




Professor Todd's Own Story of the Mars Expedition

First Article Published from the Pen of the Leader of the Party of Observation

By David Todd

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As a very young astronomer, I took no interest in Mars. Jupiter was my especial planet, because I had first seen his moons through a bit of telescope which, at fourteen, I put together with my own hands, and I kept on observing the satellites for years thereafter. A fascinating planet he is, too—none more so than Jupiter.

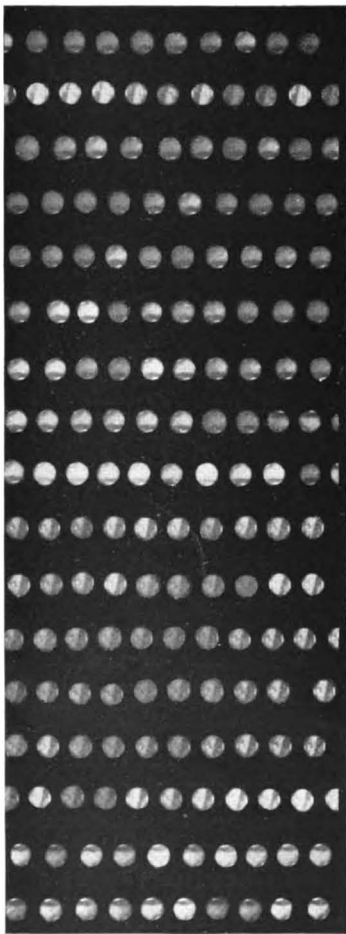
But in 1877 my attention was turned toward Mars at opposition, quite accidentally. I had graduated from college two years before, and was serving an astronomical apprenticeship at the Washington Observatory, when Professor Hall announced one August morning that he had found a moon of Mars the night before. The next evening I was allowed to look for other satellites; but my superiors went to the eyepiece before me, in the order of their naval rank, of course. Professor Newcomb saw nothing; Professor Hall, nothing; Professor Harkness, as much. Hall's outer satellite was easily visible to them, but nothing more. Then came my turn at the telescope.

The old micrometer of the Washington twenty-six-inch telescope had a mechanical defect (one might call it) of which I proceeded to take advantage: by sliding the eyepiece far off to one side, the end of the micrometer-screw could be brought into the

field of view. Behind this I carefully adjusted the great blazing ball of Mars, then at its nearest to the earth, and, searching first one side of the planet and then the other, I soon picked up a new and unknown body—the inner satellite, Phobos—so close to the flaming disk that it was invisible with the planet in the field. The professors again looked, one after the other, and verified my discovery. So mine was the first human eye that ever saw Phobos, recognizing it as a satellite. And I fancy my right to the discovery would have been recognized had not Professor Hall the night before measured the positions of several little stars, as he thought them, not even dreaming of more than a single moon; and afterward, when the orbit of the satellite became known, one of those stars turned out to have been Phobos. So without question the inner moon as well as the outer belonged to Hall.

I did not look at Mars again till his next close opposition in 1892, after the well-known cycle of fifteen years had run its course. Then, with the sixteen-inch Clark telescope at Rochester, I saw both the satellites even better than I had seen them with the larger Washington telescope. At the same opposition I saw Deimos with the 7½-inch glass at Amherst College—the smallest I believe with which that object has ever been detected.

