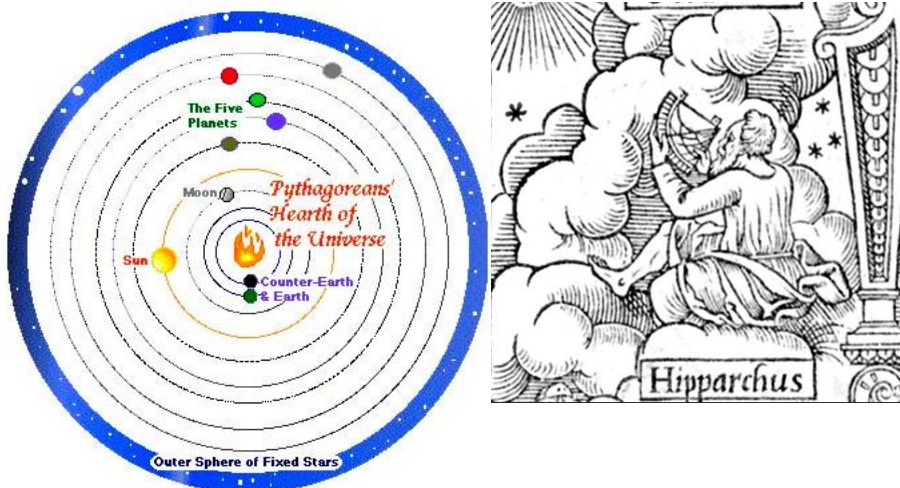


Becoming A Science: Astronomy In Ancient Greece

Although Astronomy was not born in Ancient Greece, it may be said to have first flowered there. For seven centuries, starting more than 2000 years before the invention of the telescope, the Greeks combined reason with observation and geometry to gain an understanding of eclipses, the size and shape of Earth, and the distances to the Moon and the Sun. Collectively, the Ionian Scientists created a geometric model of the Cosmos (the Geocentric Theory) that in some respects was the most successful scientific theory of all time: it stood virtually unchallenged for 14 centuries, its acceptance as an article of faith by the Roman Catholic Church setting up the classic confrontation between Science and Religion in 1632: the trial of Galileo.

Becoming A Science:



Astronomy In Ancient Greece







Piazza
San Marcos,
Venice, Italy



Bertini
Fresco of
Galileo
Showing
His
Telescope
to the Doge
of Venice in
1609



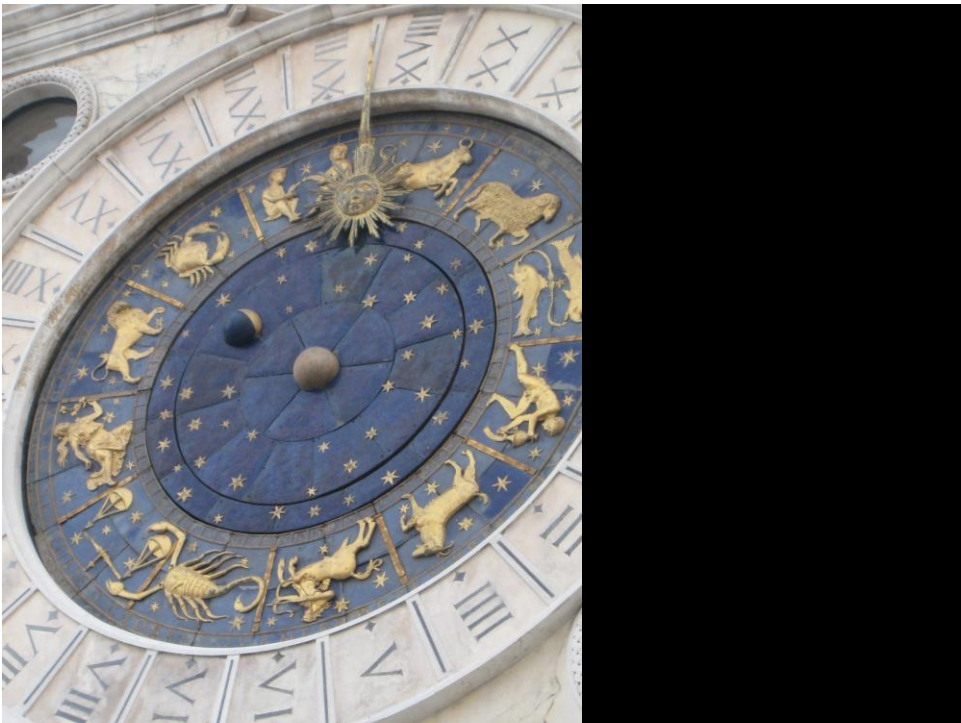


On Piazza San Marcos in Venice
 Is this building with a beautiful
 Clock. Both the Clock and the building
 It is housed in were constructed in
 1499, 110 years before Galileo showed
 his telescope to the Doge.



