

2271 p. 24.
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1906
IN: GREEK THINKERS

CHAPTER IV.

THE DEVELOPMENT OF THE PYTHAGOREAN DOCTRINE.

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Each day the sun runs his course from east to west. Simultaneously he climbs higher up the sky to sink at the end of a few months from the height he has reached. The combination of his daily and annual movements has the effect of the windings of a screw or spiral—something like the shell of a snail—and like it, too, the intervals between the circles contract as the zenith is approached. This view was hardly likely to satisfy inquirers who had approached the question of celestial motion in the confident belief that it was "simple, steady, and regular." It may be permissible to blame this belief as a prejudice; but though it was in part a preconceived opinion, yet the closer observation of facts tended

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generally to confirm it. And even where such confirmation was wanting, the belief was of excellent use as a principle of research, just like the kindred assumption of a teleological purpose in the structure of organisms. It was possible to get rid of the confusing irregularity. For a complex movement may be irregular while the partial movements that compose it are regular. What was needed was an act of mental separation. And the clue was found by separating the daily movement of the sun from its annual movement. At this point our early philosophers had a brilliant flash of inspiration. They conceived the daily movement of the sun and moon, and indeed of all the whole starry heaven, as not real at all, but merely apparent. Their supposition that the earth was moving from west to east enabled them to dispense with the assumption that the sun, moon, planets, and fixed stars were moving in an opposite direction. The question suggests itself here, Did these Pythagoreans recognize and teach the rotation of the earth round its axis? Our answer is: They did not do that, but they did recognize and teach the existence of a movement which operated in a precisely similar manner. It was, so to say, the rotation round its axis of an earth-ball with a considerably enlarged circumference. They represented the earth as circulating in twenty-four hours round a central point, the nature of which will presently occupy us. Here, however, the reader should familiarize himself with a simple feature of this doctrine. A moment's reflection will show him that, for any given point in the earth's surface, and for its shifting relations with the sun, moon, and stars, it makes not the remotest difference whether the ball on which it is situated revolves on its axis in the course of a day, or describes a circular course, while facing the same directions, which brings it back to its starting-point in the same limit of time. We can hardly exaggerate the importance of this discovery. The revelation that there were apparent heavenly motions broke the barrier that obstructed the path to further progress. The central position of the earth and its immobility

had both been given up, and the way was open for the Copernican doctrine which followed after an interval the extraordinary brevity of which is hardly sufficiently recognized. Nor need we be at all surprised that an equivalent for the theory of rotation was adopted instead of the theory. For though we never actually see a luminary turning on its axis, yet changes in its position are matters of daily and hourly observation. Nothing, then, could be more natural than that scientific imagination, which had just succeeded by a mighty effort in freeing itself from the delusions of sense, should have been content to replace the apparent immobility of the earth by a movement moulded on familiar models, and not by one unique in its kind and entirely without a parallel.

The centre round which the earth was now admitted to move served equally as the centre of the rest of the luminaries, which had formerly been supposed to revolve round the earth. The moon accomplished its course once a month; the sun once a year; the five planets visible to the naked eye required various periods, which, with the exception of Mercury and Venus, were considerably longer; finally, the firmament of fixed stars, whose daily rotation had been recognized as apparent, was similarly equipped with a circular movement of its own, though of a very much slower order—a conception which may either have been due to the mere desire for conformity, but which is far more probably to be ascribed to that change of position already observed and taken in account which we call the precession of the equinoxes. The daily movement of the sun—or rather, according to this theory, of the earth—took place in a plane which was now recognized to incline towards the plane in which the annual movements of the sun, moon, and planets were situated; in other words, the obliquity, whether of the equator or of the ecliptic, had been recognized, and the new conception was thus completely adequate to explain the changes of the seasons.

