The Alexandrian tradition was first manifested in the Royal Museum in Alexandria, established by the Ptolomies who ruled over Egypt at that time. The museum contained the royal library, one of the largest and most significant resources of the ancient world. Established in the third century BC, it functioned as a major center until Egypt was conquered by the Romans in 30 BC. It contained collections of works, lecture halls, meeting rooms, and gardens. The library was part of a larger research institution called the museum, which contained the work of Aristotle's Lyceum among others. It should be noted that the word museum was derived from this structure, dedicated to the muses. Besides the enormous library, the museum had lecture halls, zoos, menageries, observation stations, and living rooms. The Egyptian government played a larger role in scientific research than that of the Greeks. Precision, exactitude, and empiricism were found here instead of the induction and generality of the Greeks.

The Alexandrian period, between the third century and the last few decades at the end of the first century BC provided advances in mathematics and science, especially astronomy, optics, and mechanics, that encompassed not only Alexandria itself, but educated notable Greek mathematicians and scientists (Archimedes and Apollonius among them) who studied in the School of Euclid in Alexandria.

Perhaps the first great scholar that Alexandria produced was Euclid (365-285 BC). He was most important in the field of mathematics. He was characteristic of the period in his systematization of knowledge, doing little original thinking but bringing together Greek concepts of mathematics and correlating them. Scientifically he is attached to the Platonic philosophy. He made the goal of his Elements the construction of five regular polygons of Plato. Euclid's treatise has served as the basis for all elementary geometrical instruction up to the present day. In the Elements he emphasizes synthesis, although in other works he depends on analysis as well. He developed the six-stage method of proving a theorem, which is still being taught today. This methodology involves the relation of the enunciation to the diagram, construction (the arbitrary use of auxiliary lines), proof (which involves axioms, definitions, and previously proved theorems) and finally the restatement of the enunciation (at the end of the proof).

There is a careful avoidance of whatever is not geometrical and no attempt is made to develop initiative or invention on the part of the student. In Euclid's mathematical system are found postulates, definitions, common notations and rules of inference that constitute its framework. Euclid characterizes the Greek avoidance of infinities by careful definition and limitation, so as to exclude infinity not immediately apparent to the senses. Euclid based his definitions on elements that were "apparent," characterized by the "setting out" of his theorems. Thus we find here a leaning toward geometrical intuition, found in such axioms as "the whole being greater than any of its parts." In recent times, the question has arisen whether the basic axioms of Euclid need be accepted. It is felt that they are not necessities of thought and that quite different axioms can be postulated and a perfectly self-consistent system of geometry built up from them. This is the case with the non-Euclidean system of Riemann for example. In that period, however, it was probably inconceivable that a universe could be finite in space, the space itself still being considered unlimited. Possibly, with the avoidance of infinities prevalent at the time, it would be extremely interesting to see how the Euclideans would have reacted to the theoretical Klein bottle or Mobius strip, concepts of three or two dimensional infinities respectively. For Euclid, they could not exist because they could not be defined.

Besides the Elements, Euclid wrote treatises on Fallacies, designed to safeguard the student from erroneous reasoning, on conic sections, and on the applications of geometry, as found in the Phenomena, Optics, and Catoptrics. The Phenomena is a treatise on the traditional spherics with special reference to elementary astronomy. The work is purely geometrical and there was no attempt to formulate a system of planetary, lunar, or solar motions. His Optics is a study of light rays. He believed that rays of light come from the eye in a cone of vision. Catoptrics concerns the mathematical theory of mirrors, particularly the images formed in plane and spherical concave mirrors. Perspective is also dealt with in this work. Examples of several propositions found in the work are: equal magnitudes situated at different distances from the eye appear unequal, and the nearer always appear larger; parallel lines when seen from a distance appear to be an unequal distance apart. We see that he is basing his propositions of apparent phenomena that can be seen and felt geometrically. If it is felt to be "straight" geometrically, then it probably can be proven. Thus, these propositions do not depend here on absolute properties of geometric figures, but relative ones.