Fifteen years more rolled round, and it was 1907. The surface of Mars had



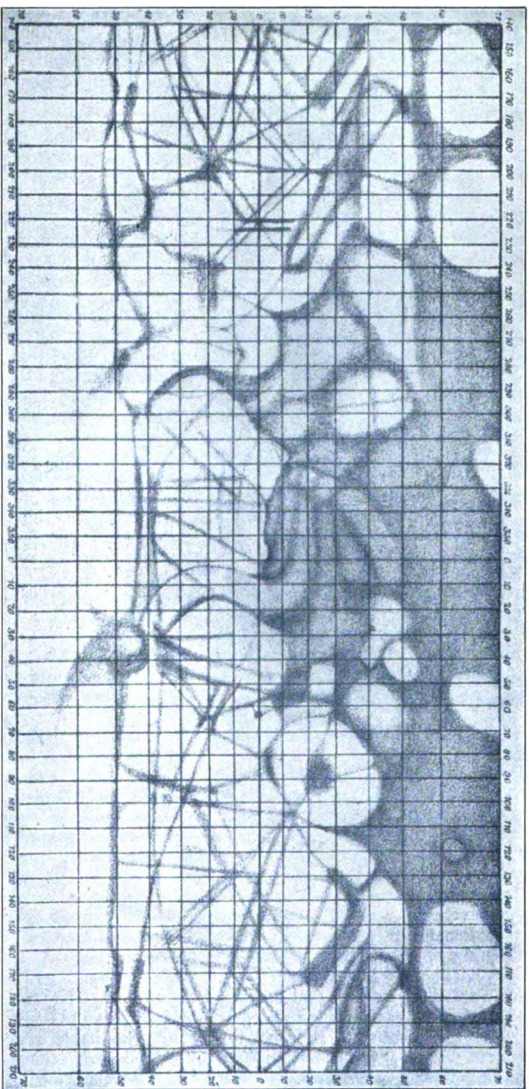
HOW MARS LOOKS ON THE PHOTOGRAPHIC PLATES

Showing exact size of the planet's image, reproduced from the films taken with the 18-inch telescope at Alianza, by the photographers of Professor Todd's party. Small as they are (only 3-16 inch in diameter) they not only show the polar snow-caps distinctly, but in every case bring out the much-disputed canals. These latter are visible, however, only under high magnifying power.

become of wide interest to the public as well as to the professional astronomer. Mars was again at his nearest, Amherst now had a new eighteen-inch Clark telescope; the southern hemisphere was the only place where it could be used to advantage on Mars. Professor Lowell provided funds for transportation and subsistence, the steamship companies between New York and Valparaiso made concessions of rates, and so the Lowell expedition to the Andes was organized, and set sail from New York in May.

But no telescope of this great size, built as it is and adapted to one latitude, can be transported to another and used there unmodified. To go from the northern hemisphere to the southern required still other changes. Either the clockwork must move in the opposite direction, or at any rate the telescope's polar axis, which follows the motions of stars in the northern hemisphere, by turning round as clock-hands do, must revolve in just the opposite way for the southern. This was not very difficult for the man who built the telescope—a little juggling with gear wheels, and the thing was done. But from latitude 42° North to 21° South was not so easy. New castings had to be made to give the polar axis its appropriate tilt, so as to be always exactly in line with the visible pole of the heavens; and new counter-weights were needed to restore the balance of the pier and preclude its toppling over.

Of the clockwork of this telescope I can hardly say too much in praise; it is the most accurate piece of mechanism I have ever had to do with—a close embodiment of the ideal in the real. Everybody knows how the stars move dignifiedly westward—sun, moon, and planets also—each at its own particular rate. Whatever that is, in the case of Mars, the telescope must follow it with absolute and unerring precision, or the planet's highly magnified image would shift about on the plate during the two or three seconds of exposure. Anyone mechanically informed can see what a difficult problem this is—to move the two tons' weight of tube and axes and counterpoises with such precision that a powerful microscope might search in vain for even the slightest deviation from absolute uniformity. This was at last secured, however, by an ingenious compensating spring mechanism and an electric control current from an astronom-



MARS ON MERCATOR'S PROJECTION, SHOWING THE DOUBLE CANALS AND OASES

This map shows how fully our neighboring planet has been charted. It appears to justify Professor Lowell's contention that the markings commonly known as "canals" are the work of intelligent beings and show design. Nature has never, so far as man has observed, produced this peculiar formation. The "cracks" on the moon, the markings made by the cooling of lava, and the crevices of the earth's crust do not exhibit the peculiar regularity of straight lines and angles that characterizes these Martian features. All the probabilities point to an artificial origin and seem to vindicate the theory that they are tremendous channels constructed for purposes of irrigation.

ical regulator which had itself been regulated by the stars themselves. But as Mars near opposition is far from stationary among the stars, clearly our regulator had to be adjusted to the planet's idiosyncrasies of motion. And this must be done afresh every two or three days; then the Martian image stood motionless upon the plate, whatever the length of exposure.