On Piazza San Marcos in Venice
 Is this building with a beautiful
 Clock. Both the Clock and the building
 It is housed in were constructed in
 1499, 110 years before Galileo showed
 his telescope to the Doge.

Notice the "Bar Americano"
 on the 1st Floor





As this clock neared completion in 1499, Polish Cleric Nicolaus Copernicus was 26 years old, still 44 years away from publishing his "*de Revolutionibus*", which would usher in the Sun-Centered concept of the Solar System.

Within 5 Months of Galileo's Demonstration to the Doge,

- Galileo stepped up the magnification of his telescope to 30 power and turned it skyward.
- *The Sidereal Messenger of 1610*, describing his observations, immediately made him one of the most famous people in the world.
- What he saw offered a powerful challenge to the Geocentric Theory, accepted and endorsed by the Roman Catholic Church.
- 24 years later, in the classic confrontation between religion and science, Galileo was convicted of heresy by a court of the Inquisition and sentenced to house arrest for the remainder of his life.

- But Galileo's observations ignited the first "golden age" of Astronomy, during which the telescope first extended our view, and led to profound new ways of understanding the *Cosmos*.

- But Galileo's observations ignited a "golden age" of Astronomy, during which the telescope first extended our view and led to profound new ways of understanding the *Cosmos*.
- A second "golden age" of Astronomy is occurring right now, as we rocket above our atmosphere to peer deeper into space than ever before, and use tools no Greek or Italian ever dreamed of in centuries gone by.

But Something Equally Important to Astronomy Happened 26 Centuries Ago

In a small city on the eastern coast of the Mediterranean Sea, Nature began to be approached in a whole new way.

The city was Miletus, and what took place there and in the next few centuries in Greece would play a big part in turning Science into “the greatest invention of all time.”

The Sky Was Common Knowledge

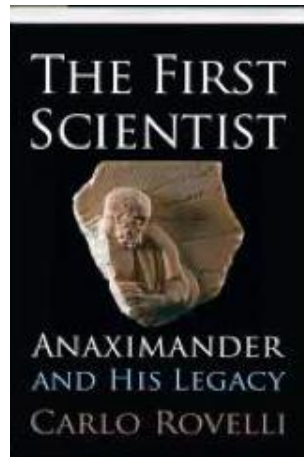
- The sky was at once a calendar and a clock. A quick glance at the constellation visible in the east at dawn would reveal the time of year.
- In *The Odyssey*, Homer writes that Odysseus is given instructions to return to Ithaca. “Keep the Great Bear on your left, and sail toward the rising point of the Pleiades.” That would send Odysseus on a course due east.

Chinese and Babylonian Astronomy

- Had observed and kept written records for centuries prior to the 6th Century BCE.
- The Chinese were mandated to clarify the calendar, and were driven by religious considerations. Until 300 years ago, the Chinese Astronomical Institute had not yet come to understand that Earth is round.
- Babylonian Astronomers were motivated to find patterns and relations between happenings in the heavens and those on Earth. They collected centuries of data, but had no conceptual understanding of the structure of the Cosmos.

Carlo Rovelli Comments:

“At a certain point in humanity’s history, the idea came into being that it was possible to understand these phenomena – their interrelation, causes, and connections – without recourse to the caprices of gods. This immense turning point took place in Greek thought of the 6th century BCE, and it is consistently attributed to Anaximander in all of the ancient texts.”



It is said that Anaximander of Miletus first opened the doors of nature.

Pliny, Natural History 2

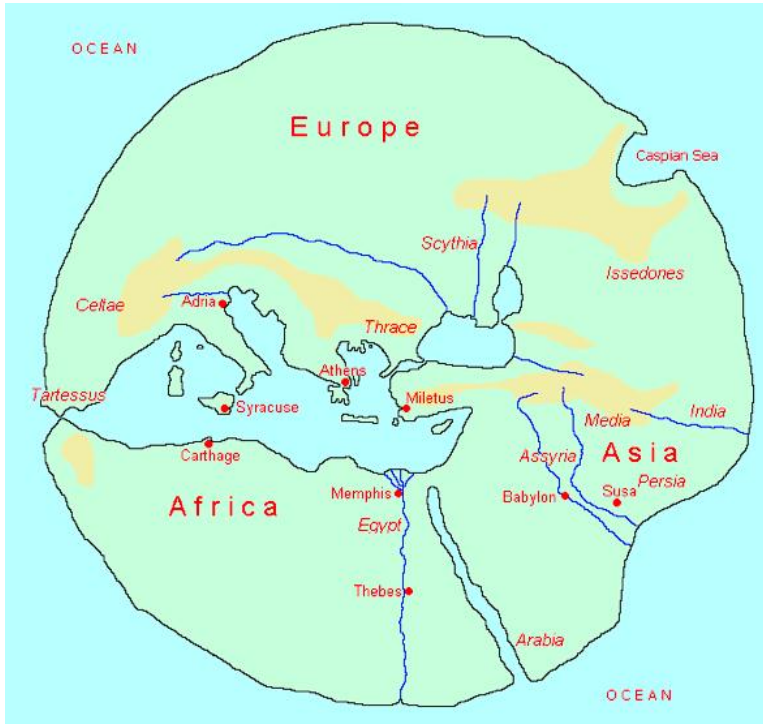
Rovelli Comments:

“When he ‘opened the doors of nature’, Anaximander ignited a conflict between two profoundly different ways of thinking. On the one hand, there was the dominant mythical and religious way of thinking, based in large measure on the existence of certainties that, by their very nature, could not be called into question.”

“On the other hand, there was the new way of looking at the world, based on curiosity, rejection of certainties, and change. This conflict has run through the history of Western civilizations, century after century, with alternating outcomes. It is still open. This clash [which we see strengthening today] is measured in millennia rather than centuries.”

Dirk Couprie, Anaximander Biographer:

“We are convinced that Anaximander was one of the greatest minds that has ever lived. . . I do not hesitate to put him on a par with Newton”



Reconstruction of a World Map By Hecateus Of Miletus, 550-490 BCE



At Anaximander's Birth in 610 BCE:

Humans had been living in cities for at least 10,000 years.

The Great Kingdom of Egypt had been in existence for 26 centuries, the same time period that separates Anaximander from us.

Babylon, with 200,000 inhabitants, was the largest city in the world.

The Babylonians had developed the concepts that, in our time, are studied by seven-year-olds.

Thales of Miletus (635-543 BCE)

- Commonly referred to as "The First Scientist"
- Anaximander studied under him.
- Is said to have predicted a solar eclipse.
- Believed the Universe came from water.
- Introduced Deductive Logic
- Used Geometry to find the distance to a ship at sea & the height of a pyramid
- Held that Earth is flat and floats in water

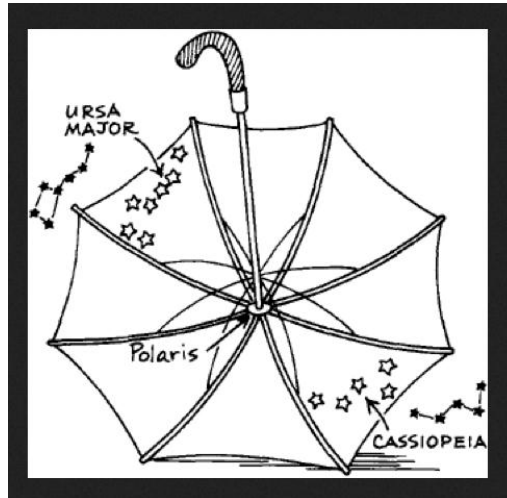
Then why the Emphasis on Anaximander?

- Anaximander's contributions were far more wide-ranging – from meteorology and geology to astronomy and biological evolution
- Anaximander was a student of Thales but did not feel compelled to support his worldview.



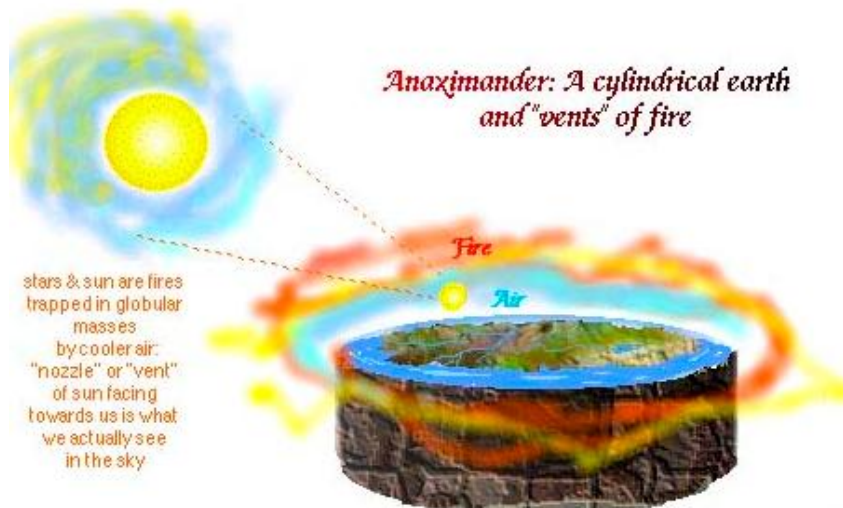
Anaximander reasoned that nothing supports the Earth – anything underneath it would block the stars in their daily paths.

