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William Sheehan *Editor*

Camille Flammarion's The Planet Mars

As Translated by Patrick Moore

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Editor
William Sheehan
Willmar, MN, USA

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Editor's Preface

In November 1893, a wealthy Bostonian, Percival Lowell, was in Japan, as he had been off and on for a decade, renting an 18-room Tokyo house with no clear idea as to what he was going to do when he sailed from Yokahama Bay back to the United States. Toying with the idea of an Easter jaunt to Seville with a friend, he had no sense of imminent destiny, no idea that by then he would be headlong into what his biographer David Strauss called the "daring enterprise" of founding an observatory, at first a temporary and makeshift one, for the purpose of studying Mars and trying to answer the question of its being an abode of intelligent life.

Lowell was back in Boston by Christmas, and there, a great thumping book awaited him that would determine his fate. It was a gift of his old aunt Mary Traill Spence Lowell Putnam, the sister of the late poet James Russell Lowell: *La Planète Mars et ses Conditions d'habitabilité*, Volume 1, by the French astronomer and prolific writer Camille Flammarion. Seldom has a more fateful collision of a book and a man occurred.

The author of that book, Nicolas Camille Flammarion, had been born into modest circumstances in 1842 at Montigny-le-Roi in the department of Haute Marne. His passionate interest in astronomy was awakened at the age of 5 when he witnessed the July 8, 1842 total eclipse of the Sun. By 11, he was using a pair of opera glasses and discovering with them, "Mountains in the moon, as on earth! And seas! And countries! Perchance also inhabitants!" (Flammarion 1890). When he was 14, his parents faced financial ruin and had to surrender their property. They moved to Paris, where his father found employment in a photographic studio. There were no longer funds to keep Flammarion in school, and he went to work as an engraver.

In his spare time he was "taken up with cosmographical questions, and working on a big book on the origin of the world." The manuscript, entitled *Cosmogonie universelle*, grew to 500 pages long. It came to the notice of a physician who called to the home to treat Flammarion for an illness. Recognizing a precocious talent, the physician recommended him for employment as a human computer at the Paris Observatory, then directed by Urbain Jean Joseph Le Verrier, the mathematical genius whose calculations had pointed the way to a new world, Neptune. Flammarion later recalled his reverential feelings when he entered the sublime building dating from the reign of Louis XIV:

> I entered it as though it were a temple, or a holy sanctuary, with all the innocent ardor of the neophyte. There was not the least shade of skepticism; and despite my poverty, I did not think in terms of present payment or future gain. I lived alone for science.

His expectations of Le Verrier were at first romantic:

> Since my childhood I had seen the name of the illustrious astronomer recorded on maps of the sky, for this planet had borne his name for several years, in the classic books, before it was called Neptune. This scientist, this genius, who had discovered a star with the tip of his pen… and had boldly rolled back the frontiers of the System of the World, this man was for me a kind of saint, an inhabitant of the heavens.

He was soon disillusioned. Le Verrier was long on mathematics but short on interpersonal skills. At their first meeting, the Director gave him an elementary mathematics exam. He passed. He was then summoned to the Director's large office. The great man dismissed him with a brief statement: "You start on Monday. Farewell, and to your work." The work involved standing at a desk from 8 till noon and then from 1 till 4, doing mind-numbing computations. Flammarion's assignment was the correction of the apparent positions of stars observed with a telescopic instrument known as a meridian-circle for effects of atmospheric refraction, which required him to take columns of numbers and add or subtract them from the recorded positions, all day, day after day after day. "After the first week," he would bitterly recall, "one manages to carry out this work almost unconsciously—and while thinking of something else…. From my first days of service, I perceived that of my five colleagues, none cared the least for astronomy."

A poet at heart, he could never reconcile himself to the drudgery of his routine. He dreamed of other worlds, and their possible inhabitants.

He had lost the Catholic faith of his youth, finding it irreconcilable with post-Copernican astronomy. He substituted for it another faith, based on the teachings of Jean Reynaud, whose *Terre et ciel* (1854) promoted the idea of the immortality of the soul. Each soul, Reynaud taught, passed from planet to planet, progressively improving at each stage. Flammarion was also familiar with the works of such pluralist authors as Fontenelle, de Bergerac, and Huygens, and "consecrated the year 1861" to the writing of a book advocating the plurality of worlds, "enflamed with a fiery ardor as one has at age nineteen, not doubting for an instant that I would demonstrate to myself that my conviction in extraterrestrial life was well founded" (*Memoires biliographiques et philosophiques d'un astronomer*, Paris, 1911, pp. 218–219).

The result was a 56-page booklet, *La Pluralité des mondes habités* (the plurality of the inhabited worlds), which laid out the program of what became the preoccupation of his life. On the title page, he grandly introduced himself as "ancien calculateur a l'observatoire impérial de Paris, professeur d'astronomie, member de plusiers sociétés savantes, etc." Le Verrier disapproved of the extracurricular activities of his young computer, and after a curt meeting, dismissed him from the observatory staff. But the booklet, as Flammarion recalled long afterward, "at once made my reputation. It was published by Mallet-Bachelier, the printer to the observatory, at two francs a copy, and the first edition was immediately sold out. I was then approached by the publisher Didier, who offered to undertake the second edition, for which purpose I rewrote many of the chapters, and made important editions to the text." The second edition grew to 468 pages, and by 1835 had gone through a 35th edition.

Flammarion, still in need of a regular income, managed to catch on as a computer at the Bureau des Longitudes where he worked for a few more years, but he had discovered his real talent—science journalism. While employed at the Bureau, he joined the staff of the scientific magazine "Cosmos," founded by the well-known popularizer of science the Abbé Moigno, and also began collaborating on a scientific review, "Le Magasin Pittoresque." He also began contributing to "Le Siècle," the most important daily in Paris at the time. He moved into a house in the Rue Gay-Lussac, near the Luxembourg, and carried out astronomical studies of sunspots and the surface features of the Moon in a small private observatory, and was appointed a professor at the École Turgot. He resigned from the Bureau in 1867 in order to devote full time to writing and lecturing. That year he joined the French Aerostatic Society, of which he was named president, and commenced a series of balloon ascensions, which included one undertaken as a honeymoon with his 8 days' bride, Sylvie Pétiaux, on August 28, 1874. "What could be more natural," he asked, "than for an astronomer and his wife to fly away thus like birds?" The voyage lasted 24 hours, and ended in a descent at Spa.