A seven-ton telescope offers a quite different proposition in mere transportation from that of usual commodities. Of course it had to be taken to pieces, and then most of it could go classified as "machinery knocked down," all that was needed being especially careful packing. But the great lenses absolutely must suffer no risk whatever of rough or careless handling; and so, after being sewed tightly each into its own flannel bag, to prevent scratching of the delicate polished surfaces; wrapped in white tissue paper, for softness and "looks"; glued in tight manila bags, to exclude dust; and then packed in shallow boxes with resilient bags of cork stuffed closely all around them, to intercept a fatal shock, the lenses of flint and crown were carried with as much care as twin babies, all the way from Amherst to Iquique and back. Almost the only difference was that they didn't require feeding, and could be stowed away in the captain's cabin for days at a time with no thought except to look in occasionally and see that they were there—and they didn't cry when left alone. But now that the trip is over, I think real twins would have been less trouble, certainly less anxiety.

They started out from Amherst late one rainy May night in an automobile. At Springfield the drowsy porter protested: "Wha'd ye bring such things into a Pullman for? Why don't you check 'em?" For a day or two at New York they were perhaps as unsafe as anywhere on the whole trip—in a large storehouse not particularly fire-proof; in Panama they came near liquefying with the oppressive heat; in Iquique a ruinous tidal wave was a continuous and dreaded possibility; in the elevated desert pampa, at Alianza, earthquakes terrified us every little while, though fortunately the worst one held off till after our work on Mars was finished and the big lenses were securely packed for home again.

These special disks were the work of C. A. R. Lundin, M.A., optical expert of

Alvan Clark & Sons, but the mounting of the telescope was built in large part by Mr. Albert G. Ilse, the instrument-maker of that firm, whom I also appointed mechanician of the Lowell expedition. For expert photographer Professor Lowell selected and specially trained for the work Mr. Earl C. Slipher, who had been on duty many months at the Lowell Observatory in Arizona. Our working force was further supplemented by Mr. R. D. Eaglesfield, Amherst '09, as general assistant. The entire expedition was bent on getting the best possible photographs of Mars, and worked together harmoniously to that end. For weeks at a time it was Mars, Mars, unadulterated Mars, although many other things astronomically well worth while were also accomplished.

Of much importance were our series of drawings of Saturn at its ringless phase and our experiments in the higher Andes, which look toward ultimate successful occupation of even the loftiest mountains for astronomical purposes, as Newton suggested centuries ago; at least, it has been shown that such occupation is physiologically feasible. Just the gain to astronomy and meteorology from continuous residence on Chimborazo, say, no one can predict; but by using compressed air the *soroche* or *mal de montagne* is escaped, and our expedition laid down the keel of a method of high-elevation work, and I hope to be present at the launching, although years may lapse in building.

I may say in general that in the selection of a station for planetary photography, perhaps most exacting of all astronomical work, three essentials must be regarded: the sky must be clear, the air optically steady—the "seeing" must be fine, as astronomers say—and there must be no wind, vibration of the telescope from any cause being fatal to perfect negatives.

To find a spot on this terrestrial ball that will satisfy all three of these conditions is by no means easy. At most available places, while it may be nearly cloudless all night, the water-vapor of the air occasions unsteadiness and scattering of rays of light as an inevitable result—as we say, the "seeing" is fair, indifferent, or unqualifiedly bad. At other places, while it may be both clear and steady, gusty or violent winds are almost always present, preventing the delicate clockwork of a big telescope from



THE MARS OBSERVATION PARTY MOUNTING THEIR TELESCOPE AT ALIANZA, CHILE



THE EIGHTEEN-INCH REFRACTING TELESCOPE USED BY PROFESSOR TODD IN OBSERVING AND PHOTOGRAPHING MARS

following a planet with that absolute precision needed in photographing it.

