SPASH ASTRONOMY
CHAPTER 2: HISTORIC ADVANCES: WORLDS IN THE SKY
OVERHEAD LECTURE NOTES

Greeks that made great contributions to Astronomy:

A. Thales (600 BC) speculated that **the Sun and stars were not gods**, as was then usually thought, **but great balls of fire**.

B. Pythagoras (510 BC) proposed the unusual idea that the **Earth is spherical,** and that it moves, like the Moon and the planets, around a distant center.

C. Anaxagoras (500-428 BC) is credited with **deducing the true cause of eclipses.** Thereafter, the observed roundness of the earth's shadow on the Moon undoubtedly helped to establish the theory that Earth itself is a spherical body. Anaxagoras was banished from Athens for saying that the Sun was an incandescent stone even larger than Greece.

****D1. Aristotle (384-322 BC)** said the universe was spherical and finite, with the Earth at the center. **Planets and other bodies moved in a multitude of spherical shells centered on the Earth**. Aristotle had a spherical Moon, a **spherical Earth, a Sun farther away than the Moon, and the Earth stationary**, all with powerful evidence to prove his theories.

D2. The two reasons **Aristotle** gave for the Sun being further away than the Moon are:
1). The Moon's crescent phase shows that it passes between the Earth and the Sun. (What other objects travel between the Earth and the Sun?)
2). The sun appears to move more slowly in the sky than the Moon. How far do the sun and the moon appear to move per day amongst the backdrop of stars?

D3. The two reasons **Aristotle** gave for a spherical Earth are:

1). The curvature of the Moon's terminator rules out its being a disk (flat circle), and the Earth is likely to be like the Moon in this respect.

2). As a traveler goes north, more of the northern sky is exposed while the southern stars sink below the horizon – a circumstance that would not arise on a flat Earth.

D4. What powerful argument did **Aristotle** give for the Earth standing still?

Aristotle could not detect **parallax** or the shift in position due to motion. As you drive down a highway you notice objects close to the road seem to zoom by you but objects in the distance seem to barely move. Well if the Earth went around a distance object Pythagoras claimed then when you mapped stars positions when the Earth was at one point in space and again 6 months later when the Earth you were riding on moved to the far side, the nearer stars should change position more than the far away stars. **Aristotle could not detect any stellar parallax.** Aristotle reasoned that either stars could be immeasurably far away and thus one couldn't notice parallax or the Earth did not move and all celestial objects revolved around Earth.

E. **Aristarchus (310? – 230? BC) of Samos** concluded that **the Moon is one-third as big as the Earth and the Sun is about seven times as big as Earth.** The correct figures are closer to one-fourth and 100, but Aristarchus was on the right track. Aristarchus correctly visualized the Moon in orbit around a spherical Earth and Earth in orbit around the Sun, and he developed a method of measuring interplanetary distances. **These ideas were not confirmed for another 2000 y!**

F. Eratosthenes (276? – 192? BC) was a researcher and librarian at the great Alexandrian library in Egypt. He reportedly **completed a catalog of the 675 brightest stars and measured the 23.5° inclination of the Earth's polar axis to the ecliptic pole**, as shown in Figure 2-8 page 42. **This tilt causes our seasons.** He also **estimated the size of the Earth within 20%** of the right answer be **using a shadow. He clearly understood the shape and approximate size of the Earth 1,700 years before Columbus!**

G. **Hipparchus (160? – 125? BC) compiled a catalog of some 850 stars.** His exhaustive observations enabled him to predict with reasonable accuracy **the position of the Sun and Moon for any date. The most important discovery attributed to Hipparchus is precession.** He noticed star positions handed down from centuries before had the north celestial pole at a different spot with respect to the background stars. Could the old maps be wrong? Hipparchus concluded instead that the whole coordinate system of the celestial equator and the poles were drifting slowly with respect to the distant stars. This drift came to be known as precession. In modern terms, precession is the result of a wobble of the spinning Earth due to forces produced by the Sun and the Moon. The complete cycle takes

about 26,000 years. (Figure 2-10b page 45) **Hipparchus calculated that the Moon is 29.5 Earth diameters away, close to the correct value of about 30.**

H. **Ptolemy (150 AD) was another scholar associated with the Alexandrian library. His fame as an astronomer is based on a 13-volume work called the **Almagest.** This was the Astronomy bible for more than a thousand years. **Ptolemy found a model worked for Aristotle's Earth centered universe.** The model involved epicycles or smaller circles centered medium circles that were further centered on a large circle for the orbit of a planet around the Earth. This model became known as the **epicycle theory, or Ptolemaic theory.** Figure 3-3 page 55.

I. **Hypatia (373 – 415 AD)** was **one of the first known women astronomers** and was among the last guardians of the old knowledge in Alexandria. She was widely admired for her intelligence and beauty. Hypatia wrote a **commentary on Ptolemy's work and invented astronomical navigation devices.**

Side note: In 640 AD, after a 14 month siege by the Arabs, Alexandria fell. The library buildings were burned, and much of the Greek knowledge was passed into the hands of the Arabs and Islamic societies. With the fall of Alexandria, Europe slipped into the Dark Ages. But intellectual progress occurred in other cultures.

J. **Islamic**: The next known measurement of the Earth's circumference was made near Baghdad in 820 AD and was only 4% too large. At about this time Easter was set to be the Sunday following the first full moon of spring which is still how Easter is determined today.

K. **Chinese:** Chinese astronomers were predicting eclipses before 1000 BC. According to one Chinese view around 120 BC the Earth was constantly in motion. Chinese observers kept the world's best records of supernovas and made some ancient observations of positions of Halley's comet and other comets. They developed strikingly modern conceptions of the universe, and rediscovered precession around 336 AD.

L. **Native American**: Between 100 AD and 1200 AD, especially in Central America, Native Americans built astronomically aligned observatories, tracked the planets, and devised calendars based on eclipse cycles.