All the while Flammarion remained a whirling dervish of literary activity. He published one or two titles a year, including: *Les Mondes imaginaires et les mondes réels* (1865), *Le merveilles célestes; lectures du soir* (1865), *Études et Lectures sur l'astronomie* (1867, 1869, 1872, etc.), *Dieu dans le nature* (1867), *Les Ballons et le Voyages aériens* (1867).

During the war with Prussia, Flammarion was appointed captain of engineers, and with other astronomers was involved in observing the Prussian batteries at Saint Cloud and Meudon from a small observatory established by the government at Passy.

After the Commune, he moved into an apartment on the fifth floor of a house at 16, rue Cassini (it still exists), close by the Paris Observatory. During a visit by Robert H. Sherard (Oscar Wilde's friend and early biographer), who visited Flammarion and his wife there in 1894 (see: R.H. Sherard, "Flammarion the Astronomer: his home, his manner of life, his work," *McClure's Magazine*, 1894),

> It is certainly splendidly situated, commanding views, on all sides, over Paris, and flooded with light. Outside the windows may be seen the tops of the trees of the Avenue de l'Observatoire, which is just opposite the astronomer's study… The apartment is modestly furnished. The dining-room, which is the first room into which the visitor enters, is remarkable only for an immense window which takes up the whole side of the room, reaching from the floor to the ceiling, and arranged so as to serve as a conservatory, in which are a number of plants and flowers. The walls are decorated with astronomical maps…. Against the wall, at the side of the tilted stove, is a bookcase … filled with cases fashioned to represent volumes. Each case is used for the classification of the papers which the savant receives from all parts of the world, referring to various branches of astronomical study. Thus "Mars" and

"Jupiter" each have their case, the other planets being disposed of in one labeled "Planets Other than Mars and Jupiter." The leather dining-room chairs are decorated each with one of the signs of the zodiac."

In 1873, Flammarion set up a small observatory with a 108^{mm} aperture refractor, and with this small glass observed Mars in 1873. His chief interest at the time was double stars, however. As he explained, "At the time I approached the subject, that is to say, during 1873, to my surprise I discovered a total absence of documents concerning them. A number of questions, which so far have been unanswered, presented themselves to my mind. How many double or multiple stars are known? What is their proportion to the number of single stars? In the total number of groups which have been discovered, how many are simply optical phenomena due only to the effect of perspective, and how many are genuine or physical systems?… The only way to solve [these] questions was to examine, in a detailed manner, each one of the eleven thousand double stars which up till then had been discovered; to compare my observations with those previously… This is what I did." By this time he and Le Verrier had become reconciled. Once more the Director of the Paris Observatory in 1873 (he had been pulled down by his staff in 1870 but was reinstated in 1873 after his successor drowned), Le Verrier was very interested in Flammarion's researches into double stars, and placed at his disposal the 15-in ($0^{m}.38$). equatorial in the east tower of the Paris Observatory (of poor optical quality, it was usually stopped to 8 in ($0^{m}.20$)). By the end of 1877, Flammarion had the materials for his *Catalogue des étoiles doubles et multiples*, which he noted with pride a few years later, "has since become a classic in every observatory throughout the civilized world" (for a review, see *The Observatory*, 2 (1878), 376–380).

Flammarion's real breakthrough came in 1880, with the enormously successful *Astronomie populaire*. Published, at his insistence, by his brother, Ernest, the book became a runaway bestseller by the standards of the time, selling 131,000 copies during the author's lifetime, and in addition was translated into numerous languages. Flammarion received one franc royalty per copy. (No doubt, as he later confessed, his brother made very much more out of the work than he had himself.)

Flammarion would never again have to worry about money. Also, he had many admirers. One woman, whose lovely shoulders he had praised at a dinner party, willed that on her death the skin be removed and made into leather. In due course, she died, and her wish was realized as a leather-bound copy of the *Astronomie populaire*, which still exists. More importantly, a nobleman named Méret, of Bordeaux, an admirer of Flammarion's researches and popular writings but totally unknown to him, wrote in 1882 asking the astronomer accept the fee simple of a chateau, complete with stables and horses, at Juvisy-sur-Orge. The chateau occupied the site where a lodge known as "Cour de France" had existed since the time of Charles VI as a stopover for the kings of France on their annual journeys to Fontainebleau. Louis XIV had reportedly enjoyed taking coffee in the hollow of a celebrated yew tree here. The present building dated to 1730. There, in the salon, on March 30, 1814, the emperor Napoleon learned of the capitulation of Paris and of the fall of the Empire. Flammarion accepted the generous bequest, and established a private observatory, the maintenance of which, together with the salaries of his employees, was provided for by subscription among still other admirers.

Henceforth, Flammarion would divide his time between Paris and Juvisy. From November to May each year he could be found at 16, rue Cassini; from May to November at Juvisy. The money realized by the success of *Astronomie populaire* was used to hire contractors and builders to transform the ancient chateau into an observatory, boasting a cupola housing a fine 24-cm (9.5-in.) Bardou refractor (recently restored). That same busy year, 1882, Flammarion founded the journal "Monthly Review of Astronomy" (*l'Astronomie*). Though it would never pay its way, Flammarion was glad to subsidize it as the only serial publication devoted to astronomy in France at the time. In 1887 he founded the Société Astronomique de France. It was quartered in the Hôtel des Sociétés Savantes (residence of learned societies) in the heart of the Quartier Latin of Paris, with Flammarion's 108^{mm} refractor housed in a cupola on top of the building. During this time Flammarion was competing with himself, as the Société's Bulletin and *l'Astronomie* were published separately for 8 years; but in 1895 the two were merged. The combined journal, *l'Astronomie*, has run continually to the present day.

The planet Mars had always been one of Flammarion's main interests. As early as the first edition of *La Pluralité des mondes habités*, he had written:

> The world of Mars is so like the world of the Earth that, if one day it were ever possible to make a trip there, and forget how we came, it would be almost impossible to recognize the one that is our homeland. But for the Moon, which would rise to charitably put to rest our uncertainty, we would be at great risk of arriving among the inhabitants, and supposing ourselves in Europe or some other such place.