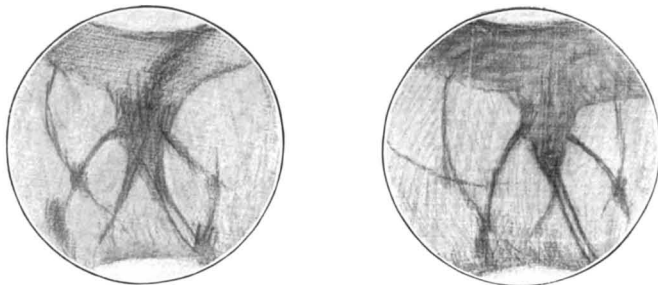
Of the entire southern hemisphere Africa had no mountains, Australia was too far away, and South America's eastern coast too verdure-clad for steady air, so I had but the west coast to choose from—a region I had never before visited. On to the south we steamed. Guayaquil and Quito were passed because a little too far north, and likely to be cloudy besides; Callao and Lima, because I got word that the season was not good up the Oroya Railway and among the mountains; Mollendo and Lake Titicaca, ditto. To one in search of cloudless lands it was, in fact, a dismal voyage from Panama down—the sun but three or four days visible, and the stars practically never.

Still we kept on. Our old Scotch captain vowed he'd never seen anything like it, in a lifetime's sailing up and down the coast—the climate must have changed utterly since the great Valparaiso earthquake of the year before. At Iquique we were abreast of the extensive desert wilds of Tarapacá, about as far south as seemed safe; so I resolved to land the telescope and risk the fate of the expedition, although Iquique itself and the

grim cliffs in its background were clouded heavily. But here I soon found that totally different conditions prevail in the elevated pampa above Iquique; so there I decided to go. And most fortunately. A desert meant rainlessness and no need of dome or protection for the telescope; in the desert of Tarapacá it meant practical cloudlessness, too, especially through the night.

Our vice-consul at Iquique, Mr. Edward E. Muecke, was untiring in his efforts in behalf of the expedition. Through him I soon met Mr. E. F. Homfray and Mr. C. W. Evans, resident managers of one of the important nitrate companies; and by their courtesy I arranged to locate the telescope and quarter the expedition at Alianza, their largest *oficina*, where vast quantities of nitrate are extracted from the earth and prepared for shipment.

About sixty miles inland from Iquique, to the southeast, Alianza lies near the western slope of an elevated table-land or saline desert, rather more than three thousand feet above the sea. The Nitrate Railway Company runs daily trains through the pampa; without them and the obliging and interested courtesy of Mr. J. Mayne Nicholls, the manager we could not have



DRAWINGS OF MARS AS SEEN THROUGH THE GREAT TELESCOPE LAST JULY

The above drawings were made by Mabel Loomis Todd at Alianza and were sent to the Cosmopolitan by Professor Todd. They show how plainly the double canals appeared to the observer through the clear atmosphere of the higher Andes.

reached Alianza, nor without the *oficina* at destination could we have survived a week. The region is an utter desert; the moon itself could not reveal greater barrenness—not a tree or a flower or a blade of grass for miles, not even moss or lichens.

When the station for Alianza was reached, luckily it was not a trail only, to house and village, but a spur track of standard gage with a quaint little car, a white mule, and an Indian rider. The clustered dwellings of workers in the nitrate fields, making a village of perhaps three thousand persons, gave an almost populous effect to the barren landscape, and the chimneys and tanks of the *maquina*, where crude nitrate is put into marketable form, rose just beyond with happy promise of all sorts of mechanical aid in setting up the telescope. On a low hill stood the manager's dwelling, a house of generous proportions; and around the whole settlement stretched the solemn, brown, impressive pampa, undulating to the great mountain border, the Andes, its peaks here and there snow-capped, lofty, and magnificent. Here, in the midst of all this forbidding waste, we found one of the best astronomical stations ever occupied, and a most comfortable and delightful home for all the weeks of our sojourn.

