PTOLEMY

The career of Ptolemy is one of the most remarkable in history. There never has been any other discoverer whose authority on the subject of the movements of the heavenly bodies has held sway over the minds of men for so long a period as the fourteen centuries during which his opinions reigned supreme. The doctrines he laid down in his book, *The Almagest,* prevailed throughout those ages. No important correction was made of the serious errors with which Ptolemy's theories were contaminated. The authority of Ptolemy as to all things in the heavens, and as to a good many things on the earth, was invariably final.

Though every child may now know more of the actual truths of the celestial motions than ever Ptolemy knew, the fact that his work exercised such an astonishing effect on the human intellect for some sixty generations, shows that it must have been an extraordinary production. We must look into the career of this man to discover wherein lay the secret of the success which made him the unchallenged instructor of the human race for such a protracted period.

Ptolemy was a native of Egypt, and though it has been sometimes conjectured that he belonged to the royal families of the same name, yet there is nothing to support such a belief. The name, Ptolemy, appears to have been a common one in Egypt in those days. The time at which he lived is fixed by the fact that his first recorded observation was made in 127 AD, and his last in 151 AD. When we add that he lived, in his own words, "on the parallel of

Alexandria," we have said everything that can be said so far as his individuality is concerned.

Ptolemy gathered up the wisdom of the philosophers who had preceded him. He incorporated this with the results of his own observations, and illumined it with his theories. His speculations, even when they were, as we now know, erroneous, had such an astonishing verisimilitude to the facts of nature that they commanded universal assent. Even in these modern days we frequently find lovers of paradox who maintain that Ptolemy's doctrines not only seem true, but actually are true.

In the absence of knowledge of mechanics, philosophers in early times were forced to fall back on certain principles which they derived from their imagination as to what the natural fitness of things ought to be. There was no geometrical figure so simple and so symmetrical as a circle, and as it was apparent that the heavenly bodies pursued tracks which were not straight lines, the conclusion followed that their movements must be circular. There was no argument in favor of this notion, other than the merely imaginary reflection that circular movement, and circular movement alone, was "perfect." It was further believed to be impossible that the heavenly bodies could have any other movements save those which were perfect. Assuming this, it followed in Ptolemy's opinion, and in that of those who came after him for fourteen centuries, that all the tracks of the heavenly bodies were in some way or other to be reduced to circles.

Ptolemy devised a scheme by which the apparent changes that take place in the heavens could be explained by certain combinations of circular movement. This seemed to reconcile so completely the scheme of things celestial with the geometrical instincts which pointed to the circle as the type of perfect movement, that we can hardly wonder Ptolemy's theory met with the astonishing success that attended it. We shall, therefore, set forth with sufficient detail the various steps of this famous doctrine.

Ptolemy commences with laying down the undoubted truth that the shape of the earth is globular. The proofs which he gives of this fact are the same proofs we give today. There is, first of all, the circumstance of which our books on geography remind us, that when an object is viewed at a distance across the sea, the lower part of the object appears cut off by the interposing curved mass of water.

Ptolemy adduced another argument, which demonstrates the curvature of the earth in a very impressive manner. He mentions that travelers who went to the south reported, that, as they did so, the appearance of the heavens at night underwent a gradual change. Stars that they were familiar with in the northern skies gradually sank lower in the heavens. The constellation of the Great Bear, which in our skies never sets during its revolution round the pole, did set and rise when a sufficient southern latitude had been attained. On the other hand, constellations new to the inhabitants of northern climes were seen to rise above the southern horizon. These circumstances are incompatible with the supposition that the earth was a flat surface. Had

this been so, a little reflection will show that no such changes in the apparent movements of the stars would be the consequence of a voyage to the south. Ptolemy set forth with much insight the significance of this reasoning, and even now, with the resources of modern discoveries to help us, we can hardly improve upon his arguments.

Ptolemy illustrated and enforced his subject by a variety of demonstrations. I must add one of them, not only on account of its striking nature, but also because it exemplifies Ptolemy's acuteness. If the earth were flat, said he, sunset must necessarily take place at the same instant, no matter in what country the observer may happen to be placed. Ptolemy, however, proved that the time of sunset varied greatly as the observer's longitude was altered. To us, of course, this is quite obvious; everybody knows that the hour of sunset may have been reached in Great Britain while it is still noon on the western coast of America. Ptolemy had, however, few of those sources of knowledge which are now accessible. How was he to show that the sun actually did set earlier at Alexandria than it would in a city which lay a hundred miles to the west? There was no telegraph wire by which astronomers at the two places could communicate. There was no chronometer or watch which could be transported from place to place; there was not any other reliable contrivance for the keeping of time. Ptolemy's ingenuity, however, pointed out a thoroughly satisfactory method by which the times of sunset at two places could be compared. He was acquainted with the fact, which must indeed have been known from the very earliest times, that the illumination of the moon is derived entirely

from the sun. He knew that an eclipse of the moon was due to the interposition of the earth which cuts off the light of the sun. It was, therefore, plain that an eclipse of the moon must be a phenomenon which would begin at the same instant from whatever part of the earth the moon could be seen at the time. Ptolemy, therefore, brought together from various quarters the local times at which different observers had recorded the beginning of a lunar eclipse. He found that the observers to the west made the time earlier and earlier the further away their stations were from Alexandria. On the other hand, the eastern observers set down the hour as later than that at which the phenomenon appeared at Alexandria. As these observers all recorded something which appeared to them simultaneously, the only interpretation was, that the more easterly a place the later its time. Suppose there were a number of observers along a parallel of latitude, and each noted the hour of sunset to be six o'clock, then, since the eastern times are earlier than western times, 6 p.m. at one station A will correspond to 5 p.m. at a station B sufficiently to the west. If, therefore, it is sunset to the observer at A, the hour of sunset will not yet be reached for the observer at B. This proves conclusively that the time of sunset is not the same all over the earth. We have, however, already seen that the apparent time of sunset would be the same from all stations if the earth were flat. When Ptolemy, therefore, demonstrated that the time of sunset was not the same at various places, he showed conclusively that the earth was not flat.

As the same arguments applied to all parts of the earth where Ptolemy had either been himself, or from which he

could gain the necessary information, it followed that the earth, instead of being the flat plain, girdled with an illimitable ocean, as was generally supposed, must be in reality globular. This led at once to a startling consequence. It was obvious that there could be no supports of any kind by which this globe was sustained; it therefore followed that the mighty object must be simply poised in space. This is an astonishing doctrine to anyone who relies on what merely seems the evidence of the senses, without giving to that evidence its due intellectual interpretation. According to our ordinary experience, the very idea of an object poised without support in space, appears preposterous. Would it not fall? we are immediately asked. Yes, doubtless it could not remain poised in any way in which we try the experiment. We must, however, observe that there are no such ideas as upwards or downwards in relation to open space. To say that a body falls downwards, merely means that it tries to fall as nearly as possible towards the center of the earth. There is no one direction along which a body will tend to move in space, in preference to any other. This may be illustrated by the fact that a stone let fall at New Zealand will, in its approach towards the earth's center, be actually moving upwards as far as any locality in our hemisphere is concerned. Why, then, argued Ptolemy, may not the earth remain poised in space, for as all directions are equally upward or equally downward, there seems no reason why the earth should require any support? By this reasoning he arrives at the fundamental conclusion that the earth is a globular body freely lying in space, and surrounded above, below, and on all sides by the glittering stars of heaven.