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Did Ptolemy support the heliocentric model. What is the Ptolemy theory. Did Ptolemy support the geocentric model.

As the stars move across the sky each night people of the world have looked up and wondered about their place in the universe. Throughout history civilizations have developed unique systems for ordering and understanding the heavens. Babylonian and Egyptian astronomers developed systems that became the basis for Greek astronomy, while societies in the Americas, China and India developed their own. Ancient Greek astronomers' work is richly documented in the collections of the Library of Congress largely because of the way the Greek tradition of inquiry was continued by the work of Islamic astronomers and then into early modern European astronomy. This section offers a tour of some of the astronomical ideas and models from ancient Greece as illustrated in items from the Library of Congress collections. The *Sphere of the World* by the 5th century B.C., it was widely accepted that the Earth is a sphere. This is a critical point, as there is a widespread misconception that ancient peoples thought the Earth was flat. This was simply not the case. In the 5th century B.C., Empedocles and Anaxagoras offered arguments for the spherical nature of the Earth. During a lunar eclipse, when the Earth is between the sun and the moon, they identified the shadow of the Earth on the moon. As the shadow moves across the moon it is clearly round. This would suggest that the Earth is a sphere. Experiencing the Sphere of the Earth Given that opportunities for observations of a lunar eclipse do not come along that often, there was also evidence of the roundness of the earth in the experiences of sailors. When a ship appears on the horizon it's the top of the ship that is visible first. A wide range of astronomy texts over time use this as a way to illustrate the roundness of the Earth. As the image suggests this is exactly what one would expect on a spherical Earth. If the Earth were flat, it would be expected that you would be able to see the entire ship as soon as it became visible. Measuring the Size of the Earth Lunar eclipses also allowed for another key understanding about our home here on Earth. In 3rd Century B.C., Aristarchus of Samos reasoned he could figure out the size of the Earth based on information available during a lunar eclipse. The diagram at the right illustrates a translation of his work. The large circle is the sun, the medium circle is the Earth and the smallest circle is the moon. When the Earth is in-between the sun and the moon it causes a lunar eclipse and measuring the size of the Earth's shadow on the moon provided part of the information he needed to calculate its size. Eratosthenes estimated Earth's circumference around 240 B.C. He used a different approach, measuring the shadows cast in Alexandria and Syene to calculate their angle relative to the Sun. There is some dispute on the accuracy of his calculations as we don't know exactly how long the units of measure were. The measurement however was relatively close to the actual size of the Earth. The Greeks were applying mathematics to theorize about the nature of their world. They held a range of beliefs about nature and the world but they were, in many cases, working to ground those beliefs in an empirical exploration of what they could reason from evidence. Aristotle's *Elements and Cosmology* In the tradition of Plato and Empedocles before him, Aristotle argued that there were four fundamental elements, fire, air, water and earth. It is difficult for us to fully understand what this meant as today we think about matter in very different terms. In Aristotle's system there was no such thing as void space. All space was filled with some combination of these elements. Aristotle asserted that you could further reduce these elements into two pairs of qualities, hot and cold and wet and dry. The combination of each of these qualities resulted in the elements. These qualities can be replaced by their opposites, which in this system become how change happens on Earth. For example, when heated, water seemingly turns steam which looks like air. The *Elements* in Aristotle's Cosmic Model In Aristotle's Cosmology, each of these four elements (earth, water, fire and air) had a weight. Earth was the heaviest, water less so, and air and fire the lightest. According to Aristotle the lighter substances moved away from the center of the universe and the heavier elements settled into the center. While these elements attempted to sort themselves out, to achieve this order, most of experience involved mixed entities. While we have seen earth, fire, air and water, everything else in the world in this system was understood as a mixture of these elements. In this perspective, transition and change in our world resulted from the mixing of the elements. For Aristotle the terrestrial is a place of birth and death, based in these elements. The heavens are a separate realm governed by their own rules. The Wandering and Fixed Stars in the Celestial Region In contrast to the terrestrial, the celestial region of the heavens had a fundamentally different nature. Looking at the night sky the ancient Greeks found two primary kinds of celestial objects; the fixed stars and the wandering stars. Think of the night's sky. Most of the visible objects appear to move at exactly the same speed and present themselves in exactly the same arrangement night after night. These are the fixed stars. They appear to move all together. Aside from these were a set of nine objects that behaved differently, the moon, the sun and the planets Mercury, Venus, Mars, Saturn and Jupiter each moved according to a different system. For the Greeks these were the wandering stars. In this system the entire universe was part of a great sphere. This sphere was split into two sections, an outer celestial realm and an inner terrestrial one. The dividing line between the two was the orbit of the moon. While the earth was a place of transition and flux, the heavens were unchanging. Aristotle posited that there was a fifth substance, the quintessence, that was what the heavens were made of, and that the heavens were a place of perfect spherical motion. The Unchanging Celestial Region In Aristotle's words, "In the whole range of time past, so far as our inherited records reach, no change appears to have taken place either in the whole scheme of the outermost heaven or in any of its proper parts." It's important to keep in mind that in Aristotle's time there simply were not extensive collections of observational evidence. Things that looked like they were moving in the heavens, like comets, were not problematic in this model because they could be explained as occurring in the terrestrial realm. This model of the heavens came with an underlying