Many were the fortunate things discovered as we first surveyed the locality critically. Mr. W. Brooke Comber, resident manager of the *oficina* at Alianza, took immediate and hearty interest in our plans, and provided labor and materials for our work to begin at once. It was already June 17th, less than a month before Mars would be at his nearest. Together we saw

at once that the recently built tennis-court in front of his dwelling was an ideal place for the telescope, and so on its concrete floor the instrument was set up. Construction of a pier was saved, although with a somewhat disastrous interruption of the happiness of tennis experts; and unremitting toil enabled us to put the big telescope at work on the fourth night.

Wind there was little, and the prevalent direction was such as to blow the dust and steam from the *maquina* safely away from all interference with our activities.

All the photographic preparations for the Mars work had been made with the greatest care before we left home, at the Lowell Observatory, in Flagstaff, Arizona, where Mr. Lampland first succeeded, in 1905, in photographing the canals of Mars. Gaertner, of Chicago, was given the order to build a planetary camera, practically a duplicate of the one at Flagstaff, with a suitable enlarging lens for lengthening the focus of the Amherst telescope nearly sevenfold, or about 150 feet. Then a variety of novel plate-holder attachments were introduced, by which as many as fifty or sixty images can conveniently be taken on a single plate about $3\frac{1}{2}$ inches square, the counterpart of those at Flagstaff. Special plates, too, had been selected with the greatest nicety from Mr. Lampland's experience; and Mr. Wallace of the Yerkes Observatory prepared special color-screens. This important work was entrusted to Mr. Slipper and Mr. Ilse, who took all the Mars photographs.

Once the telescope was set up and adjusted at Alianza, it was in use every clear

night, straight through to sunrise. This meant every night but three from June 23d to August 1st, when we began to dismount. Not only was the sky clear of clouds, but it was more than usually transparent; best of all, the air was optically steady. And superadded was the almost total absence of wind at night; the quiet serenity of the clear, starlit midnight sky made it an astronomer's paradise. Night after night we spoke our neighbor planet, as he sailed across our desert zenith in quiet majesty.

Rarely did the *camanchaca*, or fog, blow in from the sea—sometimes, if not too thick or deep, it advantageously blankets down the heat rising from the pampa, to the great improvement of subsequent vision. Often the daytime and early evening seeings were bad, but throughout most of the night conditions were exceptionally favorable for high-class astronomical work. I think it safe to say that the Buenaventura region of this southern pampa is one of the best spots on earth for locating a permanent all-the-year-round observatory.

Late in July I visited Pica, a desert oasis almost due east of Iquique, at an elevation of nearly five thousand feet. When the railway is completed, Pica will be found a spot well worth careful investigation. Late in the night the air was steadier at Pica than at Alianza, but there was also more cloud.

On first looking at Mars through a large telescope from a great elevation, as the Chilean pampa, with the sky perfectly clear, the air steady, and a high magnifying power on the planet close to the zenith, every observer, whether professional or unprofessional, was amazed at the wealth of detailed markings that the great reddish disk exhibited. Its clear-cut lines and areas were positively startling in their certainty; the splendor of that first visual glimpse in steady air can never be forgotten. First seen were the large polar caps, instantly recognizable, and hardly less obvious than the planet itself. Then, between them, a vast assemblage of curiously conformed and variously hued areas which challenged accurate and complete representation by the pencil. And spread about in all directions over these desert regions was the marvelous complex of canal and oasis, in a connected and seemingly artificial network.

Nearly everybody who went to the eye-

piece saw canals; and once I fancied I heard even the bats, as they winged their flight down the pampa, crying, "Canali, canali, canali!"

