galileo and Fabricius, discovered spots on the Sun. Eager with enthusiasm he informed his Superior of his remarkable discovery and begged to be allowed to publish it to the world. The Superior replied, "Go, my son; tranquilize yourself and rest assured that what you take for spots on the Sun are the faults of your glasses or of your eyes." This happened three hundred years ago, and yet to-day a few astronomers of this class still survive.

If one will calmly reason about the matter, let him consider a parallel case of interpretation. He digs out from the ground a fragment of stone; its somewhat symmetrical shape suggests to him the idea that it may be a rude stone implement. If he wishes to know what kind of rock it is and its geological age, he refers it to a geologist; if he wishes to know its composition, he asks a mineralogist, who, if necessary, will analyze it for him. If, however, he is curious to know whether its peculiar, fractured surface is due to frost or other natural agency, or whether it is the work of some rude savage, he inquires of an archæologist, who alone will be able to tell him whether it is a worked stone or natural fragment. He will probably tell him whether it was shaped by paleolithic man, and whether it is a rough stone implement or a core, *reject* or chip. So with the study of Mars, as we have already pointed out, there are certain matters of information about the planet which the astronomer alone can impart, while the superficial markings are just as certainly to be interpreted by another class of students who may or not be familiar with astronomical methods.

* * * * *

It was quite natural that astronomers, the most conservative of all classes of observers, should have doubted the first announcement of Schiaparelli of the startling discovery of the *canali* marking the face of

the planet, the more so as year after year went by and yet with the utmost efforts of astronomers nothing of the nature of Schiaparelli's lines could be seen.

What added greatly to the doubt about the lines, and at the same time strengthened the idea that the lines were illusory, was the subsequent announcement by Schiaparelli—undeterred by the universal skepticism—that at times the lines appeared double. What more convincing evidence could be offered than that the phenomenon was purely subjective?

A few astronomers expressed their doubts in a courteous though hesitating manner. Professor Young, in his valuable text-book, "Elements of Astronomy" (1890), in correctly reporting Schiaparelli's discovery says: "He is so careful and experienced an observer that his results cannot be lightly rejected; and yet it is not easy to banish a vague suspicion of some error or illusion, partly because his observations have thus far received so little confirmation from others, and partly because his 'canals' are so difficult to explain. They can hardly be *rivers*, because they are quite straight; nor can they be *artificial* water-ways since the narrowest of them are forty or fifty miles wide. To add to the mystery, he finds that at certain times many of them become *doubled*,—the two which replace the former single one running parallel to each other for hundreds, and sometimes thousands, of miles, with a space of 200 or 300 miles between them. He thinks that this *gemination* of the canals follows the course of the planet's seasons."

The overpowering belief that this world alone sustained creatures of intelligence formed an obstructive barrier to any and all attempts made to uphold—at least by analogy—the idea of intelligence in other worlds. One cannot but regret that some philosopher had not, years before Schiaparelli's time, expressed the conviction that Mars might perhaps be more favorable to the existence of intelligent life than our own world, and with this conviction proceed to formulate the conditions which must of necessity exist: namely, that the planet being a much older world than ours, its waters had mostly vanished by chemical combination with the rocks and otherwise. Following this assumption, the philosopher might have insisted that in the last extremity the melting snow caps would be utilized by the supposed intelligences to furnish water for potable and irrigating purposes. The philosopher might have superadded to this idea the prediction that, when telescopes were strong enough and eyes were keen enough, evidence of the truth of this supposition would be found in canals of some sort and that such lines should be carefully sought for. Fancy the exultation of Schiaparelli when at last he found the lines precisely as indicated. Such an announcement from so distinguished an astronomer would have been hailed with acclaim. Alas! for the conservatism of astronomers, such powers of prevision are sadly wanting. Le Verrier's prediction of an outer planet was a matter of dead certainty. The perturbations of Uranus could not be accounted for except by the assumption of an outside body, and had it not been for the characteristic reserve of English astronomers, Adams might have had the full credit. So rare are predictions of this nature in the history of astronomy that this instance will probably be quoted to the end of time. The masses, still ignorant of the certainty of mathematical astronomy, regard the prediction of an eclipse as in the nature of a prophecy. The liberal attitude of naturalists stands in marked contrast, and the history of their work is filled with examples of prediction and repeated confirmations. Until the middle of the last century—grounded in the belief of special creation—how wonderfully rapid was the conversion of naturalists to the theory of evolution after Darwin had offered his rational views on the subject. The existence of forms was predicted, based on the idea of evolution, and these have been found again and again. Our museums display in their cases remains of fossil animals which complete many series undreamed of in pre-Darwinian days. This wonderful work has been accomplished without resort to algebraic formulæ, and yet when mathematics can be applied, as it is in the law of variation, quantitative studies in heredity, and statistical methods generally, it is promptly seized upon by the biologist.