We come now to the problem of the central point round

which the heavenly bodies were to move in concentric circles. It was no ideal centre, but rather an actual body, consisting of universal or central fire. The enemies of Philolaus call it "a dreary and fantastic fiction," but those who try to throw themselves with temperate judgment into the modes of thought obtaining in the dawn of science will rather call it "the product of analogical inferences, the force of which must have been well-nigh irresistible." The assumption that the heavenly bodies described circles was not merely approximately true, but apart from the circular segments traversed by the sun and moon on the firmament, it appeared that no other conclusion could be derived from the circular courses described before our eyes by the circumpolar fixed stars that never set; and though that movement, like the movement of the whole firmament of fixed stars, had now been recognized as purely apparent, yet the daily motion of the earth that took its place was bound to have the same circular character. Here, accordingly, the type was given, conformably with which all the heavenly bodies had to move. But human experience supplies no example of circular movements without an actual centre. A wheel turns on its axis; a stone, attached to a string for the purpose of slinging, turns round the hand which holds it and which sets it in motion; and, finally, when divine worship invited Greek men and women to the dance, the altar of the god formed the centre of their solemn and rhythmic paces. It may be asked, however, what need there was of inventing a central fire, when it actually existed and was visible to every man's eye. What was wanted was a centre of motion and a source of vigour and life. But instead of accrediting the universal light of the sun with the rank that belonged to it, a luminous body was invented whose rays no mortal eye had seen, and, considering that the habitable side of the earth was turned away from the central fire, no mortal eye would ever see. It was an hypothesis removed by a perverse ingenuity from every chance of verification, and one wonders why its mistaken authors did not rather jump straight away at the heliocentric doctrine, and rest satisfied therewith.

Three sufficiently valid solutions may be suggested for this problem. Remembering that the delusions of sense are only abandoned by degrees, and that the human mind habitually follows the path of least resistance, we have first to note that the heliocentric theory was bound to be later than that of rotation round an axis. It was obviously impossible to let the earth revolve round the sun in a daily and yearly course simultaneously, and we have already learned to justify the precedence of the Pythagorean equivalent over the rotation theory. A second considerable obstacle to the prompt admission of a heliocentric or Copernican astronomy lay, we conceive, in the exact similarity between the sun and moon. The great luminary of day and his more modest sister of the night were visible to men as two heavenly bodies regularly relieving each other and combining to measure time by their revolutions, and it was plainly impossible that, except by a process of elimination, shutting out every other issue, men would ever be brought to believe that luminaries so closely connected differed in the fundamental point that the moon was condemned to ceaseless wandering while the sun was vowed to eternal rest. But, thirdly and chiefly, universal fire was more satisfactory as the centre of the world than the sun. Our sun is the central point of a system of luminaries by the side of which countless other systems exist without visible design or recognizable order. Human intelligence resists this belief, as it resists every other call to renunciation, till the compulsion of fact leaves it no second alternative. But first it demands a uniform picture of the world instead of a fragmentary view of this kind, and the demand springs from the natural impulse towards lightening and simplifying the intellectual complexus—an impulse assisted in the present instance, indeed, by highly developed æsthetic and religious wants.

It will be readily admitted that this picture of the universe owed no little to the contribution of the emotions and the fancy. The circular course of the divine luminaries which had been raised by the fictitious counter-earth to the sacred number ten was described as a "dance." The

rhythm of this starry dance was set to the sounds arising from the motion itself, and making unceasing music, which was recognized and known as the "harmony of the spheres." Next, the universal fire, which was the central point of the celestial procession, was known by many names. It was called the "mother of the gods," the "citadel of Zeus," and so forth, but two of its titles may be mentioned as especially characteristic. These were the "altar" and the "hearth of the universe." The stars revolved round the sacred source of all life and motion like worshippers round an altar, and the universal hearth was the centre of the world or cosmos as a man's domestic hearth was honoured as the sacred centre of his home, or as the flame that burned and was never extinguished in the civic hearth of the Prytaneum formed the holy rallying-point of every Greek community. Hence streamed the rays of light and heat, hence the sun derived his beams and communicated them again to both earths and to the moon, just as the mother of the bride lighted at a Greek wedding the fire of the new home from the parental hearth, or as a new colony would borrow its fire from the hearth of the mother-city. All the threads of the Greek view of life are combined here. We see the exalted joy in existence, the loving awe for the universe ruled by divine forces, the sublime sense of beauty, symmetry, and harmony, and not least the comfortable affection for civic and domestic peace. Those, then, who held these views, and whose universe was surrounded by the fire-circle of Olympus as by a strong wall, found in it their home, their sanctuary, and the type of their art. Nowhere else do we find a picture of the universe at once so genial and so sublime.