Not only did he observe the planet with his 108^{mm} refractor at the opposition of 1873, but in 1876 he drew up a map, *Carte géographique provisoire de la planète Mars*, on which he offered a system of nomenclature; it was first inserted in his book *Les Terres du Ciel* (Lands of the Sky) and presented to the Académie des sciences on 27 August 1877, just as Mars was swinging around to one of its exceptionally favorable perihelic oppositions. At that opposition, Asaph Hall at the U.S. Naval Observatory in Washington, D.C. discovered the satellites of Mars, while Giovanni Schiaparelli, at the Brera Observatory in Milan, produced a sensational new map which introduced not only a new nomenclature (displacing other schemes, including Flammarion's own; it is the basis of that still in use today) but showed the enigmatic features he called *canali* (canals). At Juvisy, Mars henceforth became the chief object of research. Flammarion intended that the observatory should be a nerve center of Martian observations all over the world, and thought that by gathering together and impartially analyzing all existing document, it might be possible to solve what he referred to as the "Martian enigma." His writings strongly endorsed the idea that conditions on the planet were favorable to life, and that it was almost certainly inhabited—so much so that when in 1891 a Madame Guzman, of Bordeaux, decided to bequeath 100,000 francs as a prize to be named after her deceased son Pierre, yet another keen admirer of Flammarion's writings, "for the person of whatever nation who will find the means within the next 10 years of communicating with a star (planet or otherwise) and of receiving a response, Mars was specifically excepted. As Flammarion explained (*La Planète Mars*, vol. 2, 1909, p. 500):

> Unfortunately, M. Guzman followed my writings on the planet Mars with such passion that he was quite convinced … that the question had already been asked and was half-solved, so that his venerable mother had the bizarre idea of excluding Mars from this magnificent contest.

During the winter of 1891–1892, in his study at 16, rue Cassini, Flammarion was engaged in a systematic survey of the already vast literature of the red planet on a scale which has perhaps never been attempted and rarely been equaled by any other single author. His routine at about this time (for he was a man of regular habits) was described to Sherard by Sylvie Flammarion:

> He is an extremely methodical man. He gets up regularly every morning at seven o'clock, and spends quite a long time over his toilet. Savants, as a rule, are not very tidy, but Flammarion is an exception to the rule. At a quarter to eight every morning he has his first breakfast, at which he always takes two eggs. From eight to twelve he works. At noon he has his *déjeuner*, over which he spends a long time. He is a very slow eater. From one to two he receives, and as he knows everybody in Paris, and as he is constantly being consulted on all sorts of questions by Parisian reporters, he is usually kept very busy during this hour. From two to three he dictates letters to me, and as he receives thousands of letters from all parts of the world, especially when anything new in the branch of astronomical science is occupying public attention, my time is fully occupied. At three o'clock he goes out and attends to his business as editor of the monthly magazine which he founded, and to his duties as member of various societies. He is back home again at half-past seven, when he has dinner, and spends the rest of the day in reading. He is a great reader, and tries to keep himself *au courant* with all that is said on the important topics of the day. At ten o'clock he goes to bed, for he is a great sleeper.

What is described here is, of course, his winter routine. During the warmer months, when he was at Juvisy, he would frequently spend entire nights in the observatory when the seeing was fine.

Advancing steadily in his grand project of reviewing the entire literature of Mars published up to this time, the methodical and meticulous man produced what would be nothing less than an encyclopaedic work on the subject: *La Planète Mars et ses conditions d'habitibilité*. The first volume, containing all the observations from 1636— shortly after the invention of the telescope—through 1890, appeared just as the planet came to its favorable perihelic opposition in August 1892. Of all Flammarion's books—and he published over seventy titles, not counting the many editions some of them went through, this was his Martian masterpiece—*La Planète Mars*, vol. 1 is perhaps the one work, of all his voluminous corpus, that still repays close attention today. (A second volume of the work, but only covering observations made between 1890 and 1900, was published in 1909; it is of interest only to specialists. A third, covering the period between 1900 and 1910, was in preparation at the time of his death in 1925; it has never been published.)

The stimulus of this great work was decisive and immediate. Percival Lowell was only the most illustrious of its readers. The vagabond Bostonian's receipt of that gift from Aunt Mary at Christmas 1893 directly propelled him to launch the expedition to Flagstaff, Arizona Territory, for the purpose of observing Mars at the favorable opposition of October 1894. (I have examined all of Lowell's annotations of the book; they testify to the close attention he gave to the work.) Arriving at the mesa on Mars Hill at the end of May, where he caught up with borrowed telescopes sent ahead by his assistants W. H. Pickering and A.E. Douglass, Lowell penned a poem testifying to the impulse to adventure and to what he expected to find on the planet. It is entirely Flammarionesque in theme:

One voyage there is I fain would take
While yet a man in mortal make;
Voyage beyond the compassed found
Of our own Earth's returning round….
[And] when staid night reclaims her sphere
And the beshadowed atmosphere
Its shutters to sight once more unbars,
Letting the universe appear
With all its wonderworld of stars,
My far-off goal draws strangely near,
Luring imagination on,
Beckoning body to be gone,—
To ruddy-earthed blue-oceaned Mars.

Readers of *La Planète Mars* will recognize, especially in its later chapters summarizing his views about the changes in the Martian features, on the polar caps and atmosphere, the canals and conditions for life, all the ideas in embryonic form that Lowell would develop into his startling book *Mars*, published in 1895, in which he asserted the existence of a Martian civilization of canal-builders. Lowell had to do little more than connect the dots. Immediately after seeing *Mars* through the Press, on December 10, 1895 he sailed on the Spree with Alvan G. Clark, who was to create the lens for the famous refractor that Lowell set up on Mars Hill, and on arriving in Paris, enjoyed dinner with the Flammarions at their home in Paris. He described the affair to his father, "There were fourteen of us, and all that could sat in chairs of the zodiac, under a ceiling of a place blue sky appropriately dotted with fleecy clouds, and indeed most prettily painted. Flammarion is nothing if not astronomical. His whole apartment, which is itself *au cinquieme* [on the fifth floor], blossoms with such decoration."

