Lecture 10: September 25, 2010

- What fraction of the Earth's atmosphere is CO_2 from burning of fossil fuels?

Announcements:

Second homework is posted on website and is due next Monday, the 20th.

First exam is Monday the 27th.

Next Observatory opportunity is Tuesday, September 21

Will meet at Fiske Planetarium this Friday

NEXT LECTURE!

3.2 The Ancient Roots of Science

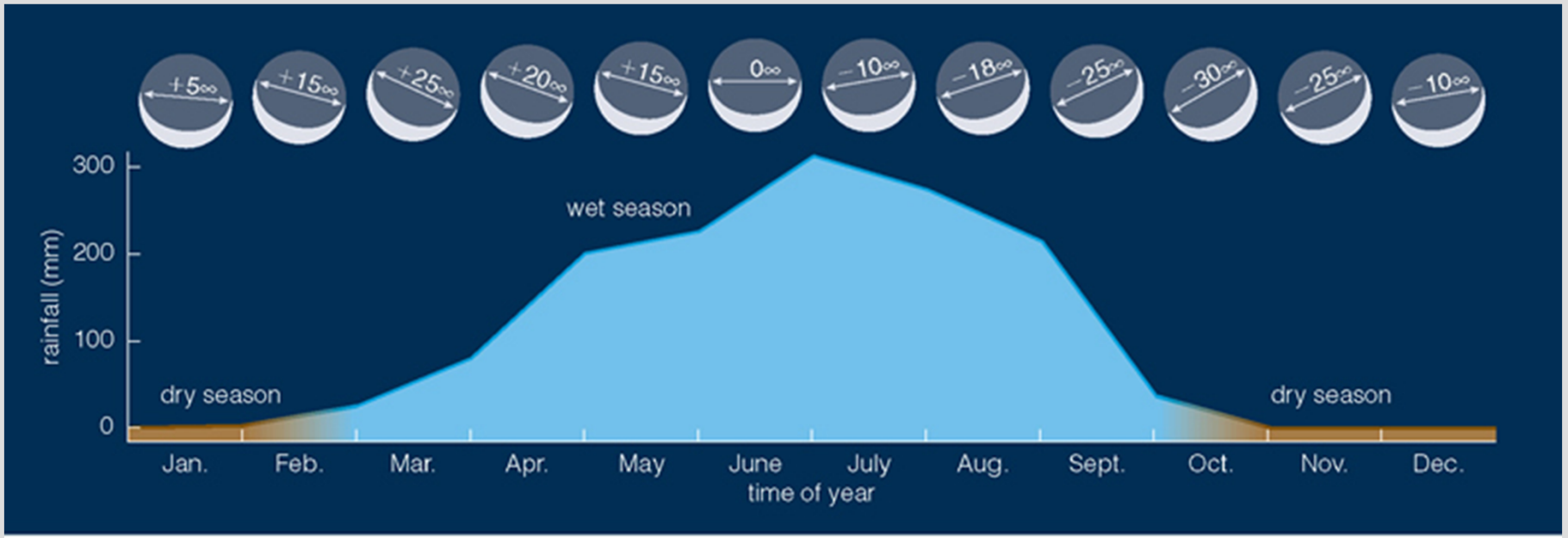
Our goals for learning:

- How is modern science rooted in ancient astronomical observations?
- Describe several impressive ancient astronomical accomplishments.

Ancient Astronomy

- Many cultures throughout the world practiced astronomy.
- They made careful observations of the sky.
- Over a period of time, they would notice the cyclic motions of:
  - Sun
  - Moon
  - planets
  - celestial sphere (stars)
  - Told of time of year, seasons, weather, etc. Important to an agricultural/hunting lifestyle.

Central Africa



Archaeologists have found a lunar calendar on an animal bone *circa 6500 B.C.*

Modern names - Ancient roots

Object	Teutonic Name	English	French	Spanish
Sun	Sun	Sunday	dimanche	domingo
Moon	Moon	Monday	lundi	lunes
Mars	Tiw	Tuesday	mardi	martes
Mercury	Woden	Wednesday	mercredi	miércoles
Jupiter	Thor	Thursday	jeudi	jueves
Venus	Fria	Friday	vendredi	viernes
Saturn	Saturn	Saturday	samedi	sábado

Planet = wanderer (Greek)