The second great name in the Alexandrian period and one of the greatest in the history of science is Archimedes (c.287-c.212 BC). He was not strictly speaking of the Alexandrian school (although he studied in Alexandria under the followers of Euclid) but was born and spent most of his life in Syracuse, which was at that time a Greek seaport. He was a geometry, mathematician,
Ptolemy did important work in mathematical geography, carrying on the tradition of Eudoxus, Aristotle, and Eratosthenes, and influenced geographic thought for the next fifteen centuries in part of a sundial that casts a shadow. He created the first map of the world incorporating parallels and meridians, based on the available geographical knowledge of the era. He also calculated the motion of the Moon during a lunar eclipse. He set the diameter of the earth at 400,000 stadia (>45,000 miles), which was too large an estimate (Stadion=600 feet). Geography was important for the characterizations of broad regions by Homer in the Odyssey and the Iliad, and the Alexandrians were concerned with the boundaries of the world around them. Geography had developed as a Greek tradition with elements tended to move upward and two downward, believing that all four were influenced by gravity. Ptolemy, we find the first person of note in the field of mechanics to be Strato, who lived in the third century BC. He may have entered the Aristotelean lyceum. He moved to Alexandria where he helped found the Museum and was a tutor to the King of Egypt. He made many experiments in pneumatics. He wanted to prove that air was corporeal. By inverting a bowl in a large vessel of water and seeing that the water would rise in the bowl but not too much, he adequately demonstrated that air was compressible, therefore corporeal, the space between the corpuscles being a vacuum. He believed that vacuums could exist naturally in a continuous condition, but did not believe there was an empty space, or vacuum, in the heavens. These ideas were influenced by the works of Democritus and Aristotle. He was opposed, however, to Aristotelian belief that two of the four elements tended to move upward and two downward, believing that all four were influenced by gravity.

Alexandrians were concerned with the boundaries of the world around them. Geography had developed as a Greek tradition with the characterizations of broad regions by Homer in the Iliad and the Odyssey. It was believed that the world was surrounded by an ocean. It was generally accepted among the Greeks that the Earth was a sphere. Aristotle, in his work on meteorology had proved the shape of the Earth by seeing the shadow of the Earth in the Moon during a lunar eclipse. He set the diameter of the Earth at 400,000 stadia (>45,000 miles), which was too large an estimate (Stadion=600 feet). Geography was important for the Alexandrians because of their extensive trade. In the third century BC, Eratosthenes, the chief librarian of the Alexandrian library, determined the latitudes of places on Earth using the gnomon, the part of a sundial that casts a shadow. He created the first map of the world incorporating parallels and meridians, based on the available geographical knowledge of the era. He also calculated the circumference of the Earth and its diameter using stadia, but his measurements were more accurate than that of Aristotle. He also calculated the distance from the Earth to the Sun with reasonable accuracy. Further, he provided measurements of chronology and invented the leap day.

Ptolemy did important work in mathematical geography, carrying on the tradition of Eudoxus, Aristotle, and Eratosthenes, and influenced geographic thought for the next fifteen centuries in this field. He enriched Euclidean geometry, made important progress in algebra, laid the foundations of mechanics, and anticipated calculus. With the latter we come to the problem of infinitesimals again. In Archimedes Method Archimedes showed the use of notions of infinitesimals as means of discovery. He used geometric construction to analyze areas under curves, by dividing the areas into smaller and smaller strips and summing up the total of these small areas, anticipating integral calculus. He dealt in this way with volumes within complex curves. He was still cautious, however, about discussing infinitesimals between the lines, in plane figures, or between planes, in solids, even though his method involved such a concept. This reflects the wariness of the mathematicians of the time towards discussing the infinitesimal and had been found in the criticisms of Zeno (cf. III- The Science of Greece). Archimedes was more original in his mathematical papers than Euclid. Among some of his achievements in mathematics is the calculation of the ratio of the circumference of a circle to its diameter, important advances in measurements of the circle in general and in the geometry of spheres and cylinders. Archimedes achieved a more developed sense of numerical computation than Euclid, who discussed proportionality without regard to an actual proportionality factor. Archimedes had a far-ranging interest in applications; for example, discovering the principles of hydrostatics and inventing several war machines to protect his native Syracuse from invasion.
Astronomy advanced during that period with the work of Ptolemy but preceded by the Greek astronomers Heracleides, Aristarchus, and Hipparchus, and we should consider their work before that of Ptolemy. Heracleides, a fourth century BC Greek, who was connected with both the Pythagorean and Platonic schools, is said to have been the first one to teach that the Earth turns on its own axis from West to East in twenty-four hours. He is said to have advanced the hypothesis that Mercury and Venus revolve about the Sun. He did not bring forth, however, any conception of the orbital or progressive motion of the Earth. Although he conceived of concentric spheres he could not explain why these planets were at times closer and other times farther from the Earth. It was during the Alexandrian period that epicycles, described previously, were contrived to explain irregularities in the motions of the planets.