Flammarion was just 50 when *La Planète Mars* appeared. Though he lived another third of a century, the book marks the high-water mark of his career. He continued to observe with the Bardou refractor, though in the domain of practical astronomy he was soon surpassed by others. Lowell, equipped with the 24-in (61-cm). Clark refractor at Flagstaff, was at once acknowledged as the world's leading expert on the red planet; while even at Juvisy itself Flammarion was overshadowed by the extravagantly gifted amateur astronomer E. M. Antoniadi, who arrived via the Oriental Express from Turkey in the latter part of 1893 to become Flammarion's assistant, made a series of marvelous observations of the planets with the Bardou refractor, and then, achieving independence by marrying into wealth, left Flammarion's employment in 1902. As an "observateur volontaire" with the Grand Lunette of the Meudon Observatory, at the perihelic opposition of September 1909, Antoniadi made definitive observations of the surface markings on Mars so as to effectively demolish the canal illusion that had so puzzled Flammarion and others, once and for all.

As with H.G. Wells, after turning 50, Flammarion's best work was behind him. The habit of literary activity continued, of course, but he was now largely revered for his past achievements. He published his *Mémoires* in 1911. The following year he was named an officer in the Légion d'honneur. When war broke out in 1914, Paris was threatened by the advancing Germany army, he took up refuge first at Arachchon, then at Cherbourg.

Sylvie died in February 1919, and 7 months later he married Gabrielle Renaudot, who even during Sylvie's life had lived at the observatory as Flammarion's assistant and soul mate. She was 42; he was 77. From early days he had been as interested in psychic phenomena as in astronomy, and increasingly in these last years—with the losses of the war in everyone's mind, and his own death approaching—he returned with a will to the problem of life after death. Three volumes of *Avant la mort* appeared in 1920, 1921, and 1922, respectively. He was promoted to commander of the Légion d'honneur in 1922, and elected president of the Society for Psychical Research of London the following year. His last book, *Maisons hantées*, appeared in 1923. He died at Juvisy on 3 June 1925. He is buried, with Sylvie and Gabrielle, in the park of Juvisy.

The work of the observatory continued, under Gabrielle and assistant astronomer Fernand Quénisset, a skillful astrophotographer and noted comet discoverer, who had been Flammarion's assistant during 1892–1893 and again from 1906. Quénisset died in 1951, and Gabrielle—still serving as general secretary of the Société Astronomique de France—lived on until 1962. By then the chateau, too costly for her to keep up, was crumbling around her; it is now, alas, in ruins, but at least it has a new cupola under which the refurbished Bardou refractor is once more seeing active duty, under the auspices of the Société Astronomique de France. Through the courtesy of one of its officers, François Oger, I was able to make some of the first observations with the restored instrument, in February 2012, of Mars near its aphelic opposition; it was a cold night, the winds were high—or perhaps the revenants of Flammarion, Sylvie, and Gabrielle were restless. In the telescope, Mars was a small colored disk, which, in a moment of suspended disbelief, seemed the "ruddy-orbed and blue-oceaned" world of yore. It was a thing of beauty, and still able to stimulate the imagination.

La Planète Mars is a rare book today, and has never been translated into English. In 1980, an astronomy popularizer even more prolific than Flammarion, Patrick Moore, produced a translation, but until now the translation has been far rarer than the original. There were only four copies. I had one of them.

I came by it as follows. In 1993, I visited Patrick at his home in Selsey, Sussex. For several years we had corresponded about publishing translations of classic works of lunar and planetary astronomy—I had, for instance, undertaken at his request a translation from the German of part of Beer and Mädler's *Der Mond*. We began to discuss the Flammarion volume; Patrick's original plans to publish it were foundering, and he hoped that I might succeed where others had failed. But it proved more difficult than either of us expected. Patrick's transcript had been produced on his old 1908 Woodstock typewriter—this was before the computer era—so to begin with, the whole work had to be retranscribed. Also there were many editorial matters to attend to; by the end, the work was almost as much mine as Patrick's. Several times we thought we had found a publisher, but in each case they backed out when they realized the sheer scale of the project. Fortunately, and earning the gratitude of all lovers of things Martian, Springer has come to the rescue. I now present it at last, a work that will find "fit audience even if few" among the true lovers of the red planet.

I dedicate this book to the memory of my friend Patrick Moore, who unfortunately did not live to see it published, though he awaited it eagerly (and at times impatiently) for some three decades.

It is fitting that Sir Patrick's very first published book had appeared in 1950—*The Planet Mars* (London: Faber and Faber), a translation of a monograph by the French astronomer Gérard de Vaucouleurs. His last is a translation from French of Flammarion's book also entitled *The Planet Mars*.

Willmar, Minnesota, USA William Sheehan
May 23, 2014

Author's Preface

Astronomy should not stop at measuring the *positions* of the celestial bodies: it should also study *their nature*.

In acceding to the request that has been made to me to publish a specialist work about the planet Mars, establishing and defining the present state of our positive knowledge concerning the physical constitution of our neighbour world—of which studies are indeed already far enough advanced to merit a summary and a general discussion—I have hesitated for a long time before deciding upon the method which will give the best scientific results.

Two methods of presentation come naturally to mind.

One is to deal with our various observations and studies of Mars in special chapters, such as: distance from the Earth, revolution around the Sun, year, day, seasons, climates, calendar, light, heat, mass, density, gravity, volume, geography, continents, seas, polar snows, atmosphere, water and clouds, observed movements and changes, satellites, etc.—and to treat each of these subjects separately. The other is to take the planet as a whole, and give all the results, and the deductions arising from them, in simple chronological order.

I have chosen the second method, mainly because it seemed to me to be the more interesting inasmuch as it gives us an immediate picture of facts and deductions which in themselves provide a history of the planet; and also because it provides a better account of the gradual development of our knowledge—in particular that of the subject which dominates all our studies of our neighbour world: that of its physical geography, seas, continents and polar ices. This is undoubtedly the most essential part of our telescopic observations. Therefore, it seems more logical to give in chronological order the studies made, up to the present time, of this world—which because of its closeness to the Earth and its favourable position for observation seems likely to be the first to give us answers about the great and deep questions which thinking Man has been asking over the centuries, faced with the silent enigma of the starry heavens.

A technical work must explain *what* we know; the historical account tells *how* this information was obtained. This is an advantage: the progress of Science speaks for itself, and renders literary embellishment unnecessary.