Photography alone was competent to grapple with the intricacy of this network. And most fortunately we had the best camera and plates and developer to do this. Seed L orthochromatic and Cramer isochromatic instantaneous were most depended on. Practically every plate exposed has canals on it, and perhaps twenty exhibit clearly the mysterious double canals, photographed for the first time at Flagstaff at this opposition and at Alianza. The Nilokeras and Thoth, Euphrates and Phison, Astaboras and Djihoun, Amenthes and others came out on the plates double, to our great delight and gratification, as the crowning success of the expedition. The air should have been a little steadier, the telescope a little larger, and the photographic process a little better, for perfectly ideal conditions. But as it is our plates ought to silence forever the optical-illusion theorists.

Night after night the little automatic plate-holders went on with their click, click, click, for all the hours of darkness. One night was much like another; our summer's work on Mars gave us something over nine thousand separate photographs of the planet in all. And beginning with the Syrtis Major in June, our plates were pretty evenly distributed all the way round the surface of Mars, and back to the Syrtis again, with a little overlapping. Already Professor Lowell and his able corps have been for some months at work upon them, and their substantial advances in areography will not be open to question.

I shall touch but lightly and in outline on the interpretation of our work, as it must be many months before the photographs can be critically examined, enlargements from them made, their salient points measured up and projected on a globe, and ultimate deductions drawn as to the meaning of all the delicate tracery. Meanwhile, we can safely and confidently say this. Nobody ever questions the fact that Mars turns round on an axis, just as the earth does, and in about forty-one minutes longer time. Nor do the obvious polar caps leave so much as a shadow of doubt of the direction in which that axis stands: its tilt to the planet's path round the sun has been measured over and

over again, and is very nearly the same as the earth's to its own orbit.

Clearly, then, this settles the question of seasons upon Mars—they will be substantially the same as ours on the earth, only much longer, because it takes Mars longer to go around the sun. And they will be less intense, less pronounced, because Mars has a much less dense atmosphere than ours. But we know about the Martian seasons quite as well as we do our own—when spring and summer, autumn and winter begin on Mars, how long each lasts, that the seasons alternate in the northern and southern hemispheres, and so on. All this we know as a deduction from exact astronomy, precise observation, and infallible mathematics conjointly. And we can accurately foretell the recurrence of these seasons for indefinite years to come, even if we were never to look at Mars again through the telescope.

Now the very curious and highly significant thing about the delicate, spider-line markings called canals is this: in the Martian winter they cannot be seen; as spring comes, the canals begin to reappear, fine and very faintly at first; with summer their filamentous markings attain their full development, and with them their connecting links, the oases, also; with the progress of autumn all vanish rather rapidly together, and are again invisible throughout the planet's winter.

This is observed to go on year after year, in one and the same cycle, and that cycle is coincident in position as well as period with the motion of Mars around the sun; that is, with its year, or, we may say with entire confidence, with its seasons. The fact of this regular seasonal fluctuation disposes at once of all such theories as that the canals are a merely ocular phenomenon—all in the astronomer's eye, so to speak—and that they are cracks in the planet's surface, and nothing else. For either of these theories to be true, we must always see canals whenever we look at Mars, wholly independently of the time of year and the Martian season. And every observer of Mars knows this is not so.

So far we have trod with practical certainty. Now for a working hypothesis as to what the complex network of canals may mean. Old earth again furnishes a ready clue to the mystery.

Just as there is no reason for supposing the Martian polar caps to be of any sub-

stance different from the ice and snow bonneting our own poles, so the first and obvious explanation of the seasonally variant canals is vegetation.

The more I visit arid regions of the earth, and observe the devices of desert-dwellers to coax the growth of even the sparsest vegetation, the more the truth of Lowell's theory of the Martian canals impresses itself upon me. Mars, older by cosmic eons than the earth, and farther on in planetary development, has but a small supply left of either air or water. The great yellowish areas formerly called seas are rather, in all probability, deserts, and the polar caps, conserving water in winter, are utilized at their melting, and the water is distributed over the arid plains.