Aristarchus of Samos (c 270 BC) met the objection that the motion of the Earth would cause changes in the apparent position of the stars by assuming that their distances were so great as to render the motion of the Earth a negligible factor. He is also said to have believed that the Earth moves around in an orbit besides rotating, a hypothesis quite daring at the time. The theory of epicycles mentioned previously came about because the Greek philosophers could not fathom the idea of motion in other than a straight line or a circle. Thus, the concept of an elliptical orbit for a planet would be incompatible with this philosophy. The theory at the time considered the Earth to be in the center of the universe and that the planets moved about in circular orbits around it. As it moved around in its orbit, a planet would also move in a second circular orbit with its center on the original orbit. The apparent retrograde motions of certain planets could be explained by this theory.

The next great Greek astronomer was Hipparchus of Nicea (c.190-c.120 BC), considered the founder of trigonometry, and considered by some the greatest astronomer in antiquity. He composed star catalogues, measuring the positions of stars and comparing these determinations with those made 150 years before. He thus discovered that the Earthâ€™s axis itself rotates slowly and completes the cycle of rotation in thousands of years. This was concluded when he found changes, very slight in some cases, as much as two degrees in others, in the relative positions of stars mapped out during his time and in periods preceding. He determined the length of the year within six minutes, striving for greater accuracy and completeness of data. He made substantial improvements in the assessment of solar and lunar eclipses, and obtained a close approximation of the distance of the moon. He also laid the foundations of trigonometry by construction for astronomical use a table of chords, equivalent to the natural sine tables. He made very effective use of the records of early astronomers, critically considering their value, and worked out a consistent mathematical theory of the motions of the heavenly bodies so far as his data warranted. These astronomers and mathematicians preceded Ptolemy and it was over 250 years after Hipparchus, in the second century AD, that Ptolemy further advanced the knowledge of astronomy. He lived in the city of Alexandria in the Roman province of Egypt, wrote in A Greek, and held Roman citizenship. For Ptolemy, the Earth was still the center of the heavens and had no translatory motion. Discrepancies between observed and computed data, however, led Ptolemy to modify the Aristotelian concept that celestial bodies move in circular paths by assuming circles eccentric to that of the Earth. The line joining the centers of the circle and the Earth would revolve. His astronomical models were placed in convenient tables, useful for computing past or future positions of the planets.

Ptolemyâ€™s treatise in astronomy is presented in the Almagest, the only surviving comprehensive ancient treatise on astronomy, perhaps the reason his name is more prominent than that of other ancient astronomers. The Almagest contains catalogues of stars and lists forty-eight constellations covering a limited area of the sky, using the work of Hipparchus in compiling the catalogues. The Almagest became the authoritative source for European astronomers over the next millennium. Ptolemy was also a geographer, providing a system for creating maps of the inhabited world. These maps characteristically covered the territory from the Atlantic Ocean (West) to the middle of China (East) and from the Shetland Islands (north) to the East coast of Africa (South). cf â€“ Eratosthenes illustration above.

After Ptolemy, astronomy did not advance to any great extent for a millennium. In Ptolemyâ€™s time, astronomers relied more on observation that the early Greek astronomers, basing their theories on observation, rather than the reverse as with earlier Greek astronomers. We find illustrations of genuine scientific caution, especially with Hipparchus, who, having tested the planetary theories then in vogue and discovering their insufficiency, patiently collected fresh material so that some future astronomer could arrive at an improved theory.

Aside from mathematics, astronomy, and geography, the Alexandrians were noted for their medical tradition. It was there that anatomy was first freely studied with the result that many of the grotesque errors of the earlier Greeks, including Aristotle, were corrected. Erasistratus (c.304-c.250 BC) founded a school of anatomy in Alexandria and undertook anatomical research. He opposed the Hippocratic theory of the four humors (blood, phlegm, black bile, and yellow bile) but instead favored the concept that Air, Fire, Earth, and Water were the constituents of all things. He also taught that the father of experimental physiology. It is believed that the valves of the heart were first studied and named by him, as well as parts of the brain. He also concluded that the heart was a pump, not a center of sensations. He attributed the pulse to cardiac contraction although he believed that contraction of the portal vein to the liver also promoted blood flow, a concept believed by others at the time. He was the first of to distinguish between arteries and veins. He still believed in an â€œanimal spiritâ€ (pneuma) with the arteries carrying it as part of the air. When an artery was severed, blood escaped and blood in the veins filled it due to the vacuum created.Â He also believed that this spirit was carried in the nerves. However, he did separate the function of sensory and motor nerves and associated them with the brain, providing a description of the cerebrum and cerebellum. Many of Erasistratusâ€™ concepts were later accepted and popularized by Galen, who corrected and modified them based upon his later investigations.