2. The emotional faculties, then, were satisfied in a truly wonderful degree, though at the cost of the intellect. We have now to estimate the price which reason had to pay, and which will be found to have been by no means exorbitant. Even the "dreams of the Pythagoreans" contained a modicum of truth; or, where that modicum was wanting, there was at least an indication given of the road which would ultimately lead to truth. At first sight, for

instance, no doctrine could appear more arbitrary than that of the harmony of the spheres. It obviously sprang in the last resort from an æsthetic demand which was formulated as follows: Our eyes are filled with the grandest sights; how is it, then, that the twin sense of our ears should go empty? But the premise on which the answer rested was not wholly unreasonable. For unless the space in which the stars revolve is completely void, the matter that fills it must undergo vibrations which in themselves are capable of being heard. Even in recent times, no meaner philosopher than Karl Ernst von Baer, the great founder of embryology, has asked if there is not "perhaps a murmur in universal space, a harmony of the spheres, audible to quite other ears than ours." Now, it was objected to the Pythagoreans that we do not actually hear such sounds; but they deprecated the astonishment of the cavillers by the following happy analogy. A blacksmith, they said, is deaf to the continuous, regular beat of the hammers in his workshop; and herein they anticipated the teaching of Thomas Hobbes, who argued that the operation of the senses depends on a change in the stimuli; the stimulation must be interrupted, or altered in degree or kind. There was nothing fanciful in the Pythagorean doctrine except only the belief that the differences of velocity in the movements of the stars were capable of producing a harmonious orchestration and not merely sounds of varying pitch. At this point their artistic imagination had a freer rein, inasmuch as they were completely unable to determine the relative distances of the planets and the absolute velocities that ensued from them, though they could arrive, approximately at least, at the circular segments which the planets described in a given time—in other words, at the angular velocities of their movements.

But here, too, we shall presently find ourselves ready to mitigate our judgment. We have to remember that the premise of law and order, as pervading the universe, could hardly have been applied by the Pythagoreans to any other relations than those of geometry, arithmetic, and music—the last named because of the importance of

acoustics in their natural philosophy. Simplicity, symmetry, and harmony were ascribed indifferently to all three. They neither knew nor divined anything of the forces which produce celestial movements, so that, even had they been acquainted with the elliptic orbits of the planets, that knowledge, we may remark, would never have satisfied their demand for order. They would not have recognized the curve as the resultant of two rectilinear forces. Their heaven, says Aristotle, "is all number and harmony," and we may add that a correct intuition of the highest significance was still clothed in unsuitable shape. The seekers were incapable of discovering law where it was really in operation, and it was anyhow better to look for it where it did not exist than not to look for it at all. Further, the assumption that the sun shines with borrowed light may be traced in the main to the parallelism between the sun and the moon which we mentioned just now. Moreover, the homogeneous conception of the universe might conceivably have suffered if a second independent source of light had been assumed so near the centre of the world. But since they could not altogether dispense with such an assumption, they found it in the Olympus alluded to above as the girdle of the universe, containing all the elements in their unsullied beauty. The firmament of fixed stars, and possibly the planets, derived all their light from Olympus, and the sun borrowed a part of his from the same source, to make amends, we presume, for his otherwise too frequent obscurations. The porous and glass-like qualities of the sun, which enabled it to collect the rays of light and to emit them again, should be noted in this connection. Next we come to the second great fiction of the Pythagoreans—that of the counter-earth. We may readily follow Aristotle in believing that the sacredness of the number ten played a part in this conception. But the introduction of a new luminary and its insertion between the earth and the central fire had many important consequences, and there is no reason to doubt that this fiction of the counter-earth was recommended to its inventors as

much for the sake of its results as for the reason alleged by the Stagirite. The lacunæ in the information at our disposal do not permit us to pass definite judgment; but Boeckh's opinion that the counter-earth was to act as a screen of the central fire, so as to explain its invisibility, is certainly defective. For the supposition that the uninhabited western hemisphere of the earth was turned towards the fire was a quite sufficient explanation. It is more probable that the counter-earth was invented partly as an ostensible cause for the eclipses of the moon which occurred so frequently as to seem to require the shadow of the counter-earth in addition to the shadow of the earth.