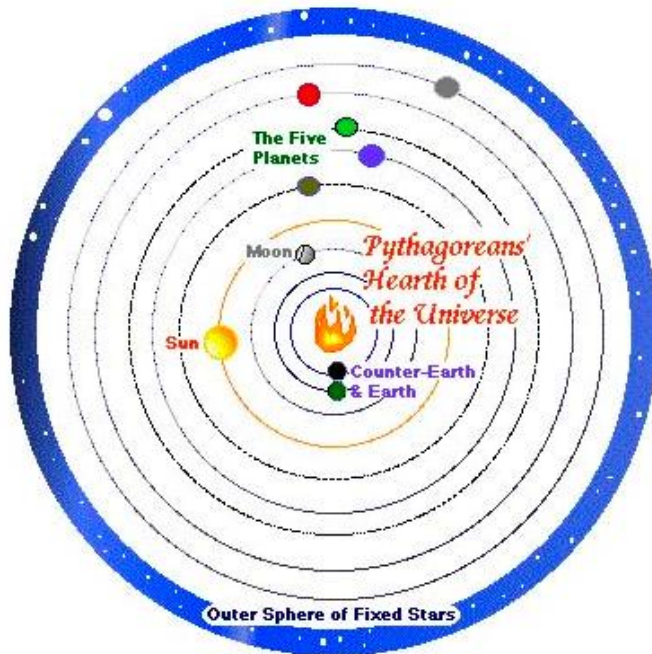
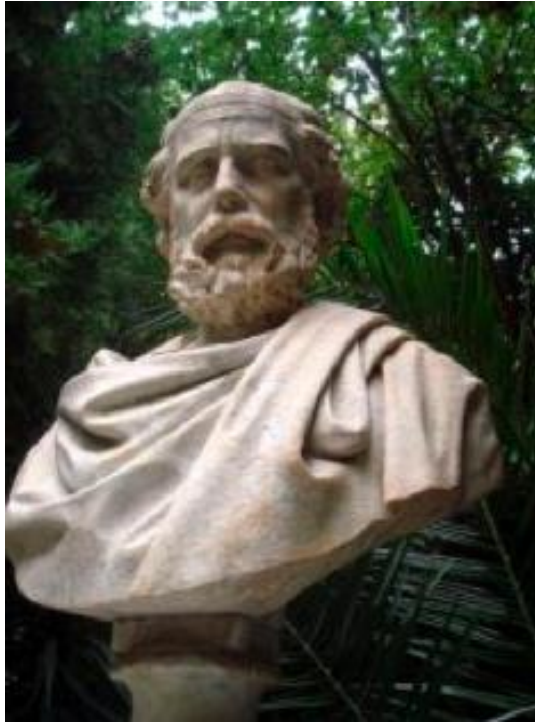
A way to envision the movement of stars above (and below) the Northern horizon:



Twirl the umbrella counterclockwise, using its handle as an axis.

