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ANCIENT ASTRONOMY.

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Astronomy is probably the oldest of the Sciences, and had its origin in the East. South Western Asia - the country between the Nile and the Euphrates, the cradle of mankind - may be regarded as its birthplace. This district possesses the advantages for observation of a level country, a serene sky, and a remarkably transparent atmosphere. One of the proofs of the remoteness of astronomical inquiry is furnished by the asterisims in the book of Job. Again Birs Nimrood, the ancient temple of Belus the Sun God at Babylon, coeval with the foundation of the city, is supposed to have been connected with astronomy. It is pyramidal in form, with its four faces opposite to the four cardinal points, and upon its summit we learn that the Chaldean priests observed and exactly noted the risings and settings of the stars. When Alexander captured the city (B.C. 331), his tutor Aristotle is said to have received a catalogue of eclipses dating back for a previous period of 1903 years. It was by a comparison ~~with~~ of these ancient with modern records, that led Halley to the discovery of the Moon's accelleration. How diligently the Chaldeans must have carried on their observations, is proved by the fact that they were acquainted with this cycle of 6585 1/3 days, in which time the moon makes 223 revolutions, and

the same number of eclipses occur, alike in order and magnitude. The Chaldeans are thought to have invented the Zodiac, and the duodecimal division of the day. They made use of the clepsydra or water clock, the gnomon for determining the solstices, and a hemispherical dial for assertaining the positions of the sun. Their diligence is largely to be explained by the fact, that not only were the heavenly bodies objects of religious veneration, but also by them it was supposed to be possible to predict future events. The marvellous physical phenomena produced by the sun, not unnaturally caused them to suppose that glorious orb to be an intelligent body; and what was performed by one heavenly body they naturally assigned to the rest. The Chaldean priests noted the positions of the stars and moon for astrological purposes. Hence we find in Isaiah. 47.13. "the astrologers, star gazers and the monthly prognosticators" challenged to avert the doom which prophesy denounced against them.

It should be pointed out that the honour of priority in making celestial observations, is also claimed for the Hindoos, Chinese, and Egyptians. The question cannot easily be decided, but the preponderance of evidence seems to favour Chaldea. From this country the knowledge of astronomy is thought to have radiated to India and China on the one side, and to Egypt on the other.

The Hindoo tables claim an epoch of 3102 years before Christ, at which era a conjunction of the sun, moon and planets was said to have occurred. Modern calculation however shows such a conjunction to have then been impossible, and thus invalidates the claim of priority. In like manner computation shows how many eclipses recorded by the ancient Chinese could never have taken place. Those which may be depended upon as having been actually observed, date from B.C. 776 to A.D. 1433. The ignorance of the professedly scientific class even of the simplest operations, when first brought in contact with western civilization is well known. Again the evidence which credits the ancient Egyptians with making considerable advances in astronomy is by no means reassuring. The exactness with which some of the pyramids face the cardinal points, engenders the suspicion that they were associated with celestial observation, and authorities are cited to show that platforms for that purpose existed on their summits. But if it be true that Thales taught the Egyptian astronomers how to find the height of the pyramids from their shadow,- one of the simplest examples of practical Geometry,- and that they told Herodotus that the sun had been twice seen to rise in the west, we can entertain no very high idea of their accomplishments. The grouping of the stars into constellations illustrating the wild legends of mythology, had an oriental origin, and was subsequently altered and amplyfied by the Greeks and Romans.

It is possible that the signs of the Zodiac may be associated with the occupations of the ancients; e.g;- the figure of a ram is thought to have been assigned to that constellation in which the sun appeared in the spring, when the goats were taken from the stables to the fields. In like manner the Lion may represent the fierce heat of summer, the Scorpion the unhealthiness of autumn, while the balance might indicate the equal lenght of the days and nights.

The age of Astronomy in Greece may be said to have begun in the 7th. century B.C., though allusions in the poets Hesiod and Homer show that the risings and settings of certain stars had been carefully noted before that era. Thales, the founder of the Ionic school, may be regarded as the man who laid the basis of what little knowledge the Greeks possessed. Of him is related the familiar story, that when contemplating the stars at Miletus, his native city, he fell into a ditch, upon which Thressa his conductress exclaimed, "Why O. Thales do you seek to comprehend the things which are in the heavens, when you are not able to see those before your eyes"? If there is some doubt as to the truth of this anecdote, it nevertheless harmonizes with the general tenour of Greecian thought. The great men of the country were chiefly poets, warriors, statesmen, orators, and moral rather than natural philosophers. It was not a spirit of scientific enquiry, but a speculative and tasteful sentiment that led Plato to imagine that because the flight