We must agree, moreover, that this is the right moment to produce a work of this kind. The astronomical study of Mars is very advanced. We have had a very great number of excellent observations, begun two and a half centuries ago and continued ever since. But these observations have been heaped up in their hundreds and their thousands, and have not been compared with each other or analyzed in a way which will add to our knowledge of the planet.

Mathematical astronomy clearly leads on to physical astronomy, without which it would lose the greater part of its interest. We are looking at a great problem, not merely at the movements of stones in space. The masses of the celestial bodies are not all-important; the significance of the Sun, or of the Earth, does not lie only in its weight. The true philosopher looks higher and sees further; he looks out to fundamentals. He admires the mechanical bases of the system of the universe, but he does not stop there. When he uses a telescope to contemplate a world lost in the depths of immensity, he is naturally interested in its distance, its movements and its mass; but he wants to know more, and he asks about the nature of this world—what is its physical constitution from the point of view of habitability? This is what really interests him—everything leads to this end.

Physical astronomy was founded in the time of Galileo.[1] Its progress has been bound up with that of optics, and indeed it has gradually followed upon the improvements made in the construction of refractors and reflectors, above all with respect to increased magnification and—of paramount importance—clarity of image. But the enthusiasm of the observers, their patience, their perseverance, the practical perfection of their methods, and even their adaptation to the difficulties of their researches have made by no means been the least of contributions to the progress of practical optics itself.

This work presented here is divided naturally into two parts. The first is an account and a discussion of all the observations made of Mars, from the earliest, dating from the first half of the seventeenth century, up to the present time. The second part gives a résumé of our conclusions with regard to the general study of the planet.

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[1] But rarely appreciated, even by astronomers who write books. To cite one example: take the bibliography of astronomy, the *Traité d'Astronomie physique*, in five volumes out of eight, by J.B. Biot, Member of the Academy of Sciences, the French Academy, the Academy of Inscriptions, the Bureau of Longitudes, Professor of the Faculty of the Sciences of the Collège de France, etc. These five volumes of "Physical Astronomy" include no less than 2916 pages—of which less than 100 really deal with the physical condition of the celestial bodies! The physical constitution of Mars receives a grand total of one page (Vol. V, 1857, p. 401). This work would have been better called "Traité d'Astronomie *mathematique*." The same is true of most other authors. Delambre, speaking of the observations made of the rotation of Venus, the physical constitution of Mars and the spots on the Sun, dismissed such work as a waste of time! Etc.

Our first section is itself divided into three parts. The first begins with the very earliest observation, that of 1636, and extends up to the year 1830. It therefore includes almost two centuries. The drawings made during this period were rudimentary, and absolutely insufficient to give much idea of the physical constitution of the planet. The second period begins in 1830 and lasts until 1877. It sees the start of the study of Martian geography—or, to be more accurate, areography. During this period, studies made during the most favourable oppositions of Mars—the times of closest approach to the Earth—have led to more extensive and precise knowledge of the state of our neighbour world. The third period begins in 1877, with the first geodesic (areodesic) triangulation of the continental and marine surface of the planet, and continues today with the surprising discoveries and details with regard to this bizarre geography—and particularly to the changes in this remarkable country.

In the first period, information was obtained about the volume of Mars, the mass, density, surface gravity, axial inclination, lengths of the year and seasons, rotation period, and therefore the lengths of Martian days and nights and the existence of polar patches and their variations in summer and winter. It was deduced that the snows were analogous to those of our poles; astronomers began to think that the dark areas represented seas, and that the continents were yellow. The atmosphere was recognized rather than studied.

In the second period we find the first geographical maps of the planet, confirming that the polar patches are snows, which melt regularly under the influence of the rays of the Sun. It was thought that the only way to account for the dark areas was to consider them as seas, and it was found that their contours were subject to variations—the gulfs and estuaries of great rivers were traced. The atmosphere was chemically analyzed by means of the spectroscope, and the existence of water vapour there was proved; it was shown that the atmosphere could not be the cause of the red colour of the planet, because this colour is more pronounced near the centre of the disk, where the thickness of atmosphere as seen from the Earth is less than that near the edges of the disk where the colour is less pronounced. It was found that the temperature depends principally not upon the distance from the Sun, but upon the state of the atmosphere (e.g. the summit and the foot of Mont Blanc); and that certain vapours, notably water vapour, absorb the solar rays to a greater extent than some gases such as oxygen and nitrogen and it was recognized that the conditions for life on the surface of Mars are not essentially different from those on our own planet.

In the third period, areographical details were better distinguished and studied; the seas, the lakes, the gulfs, the straits and the rivers were drawn, watched and followed, so that surprising variations were seen unmistakably—the discovery was made of an enigmatical réseau of dark lines crossing all the continents in the manner of trigonometrical outline. It was suggested that the changes might be due to water flow; it was also recognized that the atmosphere is generally clearer than that of the Earth, and that clouds are rare, particularly in summer and near the equatorial regions. Analogies with the Earth grew in certain aspects, while in other respects dissimilarities were confirmed.

These three periods; therefore, form natural divisions in the first part of the present work. The second part gives the results and ends with a discussion.