* * * * *

To one unconvinced of the existence of some signs of intelligent activity in Mars the suggestions that have been made to account for certain appearances in the planet will seem absurd. If, on the other hand, he finds himself in agreement with those who believe the markings are the result of intelligent effort, then he is justified in using the various artificial markings of the surface of the Earth as standards of comparison in explaining the many curious markings of Mars. Indeed, he is compelled to do so, just as would be demanded of him if he should stand on some high mountain peak in some hitherto unexplored region of Africa and should minutely scan the hazy stretch of plains below. Large white spots in equatorial regions which could not possibly be snow-covered hills, might be masses of white flowers or cloth-covered areas for the better cultivation of certain plants. Lines that dimly stretched across the surface might be rivers, cañons, rifts, or bands of irrigation, according to their character.

As we compare the circular markings on the Moon with our terrestrial craters and fissures, and cracks on its surface with similar fissures on the Earth, so we are forced to compare the markings on the surface of Mars with what seems analogous to them on the surface of our own Earth.

Once proved that the markings of Mars are due to erosion, cracks, encircling meteors big enough to raise ridges by their attractive force, then all that has been written in demonstration of their artificial character goes for naught. The intelligent reader unprejudiced in the matter will, however, judge for himself the merits of our contention and will determine the reasonableness of the comparisons that have been made by Lowell in solving the mystery of Mars.

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FOOTNOTES

[1] Some of our readers may not know that light travels, in round numbers, at the rate of 186,000 miles a second.

[2] The terminator represents the limit of light on that side of the planet in the shade, in other words, where the light terminates. In viewing the Moon, when at quarter or half, the terminator is seen very ragged on account of the illumination of higher points on the surface. If the Moon was as smooth as a billiard ball the terminator would be clear cut.

[3] The world in its ignorance of Italian assumed that the word meant exclusively canals, and, if canals, then dug by shovels. What! a canal thirty miles wide and two thousand miles long dug in the snap of the finger? Impossible conception, you say. We shall see later the sober utterances of a member of the British Astronomical Society on this gratuitous assumption, and an equally serious comment by the chief assistant of the Royal Observatory at Greenwich (E. S. M.).

[4] The views so long held that the dark shaded regions were bodies of water, or seas, was disproved by the observations of Pickering and Douglass, who distinctly traced the course of the canals across these dark areas. The observations of Dr. E. Barnard certainly sustain the contention that they are land areas and probably depressions, representing ancient ocean beds. Dr. Barnard, using the telescope at the Lick Observatory, says: "Under the best conditions these dark regions which are always shown, with smaller telescopes, of nearly uniform shade, broke up into a vast amount of very fine details. I hardly know how to describe the appearance of these 'Seas' under these conditions. To those, however, who have looked down upon a mountainous country from a considerable elevation, perhaps some conception of the appearance presented by these dark regions may be had. From what I know of the appearance of the country about Mt. Hamilton, as seen from the Observatory, I can imagine that, as viewed from a very great elevation, this region, broken by cañon, and slope and ridge, would look like the surface of these Martian seas."

[5] Sterling Heiley, in "Pearson's Magazine," June, 1905.

[6] A translation of which may be found in the "Popular Science Monthly," Vol. XXXV, p. 532.

[7] I may add that in a similar case an American student of Mars moved his telescope to Mexico and remounted it at a cost of some thousands of dollars.

Transcriber's Notes

Punctuation and spelling were made consistent when a predominant preference was found in this book; otherwise they were not changed.

Simple typographical errors were corrected; occasional unbalanced quotation marks retained; inconsistent hyphenation retained.

Ambiguous hyphens at the ends of lines were retained.

Page 146: Quotation mark preceding 'The sale value' has no matching closing mark.

Page 192: "Stetefelt's" is spelled "Stetefeldt" on page 129. The latter is correct.

Page 192: "Tycho Brahe" probably should be indexed as "Brahe, Tycho".

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