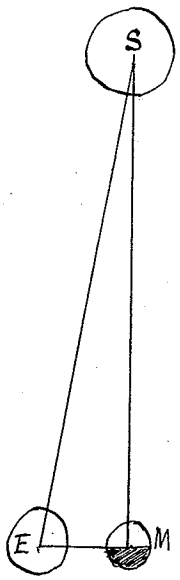
of birds and the movement of any object was accompanied by a vibrative sound, therefore the motion of the celestial bodies must occasion a ravishing harmony, fitly called the music of the spheres. Thales and his successors were exceptions to their countrymen, and their conclusions are largely born out by modern thought. Instead of being content with a rough approximation to the north by means of the Great Bear, he substituted the constellation of the Little Bear, by which the Phoenicians had long been accustomed to steer: he made a near approach to the diameter of the sun, taught the sphericity of the earth, and most wonderful of all, even predicted the eclipse of the sun, which occurred at the time specified. One of Thales' successors, Anaximander, believed that the earth rotates round its axis, and that the Moon's light is reflected from the sun. Anaxagoras conjectured that the moon like the earth had mountains, hills and valleys. These doctrines were taught on a more extended scale by Pythagoras, who appears to have advanced so far as to grasp the truth of the earth's revolution round the sun - a doctrine supposed to have been proclaimed openly by his successor Philolaus. The Pythogorans held indeed that not only the planets, but also comets are in motion round the sun. But these were mere conjectures of sagacious minds, without sufficient proof, and directly opposed to the evidence of the senses. Hence they met with but little acceptance, and the dogmas of the Aristotleans were generally received, which taught that the earth remains motionless at the centre of the universe, the heavenly bodies moving round it in circular orbits with uniform velocities, while comets

are simply meteors generated in the terrestial atmosphere. The "divine" Plato is however said to have admitted in his old age that the centre should be appropriated by some more noble object than terrestial substance. Anaxagoras was condemned to death for his philosophical views, a sentence commuted through the interest of Pericles to perpetual banishment. Philolaus also suffered persecution on account of his doctrine of the earth's annual revolution, which so shocked the prejudices of men, as to subject him who held it to the suspicion of impiety.

Alexandria became the chief seat of astronomical research soon after the age of Aristotle. The first of the Ptolemies laid the foundation of its famous library, perhaps the largest collection of books ever brought together before the age of printing. His successor established with it a college for the cultivation of the pure sciences, invited the most accomplished of the Greeks to repair to it, and supplied them with whatever instruments were necessary for their pursuits. On account of the advances which were made, the college received the flattering epithet of "Divine". The planets and fixed stars were carefully scrutinized, and solar and lunar inequalities more accurately ascertained. Angular distances were computed by means of trigonometry, and ultimately the Alexandrian School presented to the world the first system which included an entire plan of the celestial motions.

This system we know to be wrong and inferior to the Pythagorean notions, but it had the merit of being founded upon a long series of observations, which finally brought about its own destruction, while the previous theories were the result of pure hypothesis.

The most interesting circumstances connected with the Alexandrian School are the endeavours to measure the distance of the sun from the earth, and the circumference of the globe. The first problem was attempted by Aristarchus of Samos in the following manner.

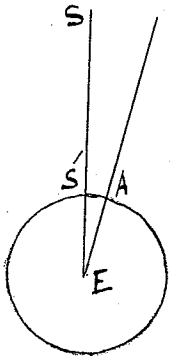


Let S. be the sun, M. the moon and E. the earth. When the moon is half illuminated by the sun, it is evident that lines drawn from S. to M. and from E. to M. must form a right angle. The length of the base line E.M. being known, it only remained to measure the angle S.E.M, from which data the length of S.E. could easily be deduced. Aristarchus arrived at the conclusion that the sun is 19 times the distance of the moon from the earth. We know of course the distance of the sun is far greater. The error was due to imperfect instruments, and the impossibility of determining the exact time of the moon'snsemi-illumination.

But the highest honour must be awarded this observer for his ingenious method, which is founded upon correct principles. Aristarchus held the Pythagorean doctrine of the movement of the earth in space. He had to encounter the formidable objection made for long afterwards, that this movement produced no annual parallax. To this he made the right answer, viz;- that the earth's orbit is as compared with the vast distance to the fixed stars but a mere point in space. The boundaries of the universe were thus revealed to his mind far beyond the limits of his predecessors. He flourished about B.C. 280.

The measurement of the circumference of the earth, was made by Eratosthenes. This it is believed is the first time an attempt had been made to solve the problem, as certainly it was the first to do it on a true principle. Syene - the modern Assouan - is associated with the experiment. It was supposed to lie exactly on the Tropic of Cancer, as it was observed that at noon on the day of the Summer Solstice, a well was enlightened to the bottom, and vertical objects cast no shadow for 300 stadia around it. At noon therefore at Alexandria, (supposed to lie on the same meridian as Syene where the sun was thought to be vertical) Eratosthenes measured his zenith distance from the sun, or the value of the celestial arc corresponding to the arc of the meridian between Alexandria and Syene. The value of his measurement amounted to $7° 12'$, or 1/50 the circumference of a circle.