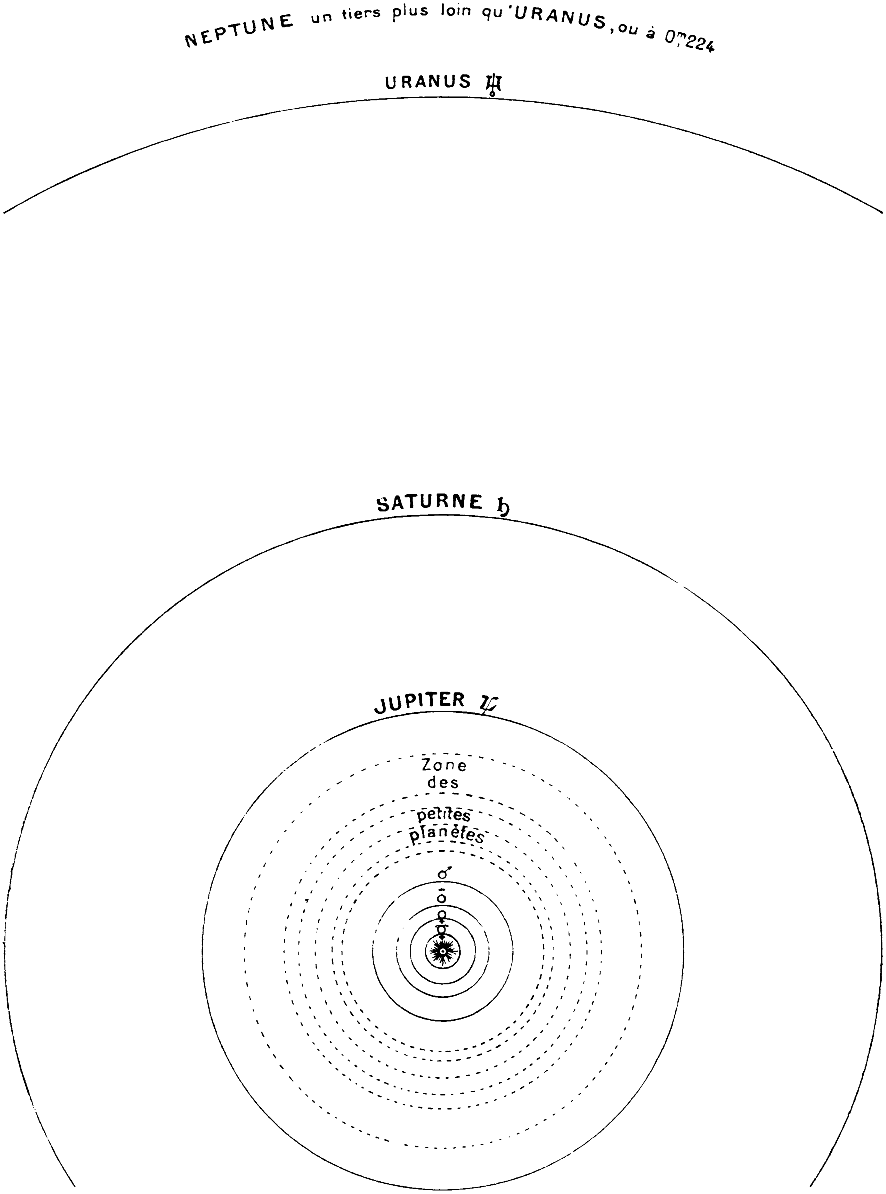
We Earth dwellers, accustomed to judging phenomena according to the evidence of our eyes, and unable to imagine the unknown, have extreme difficulty in explaining phenomena which are strange to our own planet, and consideration of them can even plunge us into hopeless embarrassment. For example, on Mars we observe variations, which are certainly real, and are not minor, in the tone of the dark patches, which are regarded as seas. There is nothing analogous on the Earth, at least to a comparable degree. On Mars we also see a geometrical réseau of straight lines, crossing each other at angles, and which have received—not without analogy—the name of *canals*. On Earth we have nothing comparable to guide us in explaining these features. We are dealing with a new world, incomparably more different from ours than the America of Christopher Columbus, differed from Europe. How can we give an exact interpretation of these telescopic discoveries? All our efforts should be directed toward this interpretation, without preconceived ideas and with complete independence of spirit.

I propose to deal here with all the observations, and with all the accounts which have been written in every language.

It is very clear that the only way to attain anything like a complete knowledge of the state of the planet is to make a comparison between all these observations. The historical method used here speaks for itself. Scholars who want to gain a precise knowledge of the planet will have all the evidence and all the documents in front of them.

I cannot end this Preface without thanking MM.Gauthier-Villars, who have published this scientific work so excellently. They also know that scientific research is the aim of modern man, and that it is valuable to give the widest possible dissemination to the intellectual public, of the great and brilliant concepts of the present-day astronomy.

Before going further, let us give an exact statement of the position of Mars in the Solar System. Later we will study the orbit from the viewpoint of its precise elliptical form and its relations with the orbit of our own Earth round the Sun. For the moment it will suffice to give a table of the distances of the planets from the Sun.



Plan of the Solar System, drawn at the precise scale of $0^{mm}.8$–20 million km

Planet	Distance from the Sun			
	Earth=1	Millions of km		
Mercury	0.387	57,678		
Venus	0.723	107,772		
Earth	1.000	149,000		
Mars	1.524	227,031		
			Millions of kilometers	
Minor planets	2.175 to 4.262	Maximum zones of asteroidal density:		324 355 408 464 510 635
		2.38		
		2.74		
		3.12		
		3.42		
Jupiter	5.203	775,217		
Saturn	9.538	1,421,281		
Uranus	19.183	2,858,312		
Neptune	30.053	4,478,195		

The diagram has been constructed from the numerical data, on a scale of 1 mm–20 million km. This was the only way to show a plan of the Solar System in the format of this book and even then the orbit of Neptune would not fit on to the page. The diagram shows that Mars and the Earth are both comparatively close to the Sun. This is important, and it is interesting to take exact account of the position of our sister world compared with ours.

I have adopted a solar parallax of 8″.82, which is the most probable value. The distance corresponds to 149 million km.

We are now ready to begin telling the astronomical history of Mars, and to study our neighbour world without any preconceived ideas.

Juvisy Observatory, Juvisy-sur-Orge, France Camille Flammarion
August 4, 1892

Translator's Preface

Camille Flammarion's great book is the most complete study of the history of observations of Mars ever written. It is now almost a century old, and for some strange reason it has never before been translated. I feel that it will be of use to historians of astronomy, which is why I have undertaken the translation.

Only four copies of this typescript exist. One is in the library of the British Astronomical Association, one in the Library of the Royal Astronomical Society, one at the Lowell Observatory in Arizona, and the last in my own library.