Galen (c.129-210/216 AD), born in Pergamum, became the most noted medical philosopher of the Alexandrian school (see II: Hippocrates v Galen). In medieval Europe, Galenâ€™s writings on anatomy became the mainstay of the medieval physician's university curriculum. Galen bolstered Erasistratusâ€™ concept of the functioning of the brain as responsible for controlling the function of muscles through nerves. His theory was based on nerve ligation studies.

Galen studied the splanchic circulation and believed that partially digested food entered the portal vein circulation from the stomach, with venous flow aided by stomach compression and by attraction of the chyle to the liver. However, the portal blood ebbed and flowed, also carrying black bile to the spleen, and eventually to the stomach. In the liver, natural spirits were added to the blood which entered the heart which added â€œanimal spiritsâ€ . Blood entering the brain received â€œanimal spiritsâ€ from the brain.

Galen saw himself as both a physician and a philosopher, as he wrote in his treatise entitled That the Best Physician is also a Philosopher. Galen was very interested in the debate between the rationalist and empiricist medical sects, and his use of direct observation, dissection, and vivisection represents a complex middle ground between the extremes of those two viewpoints. He was a teleologist, believing that function develops structure, and that the structure of an organ is the best possible one for its particular function. He also believed that there were causal relationships between the heavens and the human body. He was opposed to the atomists, who attempted to reduce physiology to physics, believing the body to be governed by a rationalist and empiricist medical sects, and his use of direct observation, dissection, and vivisection represents a complex middle ground between the extremes of those two viewpoints. He was a teleologist, believing that function develops structure, and that the structure of an organ is the best possible one for its particular function. He also believed that there were causal relationships between the heavens and the human body. He was opposed to the atomists, who attempted to reduce physiology to physics, believing the body to be governed by a
exploration into the world of medicine in particular, and of healthcare in general. Along traditional lines of metaphysics, epistemology, and ethics, a cadre of questions and problems face philosophers of the Alexandrian schools. Unlike the West, the Byzantines were never cut off from this great scientific heritage. The Byzantines used the works of writers such as Euclid, Apollonios, Archimedes, and partly on account of the excellence of their institutions. They founded the great and celebrated library for which the Greek translation of the Old Testament was made; after Caesar had destroyed Alexandria it was again restored. The Byzantines made numerous contributions to philosophy, science and medicine while also making innovations and inventions. Nevertheless, those achievements of Byzantium are usually ignored as... This post is meant to illustrate Byzantine contributions in the fields of philosophy, technology, science and medicine. Byzantine Philosophy. Philosophy of medicine is a collective designation for certain tendencies in literature, philosophy, medicine, and the sciences that developed in the Hellenistic cultural center of Alexandria, Egypt during the Hellenistic and Roman periods. Alexandria was a remarkably large and great center of learning due to the blending of Greek and Oriental influences, its favorable situation and commercial resources, and the enlightened energy of some of the Macedonian Dynasty of the Ptolemies ruling over Egypt, in the final days of Greece. The Alexandrians took as their groundwork the philosophy of Plato, but availed themselves of the general development of Hellenistic science, which after Plato became acquainted with through Aristotle and all the following philosophers, and especially through the Stoics; that is to say, they reconstituted it, but as invested with a higher culture. For in Alexandria the Ptolemies had attracted to themselves science and the learned, partly by reason of their own interest in science, and partly on account of the excellence of their institutions. They founded the great and celebrated library for which the Greek translation of the Old Testament was made; after Caesar had destroyed it, it was again restored. The Byzantines made numerous contributions to philosophy, science and medicine while also making innovations and inventions. Nevertheless, those achievements of Byzantium are usually ignored as... This post is meant to illustrate Byzantine contributions in the fields of philosophy, technology, science and medicine. Byzantine Philosophy. Philosophy (φιλοσοφία) had many meanings in Byzantium, signifying eloquence, education, knowledge and the Christian way of life. Byzantine science was based on the heritage of antiquity, especially the Alexandrian schools. Unlike the West, the Byzantines were never cut off from this great scientific heritage. The Byzantines used the works of writers such as Euclid, Apollonios, Archimedes, Ptolemy, Pappos and others. Philosophers of medicine can aid by furnishing guidance towards a consensus on the nature of medical professionalism. Philosophy of medicine is a vibrant field of exploration into the world of medicine in particular, and of healthcare in general. Along traditional lines of metaphysics, epistemology, and ethics, a cadre of questions and problems face philosophers of medicine and cry out for attention and resolution. In addition, many competing forces are vying for the soul of medicine today. In A guide to culture of science, technology, and medicine, P.T. Durbin, ed. New York: Free Press, pp. 364-461. Engelhardt, Jr., H.T., and Wildes, K.W. Philosophy of medicine.
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