Anaximander of Miletus c. 550 BCE: Celestial Fire and Pipes



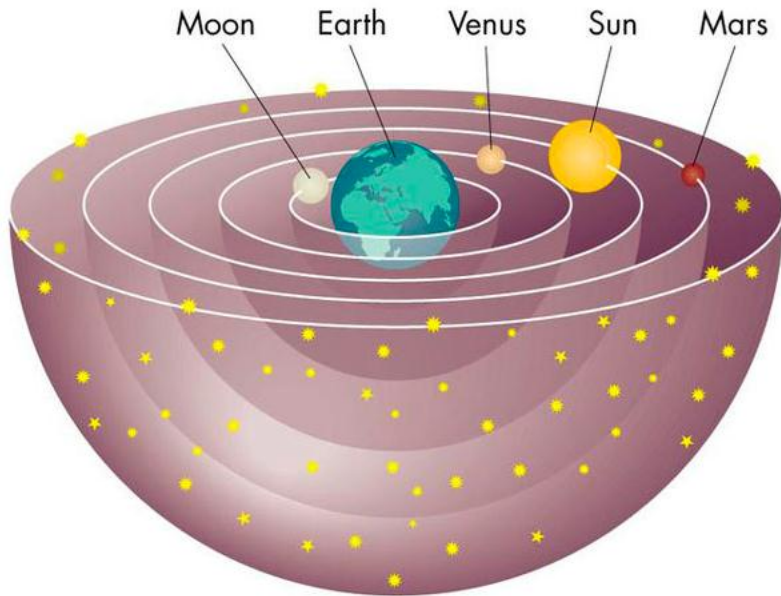
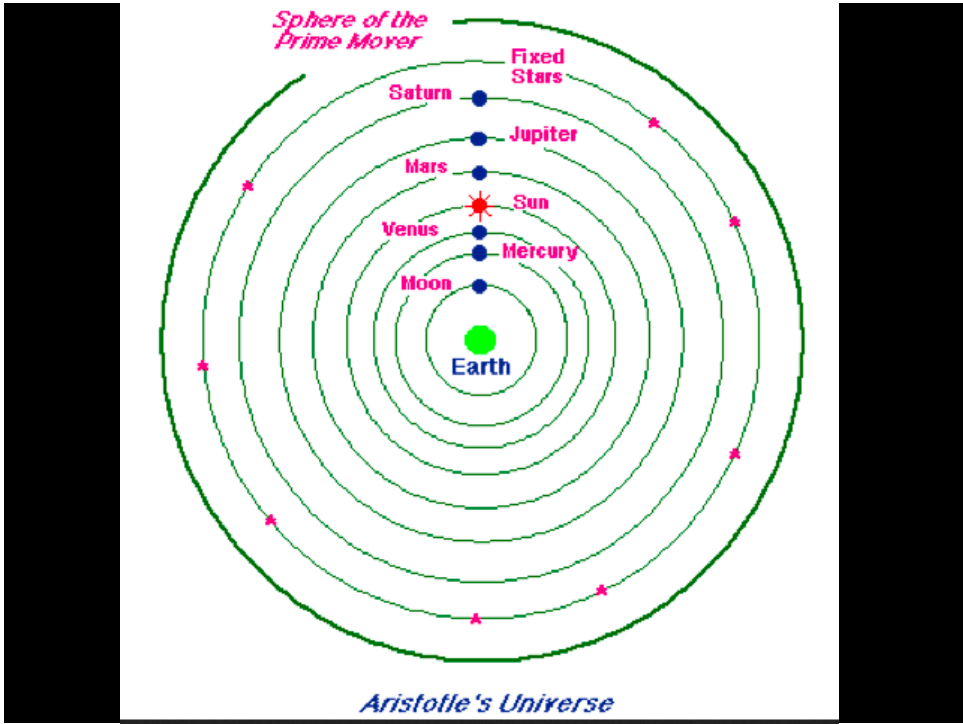


Pythagoras of Samos (572-492 BCE)

- Held that the Earth is spherical – noted that ships disappeared hull first, sails last, as they traveled into the distance.
- First to suggest that the Sun, Moon & planets could be described by numbers and mathematical precision.
- Discovered that the morning and evening star are the same thing, the planet Venus.

Plato: The Heavens Are Perfect

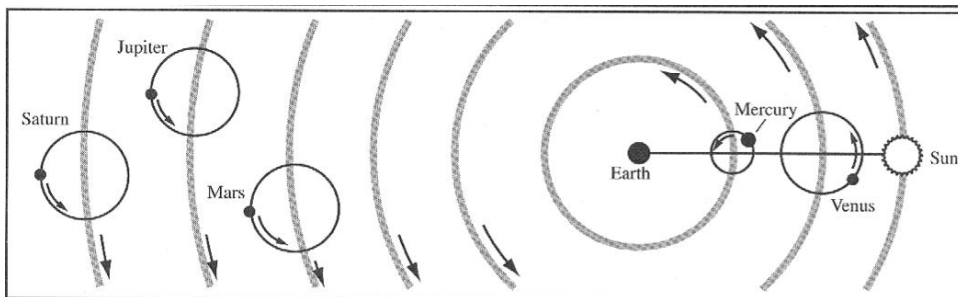
- The only permissible path must be the circle.
- Solid bodies must be spheres.
- Changes do not occur – comets & meteors must be atmospheric phenomena.
- Heavens are composed of a 5th Element – quintessence or aether. It is a “perfect, invisible crystalline material.





Claudius Ptolemy
(87-150)

Ptolemy: *The Almagest*



Epicycles and Deferents

Planets occasionally change direction.



The Ptolemaic System

- Was all done with Circles and Spheres.
- Earth was a sphere, and did not move in any way.
- The Celestial Sphere marked the limits of the Cosmos, and was only slightly further than Saturn.