Selsey, Sussex, UK
23 August 1980

Patrick Moore

Contents

Part I
Presentation and Discussion of Observations

First Period, 1636–1830

The first period of what we may call the history of Mars began with the first telescopic views of the planet, obtained in the seventeenth century. The first drawing was made at Naples, by Fontana, in 1636. We are concerned here with physical astronomy rather than mathematical astronomy; otherwise this monograph would have had to begin with Kepler's work, *De motibus stellae Martis*, published in 1609.[1]

Until the invention of optical instruments the observation of the planets, as well as the stars, was limited to determinations of their apparent positions on the celestial sphere. With the naked eye we can indeed see these brilliant objects circling in the sky. Thinkers had deduced that the planets are celestial bodies without light of their own, that they are analogous to the Earth, and that they shine only by reflected sunlight. Copernicus, in his immortal astronomical reformation (1543), had announced that in the future men would probably invent instruments capable of proving that the planets show phases, and so must be non-luminous, as is the Earth. Similarly, we of today must hope that the day will come when by methods unknown to our science we will obtain evidence of the existence of inhabitants of other worlds, perhaps even putting us into communication with our brothers in space. People laughed disdainfully at Copernicus' temerity, just as skeptics of today laugh at ours; it is only too easy to follow calmly in the rut of the past. However, even in Copernicus' own century—in 1590, 47 years after the death of the canon of Thorn—a Middelbourg

[1] This work of Kepler's begins as follows: "Durissima est bodie conditio scribendi libros mathematicos, præcipue astronomicos." The same reflections are valid today for works on pure astronomy. How many readers will my present book have? Assuredly, very few. Most inhabitants of the Earth are not greatly concerned with the sky, and do not even know that their world is part of it; they are ignorant of where they are, and live in a remarkable ignorance of reality. This ignorance satisfies their native indifference.

C. Flammarion, *Camille Flammarion's The Planet Mars*, Astrophysics and Space Science Library 409, DOI 10.1007/978-3-319-09641-4_1

optician, Zacharie Jansen, invented the first telescope, if we accept the evidence of the earliest authority.[2]

The telescope was perfected 16 years later by Hans Lippershey, who was another optician in the same town. However, it was not at once turned toward the sky. In 1609, after receiving reports from Holland about the invention, Galileo constructed the first telescope to be pointed skyward, and immediately (in January 1610) discovered the satellites of Jupiter. Shortly afterwards he discovered the phases of Venus, thereby confirming Copernicus' prediction and providing direct proof of the new system. The first observations published by Galileo were those of the satellites of Jupiter, made on 7, 8, 10, 12 and 13 January 1610.

During the years 1610, 1611 and 1612, astronomical discoveries came in rapid succession: spots on the Sun, the geography and mountains of the Moon, the satellites of Jupiter, and the starry nature of the Milky Way. Galileo, Kepler, Fontana, Scheiner and Rheita earned reputations, and discovered in the mysteries of the heavens, things that had been previously hidden from the eyes of Earthmen.

The size of the lunar disk, the extent of the largest sunspots, the brightness of the satellites of Jupiter, the richness of the Milky Way: all these early discoveries were made with rudimentary telescopes of low magnifying power. Galileo's first refractor gave a magnification of only 3–4×. The immortal astronomer then managed, in succession, to achieve magnifications of 7, 10 and even 30 diameters; but he could go no further. His skill, patience, and perseverance enabled him to make marvelous discoveries with this modest instrument. This celebrated telescope of Galileo's has been carefully preserved, and is now in the Academy at Florence. The astronomer Donati put it into my hands one day, and also one of Galileo's rulers, which had been preserved at the Academy. It was not without emotion that I touched these venerable relics. It seemed to me that his first refractor, which had ushered in modern astronomy, had kept something of the glory of the past centuries. After sunset I recaptured the spirit of the Florentine astronomer on one of the beautiful Italian

[2] The invention of the first telescope has been lost in the unknown past. It is certain that in 1609 Galileo constructed a refractor, and then, on 7 January 1610, discovered the satellites of Jupiter. (I published a facsimile of his first drawings in *Les Terres du Ciel*, in the chapter dealing with the satellites of Jupiter.) It is equally certain that from 1606 to 1608 the name of Lippershey was known in Holland as making telescopes. But a work by Pierre Borel, physician to the King, member of the Academy of Sciences, author of *Discours prouvant la pluralité des Mondes* which I have quoted in *Les Mondes imaginaires*, claimed in 1655—that is to say, only half a century after the invention—that the "first inventor" was Zacharias Jansen, whose portrait he gave, while the second was Hans Lippershey (sic.), whose portrait was also given. The work is entitled *De vero telescopii inventore* (1655). Chapter XII of this treatise, entitled "De inventioris vero nomine," specifically discusses the point. The author wrote sometimes under the name of Zacharias Jansen, sometimes Zac. Joannides; the second sometimes Lipperhey, sometimes Lipperseim. All names at this time were Latinized, and on retranslating the Latin into French I had had to make new modifications. Thus, for example, Jean Muller took the name of his native town, Königsberg, and from its royal mountain called himself Regiomontanus. This name translated into French becomes Dumontroyal.

Whatever may be said about the first essays into optics, the year 1609 was the time of construction of the first astronomical telescope, by Galileo, and, practically speaking, the observation of 7 January 1610 was the first of all.

terraces, just as the stars were coming out. With feverish excitement I turned this marvelous tube toward the new worlds that he had discovered in the heavens. I recalled that he had shown these sights to those who were incredulous, and he still shows them to us today from his grave.

Because the disk of Mars is always very small, even when the planet is closest to the Earth, these primitive instruments, which magnify the disk only slightly and give poor definition, could show nothing whatever on the Martian surface.

Galileo observed Mars during his first year of observation, 1610. In his telescope the disk of the planet was barely measurable. On 30 December 1610, he wrote to P. Castelli: "I ought not to claim that I can see the phases of Mars; however, unless I am deceiving myself, I believe I have already seen that it is not perfectly round."[3] Kepler calculated the phases of Mars in his *Epitomes Astronomiæ*, Book V, Part V (1621), where he called the greatest phase of Mars, *perfectio phases dichotomæ*. However, he never observed it, and treated the problem only from a geometrical point of view.

Improvements in telescopes followed rapidly. There was tremendous enthusiasm at the time. People were eager to discover the inhabitants of the Moon, or at least to see their handiwork. There was feverish excitement. Lenses of great focal length were made, which were troublesome to use and full of imperfections; new combinations of lenses were invented to improve the clarity of the images. The skill and energy of opticians did not keep pace with the ambition of observers. Nevertheless, from 1636—that is to say, 37 years after Galileo's first telescope—a Neapolitan scholar, Fontana, emulated Galileo and Kepler; he made a better telescope, and under the clear sky of Naples was able to make good observations of the spots on the Moon, the Pleiades, the phases of Venus, and the planet of which I propose to write the history.