The Government ascertained the distance between Alexandria and Syene to be 5000 stadia. Multiplying this figure by 50, the circumference of the earth was thus estimated at 250,000 stadia. The above will be better understood by reference to the accompanying diagram, E.



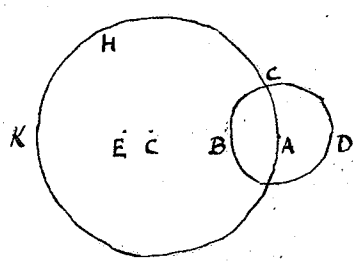
being the centre of the earth, S. the sun, S, Syene and A. Alexandria. Unfortunately the length of the ancient stadium is unknown, therefore it is impossible to appreciate the value of the measurement. We know however several errors were committed. No allowance was made for solar parallax. Syene instead of lying under the tropic of Cancer, lies 50' to the north of it, and is at the same time 3° east of the meridian of Alexandria. Eratosthenes was born at Cyrene in the year 276 B.C. The third Ptolemy entrusted him with the charge of the famous library, but becoming weary of life at the advanced age of 80, he died by voluntary starvation.

We have now to deal with the greatest name of astronomical antiquity, that of Hipparchus of Bithynia (B.C.160÷125), who must be regarded as the father and founder of real astronomy. If he is not the inventor, he was certainly the first to apply the principles of spherical trigonometry, by which the positions of celestial bodies may be accurately fixed, and variations of their movements determined. He calculated the length of the tropical year to be 4 minutes, 48 seconds, short of the generally accepted 365 1/4 days.

This is a near approach to the length of the year of his time, which according to Laplace must have been 4".2 shorter than in the present age. The observations of Hipparchus enabled him to infer the truth of the retrogradation of the equinoctial points along the ecliptic, which was not explained till Newton's time. With great labour he made a catalogue of 1080 stars - the first trustworthy one that we have - and recorded their positions on an artificial globe. He also originated the idea of marking the position of towns in the same manner.

After Hipparchus there is little to arrest our attention in the history of astronomy for 3 centuries, till we come to Ptolemy, who was born in Egypt, and flourished during the 2nd century A.D. He was the best scholar of his age - a practical astronomer, mathematician and geographer - the author of the important discovery of the evection or libration of the moon - a periodical change in the position of the moon's surface with regard to the earth, rendering narrow portions at opposite limbs visible or invisible alternately. His great work the Almagest, recorded the previous advances of astronomy, the state of the science in his own day, and developed a plan of the celestial movements. It recognized the earth to be a sphere, the immovable centre of the universe, the heavenly bodies revolving round it in circles, with uniform velocities. The relation of the

four supposed primary elements supported the Ptolemaic theory. Thus earth being the most stable, occupied the lowest place, and supported water, the second in order; above water was placed air, and then fire, either being supposed to extend to an infinite distance beyond the others. In or beyond the ether were certain zones or heavens, each heaven containing an immense spherical crystalline shell - crystalline, otherwise the light of the stars had been intercepted - the smallest enclosing the earth, and the larger spheres enclosing the smaller. There were at first eight of these crystallines, to which the following heavenly bodies in the order of their increasing distance from the earth were attached - Moon, Mercury, Venus, Sun, Mars, Jupiter, Saturn, fixed Stars. Beyond these lay that which was supposed to give motion to the spheres in its concave - the primum mobile -, while still farther out was the empyrean heaven, or paradise of blessed souls. While this extraordinary theory explained some celestial phenomena, ingenious theories were proposed to account for certain irregularities of motion. Thus the accelleration and retardation of the sun in his orbit - which we know to be elliptical - was accounted for by placing the earth at E, instead of at C, the centre of the sun's supposed circular orbit A C H K.



The peculiar paths of the planets, - now forward, now stationary, now backward - were explained by supposing the planet to revolve round the centre A of the smaller circle D C B, which was at the same time in motion round the centre C of the circle A C H K now representing the planetary crystalline. The larger circle is called an eccentric, the smaller an epicycle. As time passed by and observations became more accurate so much the more involved did the theory become. The profound of space was filled with huge globular forms, and eccentrics and epicycles were multiplied in a manner that would be difficult to make intelligible, and useless if attempted. This venerable pile of antiquated hypotheses which had received the seal of papal infallibility, after having been generally accepted in various forms for 15 centuries fell to pieces on the introduction in the 16th century, of the Copernican theory of the solar system.