

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.

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 mathématique*." 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.

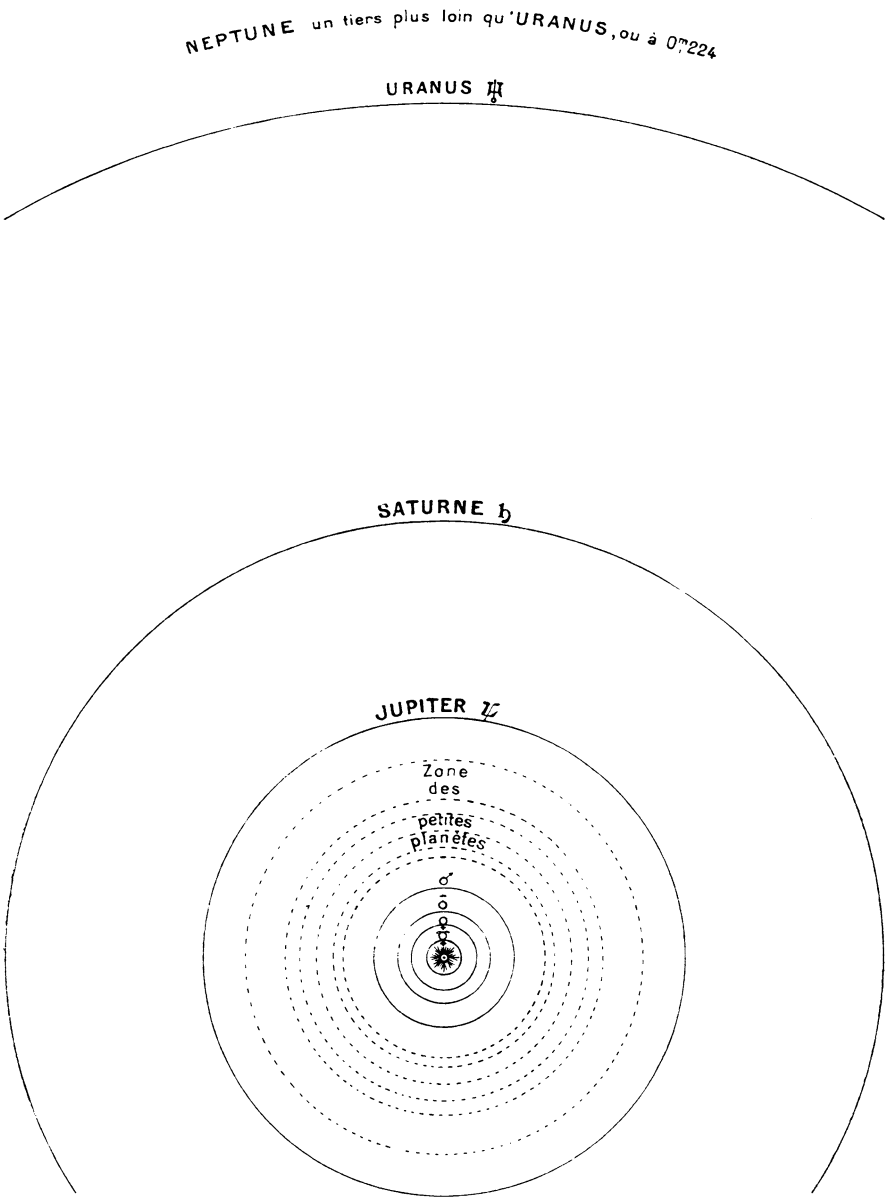
We Earth dwellers, accustomed to judging phenomena according to the evidence of our eyes, and unable to imagine the unknown, have extreme difficulty in explaining phenomena which are strange to our own planet, and consideration of them can even plunge us into hopeless embarrassment. For example, on Mars 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
		2.38		355
		2.74		408
		3.12		464
		3.42		510
Jupiter	5.203	775,217		635
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.

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