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[3] When Mars is closest to the Earth, it shows a disk 30″ in diameter. To the naked eye it is a very brilliant point, a star of the first magnitude, glittering at night-time even though it shines only by light reflected from the Sun.

Galileo's telescope, magnifying 4×, showed Mars as large as a pea 7^{mm} in diameter seen from a 12^{m} distance.

A telescope magnifying 60 times shows it as a small pea seen from $0^{m}.80$ or a little larger than the Moon as seen with the naked-eye.

A power of 100, as a pea seen from $0^{m}.47$.

A power of 200, as a peach $0^{m}.06$ in diameter seen from $2^{m}.28$.

A power of 300, as the same peach seen from $1^{m}.42$.

A power of 500, as an orange $0^{m}.08$ in diameter seen from $1^{m}.12$.

A power of 1000, as the same orange seen from $0^{m}.60$.

A power of 1500, as the same orange seen from $0^{m}.36$.

An object will subtend an angle of 1° of arc when its distance from the eye is 57 times its own diameter.

An orange $0^{m}.08$, $4^{m}.56$ distant, subtends an angle of 1°, twice as large as the Moon seen with the naked eye, and equal to Mars seen with a magnification of 120×. A power of 1,200× corresponds to a distance of $4^{m}.56$ for the same object. A moment's reflection shows that powers of from 500× to 1200× are enough to make the disk of Mars conveniently large.

1636–1638.—Fontana

Here, then, are Fontana's observations. I will give all the observations in chronological order; I will discuss them, compare them, and from them draw out progressively the conclusions, which have led up to our present knowledge of the physical constitution of the planet.

The Neapolitan astronomer published his observations in a work entitled *Novae cœlestium terrestriumque rerum observationes*, Naples 1655. I have this work in front of me, and I am happy to share its curiosities with my readers.

Here are the two oldest drawings of Mars, made by this lawyer, optician, and astronomer. The first is from 1636—he does not give the date exactly. The second is from 24 August 1638. Fontana wrote this legend (Figs. 1 and 2):

> 1636: Martis figura perfecte spherica distincte atque clare conspicebatur. Item in medio atrum habebat conum instar nigerrimae pilulae.
>
> Martis circulus discolor, sed in concava parte ignitus deprehendebatur. Sole excepto, reliquis aliis planetis, semper Mars candentior demonstratur.

I have translated this as follows:

> 1636. The form of Mars was observed to be perfectly spherical. In its centre was a dark cone in the form of a very black pill. The disk was of many colours, but appeared to be flaming in the concave part. Except for the Sun, Mars is much the hottest of all the stars.

Here is the second observation:

> Die 24 augusti, anno 1638.—Martis pilula, vel niger conus, intuebatur distincte ad circuli, ipsum anbientis, deliquim, proportionaliter deficere; quad fortarse Martis gyrationem circa proprium centrum significat.

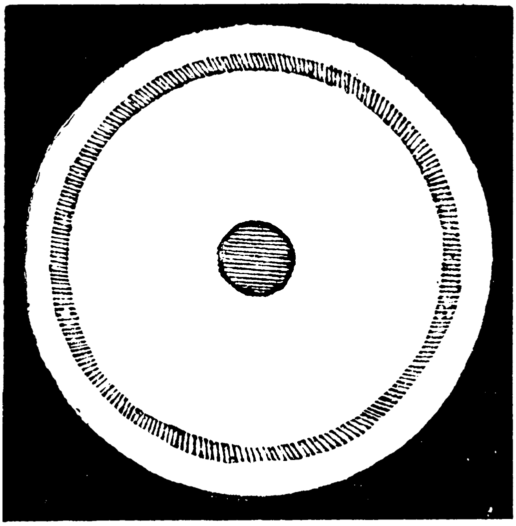

Fig. 1 First drawing of the disk of Mars, Fontana, 1636

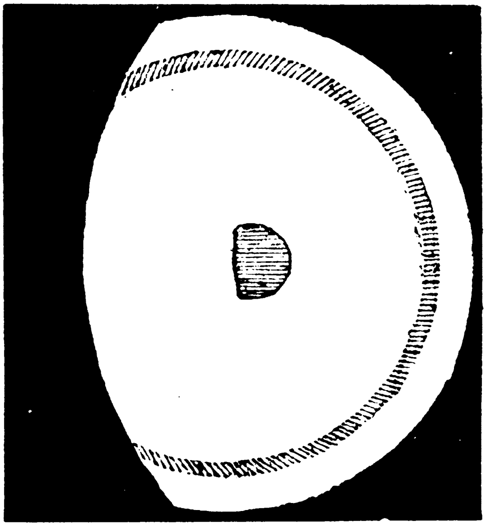

Fig. 2 Second drawing of Mars, done by Fontana in 1638

(Translation): "The pill, or black cone, showed up distinctly, with a phase proportional to that of the disk, which may perhaps indicate a rotational movement of Mars around its centre." (I admit that I cannot understand this phrase; does he mean that the patch was proportionally displaced?)

This "pill" or "small ball" seen at the centre of the disk of Mars was the first patch ever seen and drawn on this planet. These are the first two drawings ever made of Mars. I offer them to my readers in their naive aspect, if only as an historical curiosity.

The phase in the second figure is very exaggerated. Mars can never appear like that. The exact value of the phase has been given in this chapter. But at least Fontana did notice the phase of Mars. The spot is not, of course, real; it was an optical effect, due to a reflection, perhaps rather a sort of extinction of the light-rays, in the lenses of Fontana's telescope (Figs. 3 and 4).

Everything points to this interpretation: (1) the position of the round patch in the middle of the disk during the first observation: (2) the phase, corresponding with that of the planet, at the second observation. (3) the analogous effects in his drawings of Venus, here reproduced as a matter of curiosity, made on 11 November in 1645 and 22 January 1646, and in the description of which he even used the same term, "pill." These drawings of Venus are interesting to us now only because they show the phase.

But despite this, it is not without interest to publish here the very first drawings of Mars ever made—if only to preserve them.

Fontana began his book with a historical study of the invention of the telescope. He believed that the ancients had telescopes (though we know today that these were tubes without glass). He recalled what Porta had said about Ptolemy's mirror, which allegedly enabled Ptolemy to see ships at a distance of 700 miles. Fontana wrote that he had been unable to find out who had re-discovered optical instruments, and