explanation. The celestial spheres were governed by a set of movers responsible for the motion of the wandering stars. Each of these wandering stars was thought to have an "unmoved mover" the entity that makes it move through the heavens. For many of the Greeks this mover could be understood as the god corresponding to any given entity in the heavens. Ptolemy's *Circles* in *Circles* Claudius Ptolemy (90-168) created a wealth of astronomical knowledge from his home in Alexandria, Egypt. Benefiting from hundreds of years of observation from the time of Hipparchus and Eudoxus, as well as a set of astronomical data collected by the Babylonians, Ptolemy developed a system for predicting the motion of the stars that was published in his primary astronomical work, *Almagest*. Ptolemy's success at synthesizing and refining ideas and improvements in astronomy helped make his *Almagest* so popular that earlier works fell out of circulation. Translated into Arabic and Latin the *Almagest* became the primary astronomy text for the next thousand years. Ptolemaic Data The *Almagest* is filled with tables. In this sense the book is a tool one can use to predict the locations of the stars Compared to earlier astronomy the book is much more focused on serving as a useful tool than as presenting a system for describing the nature of the heavens. Trying to accurately predict the place of the stars over time resulted in creating a much more complicated model. The Ptolemaic Model By the time of Ptolemy Greek astronomers had proposed adding circles on the circular orbits of the wandering stars (the planets, the moon and the sun) to explain their motion. These circles are called epicycles. In the Greek tradition, the heavens were a place of perfect circular motion, so the way to account for perfection was with the addition of circles. This resulted in disorienting illustrations. To escape the complicated nature of this extensive number of circles, Ptolemy added a series of new concepts. To accurately describe planetary motion, he needed to use eccentric circles. With the eccentric circle the center of the planet's orbit would not be Earth but would instead be some other point. Ptolemy then needed to put the epicycles on another set of circles called deferents. So the planets moved on circles that moved on circular orbits. Ptolemy also needed to introduce equants, a tool that enabled the planets to move at different speeds as they moved around these circles. The resulting model was complex, but it had extensive predictive power. Ptolemy and Aristotle's Cosmic Legacy Ptolemy came to represent a mathematical tradition, one focused on developing mathematical models with predictive power. Aristotle came to be known for putting forward the physical model of the heavens. Ptolemy was also interested in deploying his model of the heavens to describe its physical reality. However, his most important work was the mathematical models and data he used for predicting the motion of heavenly bodies. For a long time his name was synonymous with the model of the heavens. One of the strongest pieces of evidence of the shape of the Earth came through interpretation of a lunar eclipse. During an eclipse we see the shadow of the Earth on the moon. This looks like the image at the top. If the Earth were triangular, one would expect the shadow of the Earth to look like a triangle. Diagrams of solar eclipse, from *Universal Geography*, 1711. Geography and Maps Division One of the other key pieces of evidence for a round Earth was the fact that at a distance one can see the top of a ship before seeing the rest of it. One can find this concept illustrated in a wide array of astronomical texts throughout history. M. Blundeuille his exercises. 1613. 1613. The Kraus Collection of Sir Francis Drake, Rare Book and Special Collections Division This illustration from a translation of Aristarchus work shows how he approached measuring the size of the Earth based the size of the Earth's shadow on the moon during a Lunar eclipse Geometric figure of Earth, Sun, and Moon calculated by Aristarchus to approximate real scale of the solar system Illus. in: De magnitudinibus, et distantiis solis, et lunae 1572, p. 30. This illustration from the French edition of the 13th century encyclopedic work *De proprietatibus rerum* (The Properties of Things) shows Aristotle's four elements, Fire and air are illustrated at the top of the image and water and earth on the bottom. Le proprietaire en francoys. (The Properties in French). 1491. Rare Book and Special Collections Division An illustration of an interpretation of the heavenly spheres. The round Earth is surrounded by spheres of water, air, and fire and from there the spheres of the moon, each of the planets, and the fixed stars. M. Blundeuille his exercises. 1613. The Kraus Collection of Sir Francis Drake, Rare Book and Special Collections Here you can see a medieval interpretation of the notion of the heavenly spheres. On the bottom is a depiction of the Earth, above that is fire (the lightest of the Aristotelian elements). Beyond that one finds band of the moon, followed by Mercury and Venus, then the sun, followed by Mars, Jupiter and Saturn, and beyond that the band of the fixed stars and beyond them the angels and heaven. The distinct colors and firm lines separating each band underscores the belief in these as layers that did not intersect. *Buch der Natur* (Book of Nature). 1481. Rosenwald Collection. Rare Book and Special Collections Division Ancient Greek ideas about the heavens became known as the Ptolemaic model, which had Earth at the center of the universe. In this image you can see each of the planets represented as the personifications of the gods they are named after. Each deity is seen riding a chariot through the heavens. *Harmonia Macrocosmica*, 1708. Geography and Maps Division. An example of one of the many tables found in the *Almagest*. Well over a thousand years after Ptolemy put these tables together, they were being, commented on and revised. *Almagest*, 1515. Rare Book and Special Collections Illustration of the orbit of Mercury from *Di Sphaera Mundi* originally published by Johannes de Sacrobosco. 1230. In this model, Mercury moved on its epicycle, illustrated as the three small circles. *Di Sphaera Mundi* (Sphere of the World). 1482. Rare Book and Special Collections Division. Illustrating just how extensive Ptolemy's impact was on astronomy, more than a thousand years after his work it was still being translated and commented on. Here in the frontispiece to astronomer Regiomontanus' *Epytoma in Almagestum* one can see Ptolemy and his renaissance translator and commenter Regiomontanus seated beneath an Armillary Sphere. *Epytoma Ioannis de Monte Regio in Almagestum Ptolomei*. 1496 Rare Book and Special Collections Division.

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