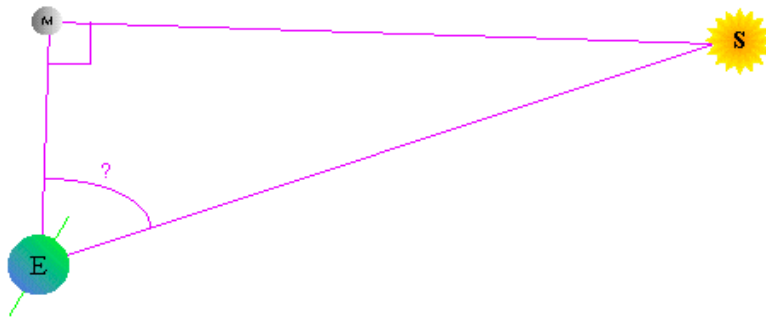
The Ptolemaic System

- Went largely unchallenged for the next 14 Centuries – in this sense, it was the most successful scientific theory of all time.
- Was accepted by the Roman Catholic Church as an article of faith, thereby greatly discouraging scientific inquiry. It became frozen in place – but it helped to provide some “certainty” to the lives of individuals of those times.

But Other Things Had Been Learned:

- Aristarchus of Samos (circa 300 BCE)
- Eratosthenes of Cyrene (276-194 BCE)
- Hipparchus of Nicaea (190-120 BCE)

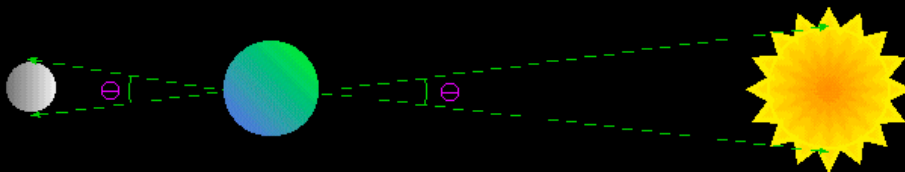
Aristarchus' method of determining the relative distances from the earth to the moon and to the sun



With the measurement of angle MES the ratio of EM and ES can be found.

He found that: $MES = 87^\circ$ so $EM/ES = 1/19$
 actually: $MES = 89^\circ 51'$ and $EM/ES = 1/400$

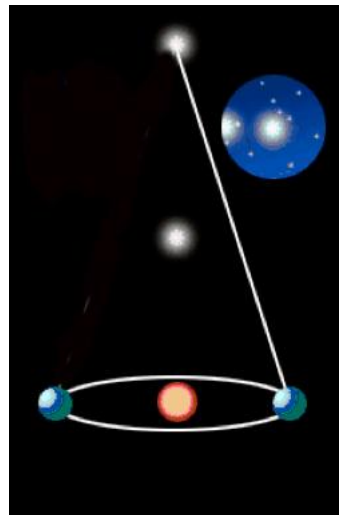
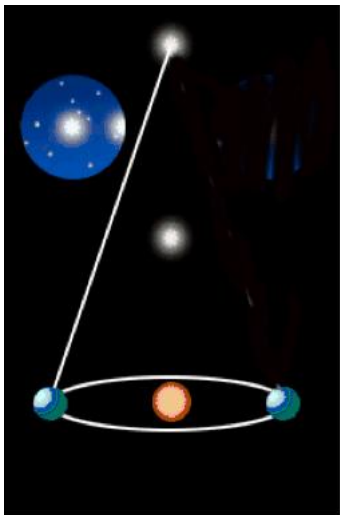
Aristarchus method of determining the size of the sun:



If the sun is 19 times farther away than the moon from the earth, as Aristarchus thought, then the sun must be 19 times bigger than the moon.
 His logic is correct, but the sun is actually 390 times farther from the earth than the moon.

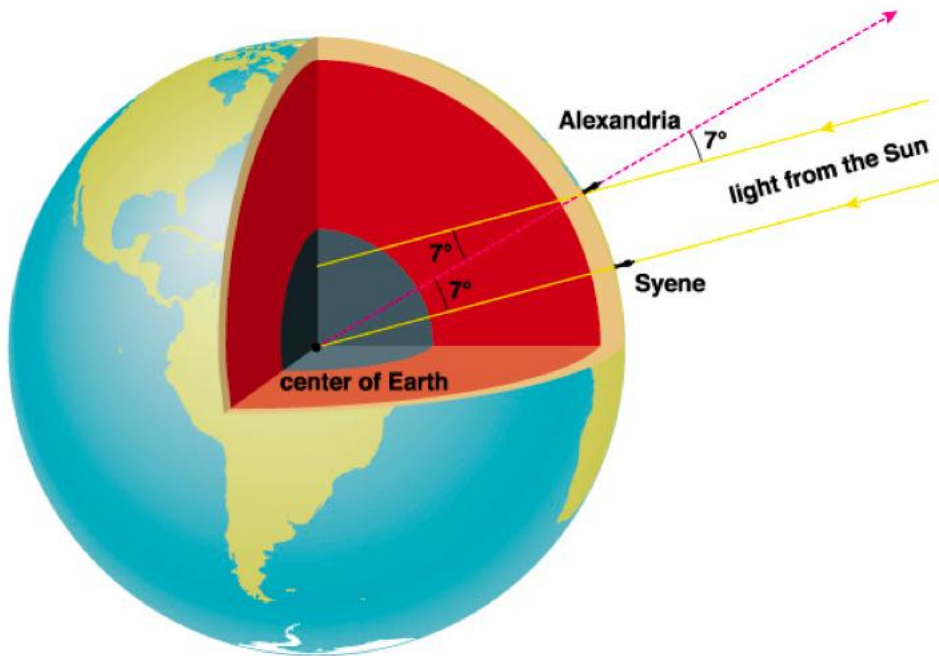
Aristarchus:

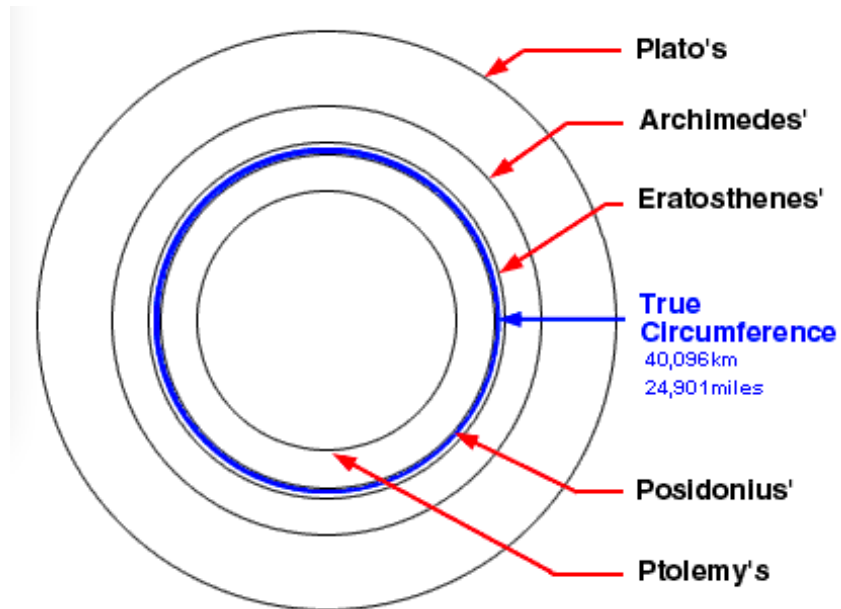
- His measurements had shown that the Sun was much bigger than Earth.
- He proposed that the Earth must orbit the Sun, and that Earth rotates on an axis in order to explain the motions of celestial objects across the sky.
- He also suggested the Universe to be much bigger than the prevailing understanding in Greece.





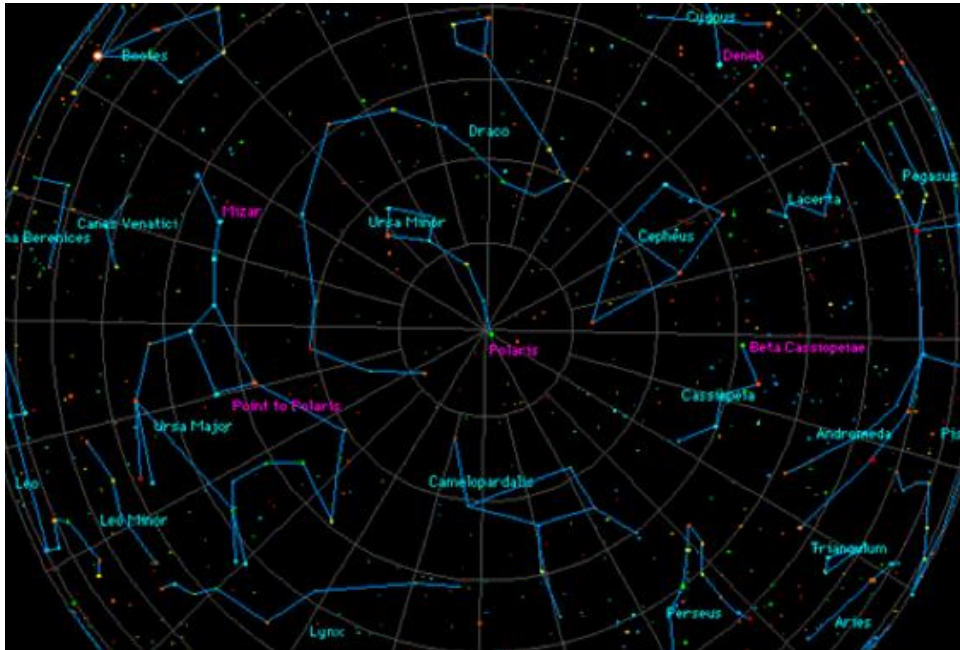
Eratosthenes (~200 BCE)