During this last summer, in the desert of Tarapacá and in similar wastes of Peru, I saw vast areas, or oases, saved from engirdling sands by just a little water—water not in great gulfs or rivers or lakes, but a tiny rivulet merely, systematically diverted from its course again and again, with the parched soil divided and subdivided in geometric figures till nothing was left of the original stream but an infinitude of trickles. But as we approached these oases of the Chilean mountains, or receded from them, they seemed one vast and consecutive mass of vegetation, much darker than the desert around. Imagine yourself suspended high above such terrestrial sands, as in a balloon, only hundreds or thousands of miles away, and the likeness of Mars to the earth and the earth to Mars would be compelling.

So it seems to me the canals on Mars are quite satisfactorily explained on the vegetation theory; at least I know of no other that comes into competition with it. No natural cracks ever assume any such regularity of figure. And of course no one now supposes their entire breadth—anywhere from five to twenty miles—to be a clear, unbroken body of water, as their unfortunate name "canal" (blunderingly translated from Schiaparelli's *canali*, meaning channels simply) would indicate.

I am free to say, too, that the canal and oasis system *in toto*, as looked at steadily night after night, impresses me more and more, not as a natural but as an artificial system, wholly or in part. This means of course acceptance of the habitation theory of Mars. And why not? Life is here, and

has apparently developed the organic out of the inorganic. The little we know of nature's workings on the earth points with practical certainty to her gift of life to every nook and crevice of the cosmos where it is ready to offer her a foothold—all the more on Mars where conditions cannot be very dissimilar to the lofty mountain heights of the Andes, where I found man and many types of animal and vegetable life enjoying a useful existence, in spite of what Professor Lowell excellently calls "pronounced inhospitality of environment." But all were unconscious of it, because it had come to them through countless generations. Even the crucial question of temperature has been reinvestigated by Professor Lowell, with fuller cognizance of all the elements concerned; and it now seems certain that Mars, in spite of his greater distance from the sun, enjoys an average surface temperature not very inferior to that we know here on the earth.

This fascinating argument for the habitableness of Mars need not be pursued further. As a knowledge of favorable conditions on that planet, or any other, approaches a certainty, with equal certainty may we say that life of one type or another is sure to exist there. Of what type, the biologist alone must surmise: perhaps it is a fair question whether, given protoplasm and all the elemental conditions that favor the evolution of organisms, man or some type of intelligent being closely resembling him would not be bound to develop. Intelligent, we believe, he must be.

If you ask me then, "Do you think Mars has been inhabited in the past?" I answer, "Yes, probably." Because we have excellent evidence of a favorable environment and works apparently artificial on the planet's surface. And if you ask further, "Do you believe it is inhabited now?" I reply, "There is no reason why not." Because life's adaptability to variations of terrestrial environment, of which I know,

leads me to the willing conclusion that Martian beings would be endowed with no less power of adaptation to their own environment, whatever that may be. Most absorbing, then, are these glimpses of our next-door neighbor in outer space. And no less absorbing, too, are the logical deductions of reason from the phenomena of our simple vision. For it is as much the legitimate realm of science to search out the true explanation of what we observe as to make the observations themselves.

Sensational? Granted; but this is nature's fault. Can anything be more sensational than her own uncounted light years, and infinitude of eons, and unfathomable depths of the abysmal space?

Whatever our achievements of 1907, the work can at best be called but preliminary to that now seemingly within early future reach. The September opposition of 1909 will bring Mars to within 36,000,000 miles only, as against 38,500,000 in 1907. A much larger telescope is a necessity, to afford larger images and more light for shorter exposures, and a new photographic process is needed most of all, so that the coarse grains of our present dry plates may be replaced by much finer and more sensitive ones. This will allow not only shorter exposures, but a greater magnification of the original images for purposes of subsequent study.

Broadly considered, then, I may call our Andean expedition of 1907 a rehearsal for 1909—so soon here that preparation is already in order and begun.

After that, Mars in the future as in the past swings farther and farther away at each returning opposition, until in 1924 mountain observatories, larger telescopes, and keener photographic processes will all play their part in threading the labyrinthine mystery of Martian oasis and canal; and a perfected ethereal telegraphy may, well within reason, permit intelligible speech from planet to planet, across the cosmic void. *Quien sabe?*