The facts of history, however, are more eloquent than all the arguments. Historically considered, the theory of central fire promoted and did not retard the progress of scientific research. In less than a century and a half it engendered the heliocentric doctrine. The fantastic excrescences of the Philolaic system fell away piece by piece. The counter-earth was the first to go: the death-blow was struck at this fiction by the extension of the geographical horizon. The foundations of the hypothetical structure built by the Pythagoreans began to give way in the fourth century at latest. At that time exacter news reached Greece of discoveries in the west and in the east. Hanno, the Carthaginian, had made his great voyage of discovery, and had passed the barrier of the Pillars of Hercules, where the Straits of Gibraltar now are, which had ranked till then as the furthest limit of the Western world; and shortly afterwards the outline of the East was more clearly defined by Alexander's march in India. A coign of observation had been reached from which the counter-earth should have been visible, and since neither the counter-earth nor the central fire, thus robbed of its last protection, came in view at that point, this portion of the Pythagorean cosmology was spontaneously shattered. Nor was this all: the daily circular movement of the earth disappeared with the fictitious centre that conditioned it, and the doctrine of rotation took the place of the theory we have described as its equivalent. Ecphantus, one of

the youngest of the Pythagoreans, taught that the earth turned on its own axis. The second step on the road to the heliocentric doctrine followed swiftly on the first. The marked increase in luminosity which the planets occasionally display was first noticed in Mercury and Venus, and the true cause of the phenomenon suggested itself inevitably as the occasional closer propinquity of these wandering stars to the earth. Thus it was clearly impossible that they could revolve concentrically round the earth. These two nearest neighbours of the sun had plainly confessed their dependence on that luminary by the revolution they respectively accomplished in the course of a solar year. Accordingly they were the first of the planets whose movements were combined with the sun's. This was the masterly discovery of Heraclides of Heraclia on the Black Sea, a man whose powerful genius, contained in a misshapen body, was familiar with the most diverse regions of science and literature, who had visited the schools of Plato and Aristotle, and had kept up a lively intercourse with the latest Pythagoreans. But here, again, there was no finality. Mars likewise displayed a conspicuous change in his degree of brightness even to the incomplete observation which obtained in that age, and thus a link was forged to unite the two inner planets with one at least of the outer ones. Philosophy was approaching the point of view reached in later times by Tycho de Brahe, who represented all the planets with the exception of the earth as revolving round the sun, while the sun with his train of planets revolved round the earth. The last and final step was taken by Aristarchus of Samos, the Copernicus of antiquity, about 280 B.C., who completed what the astronomer from the Pontus, to whom allusion has just been made, had less definitely begun. Eudoxus had given the clue to this great intellectual achievement by his discovery that the size of the sun is considerably greater than the earth's. Aristarchus computed their relative proportion at seven to one; and inadequate as this estimate was in comparison with the actual fact, it was sufficient to expose the

absurdity of setting the great ball of fire to revolve like a satellite round the small world that we inhabit. The earth had to lay down the sceptre which had recently been restored to it ; heliocentricity superseded geocentricity, and the goal was reached for which Pythagoras and his disciples had smoothed and pointed the way. As things turned out, however, it was soon to be abandoned again, and its place to be taken for another long series of centuries by the immemorial delusions fostered in the name of religion.

But it is time to return from this historical forecast to its starting-point at the old Pythagorean doctrines, and there is now nothing to prevent our resuming the thread of the inquiry which we dropped at the close of the last chapter but one.