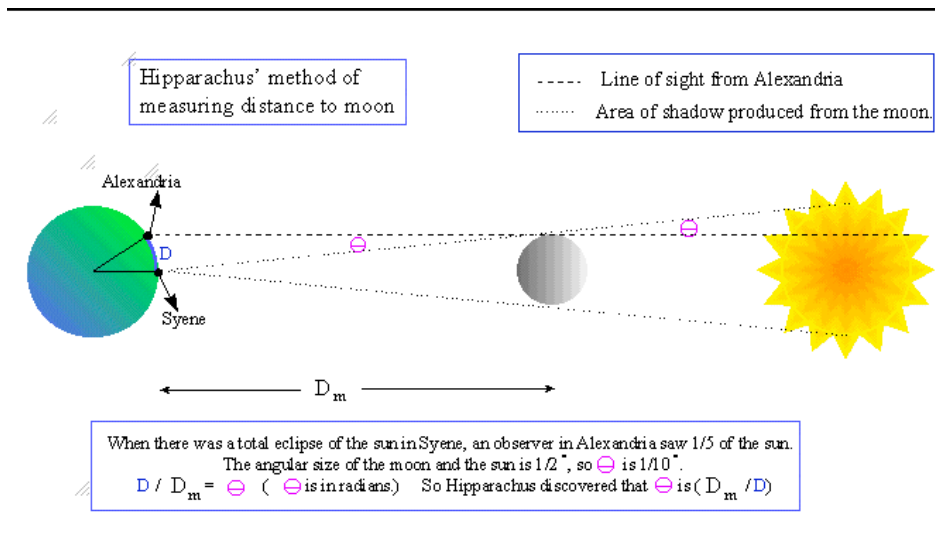
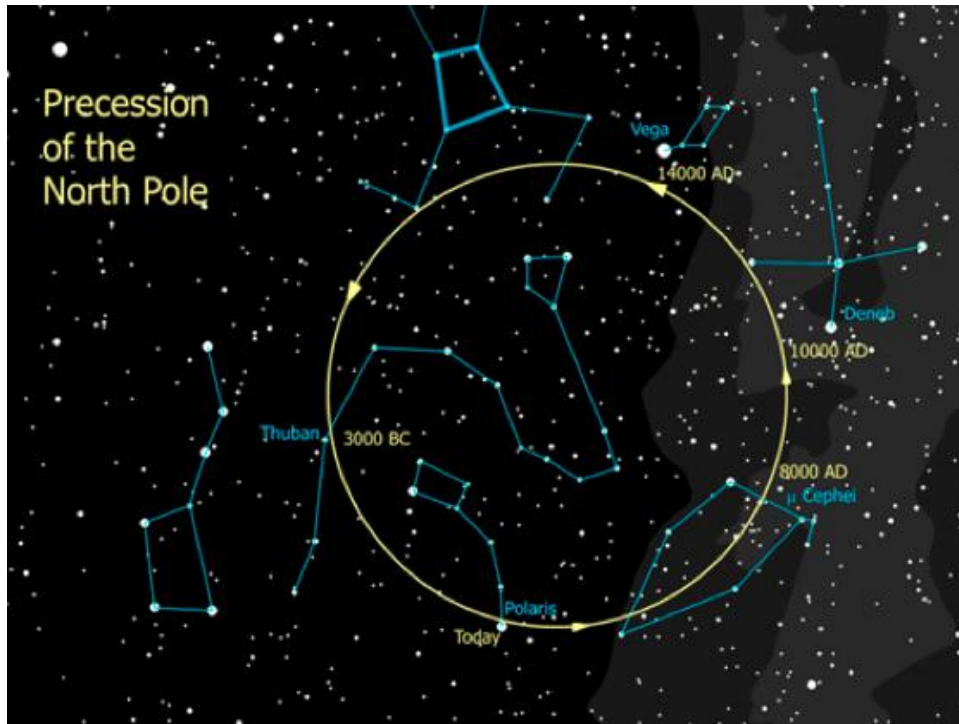


Hipparchus:

Is considered by many to be the greatest astronomer of antiquity, and by many others to be the greatest observational astronomer of ancient times.



Anaximander reasoned that nothing supports the Earth – anything underneath it would block the stars in their daily paths.



“Science, above all, is a passionate search for always newer ways to conceive the world. Its strength lies not in the certainties it reaches but in a radical awareness of the vastness of our ignorance. This awareness allows us to go on questioning what we think we know and have learned, and, thus, to continue learning. Not certainty but a radical lack of certainty nourishes the search for knowledge.”

Carlo Rovelli

The First Scientist: Anaximander and His Legacy