Month from moonth, lunar cycle

a.m. = ante meridiem

p.m. = post meridiem

A year from seasons and position of the Sun in the sky

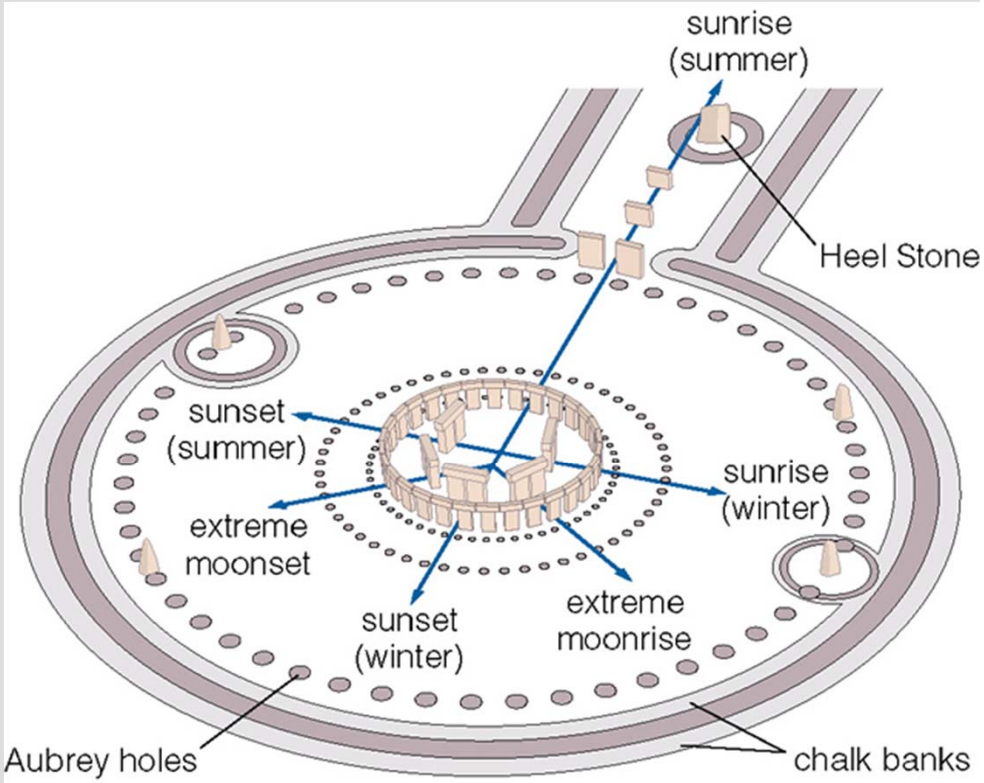
Seasons told by what stars are present

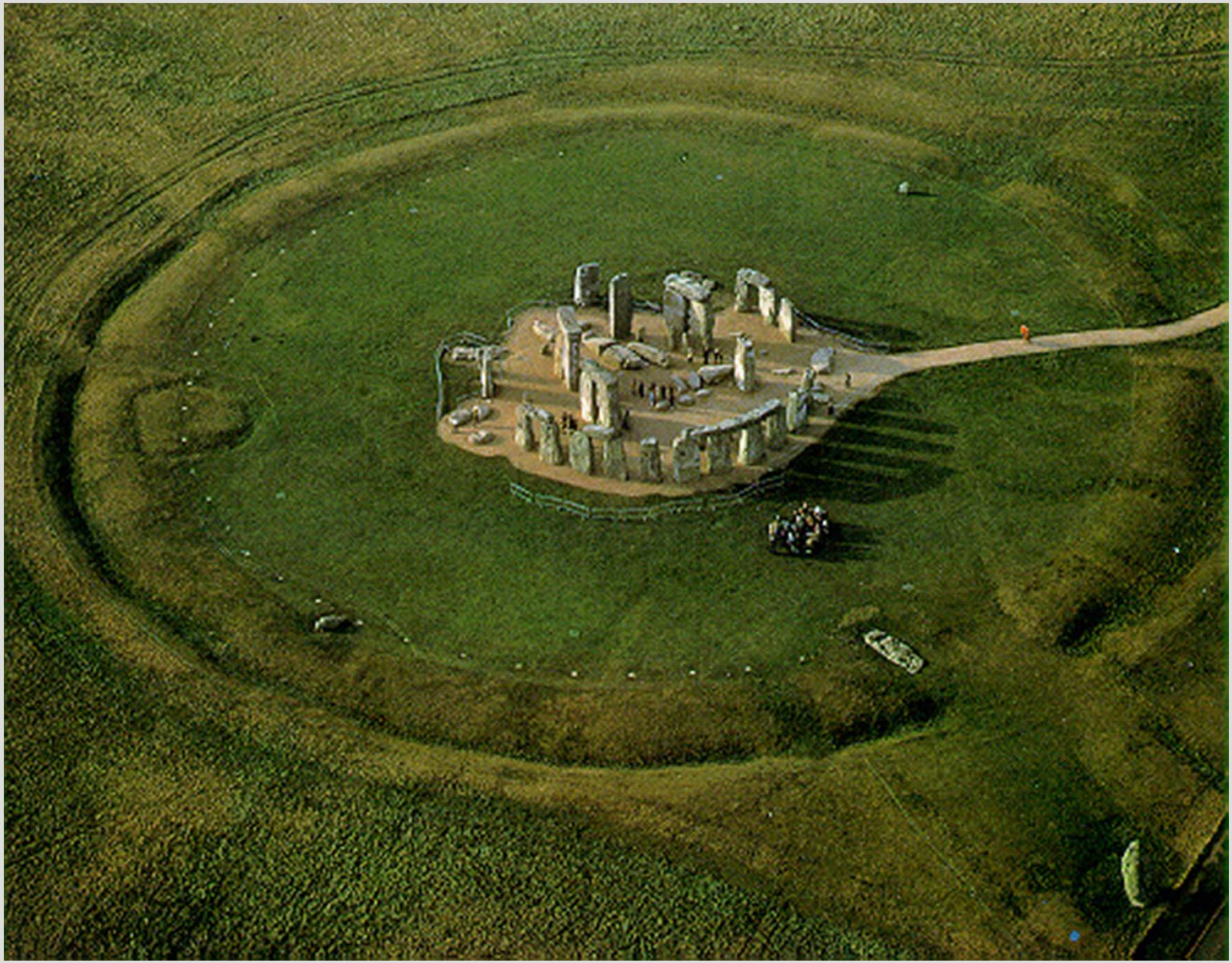
Egyptians divided the amount of daylight into 12 parts, hence a 12 hour cycle to our day.

Stonehenge (2750 - 1550 BC)

This famous structure in England was used as an observatory.

- If you stand in the middle:
  - the directions of sunrise & sunset on the solstices is marked.
  - the directions of extreme moon rise & set are marked.
- The Aubrey holes are believed to be an analog eclipse computer.



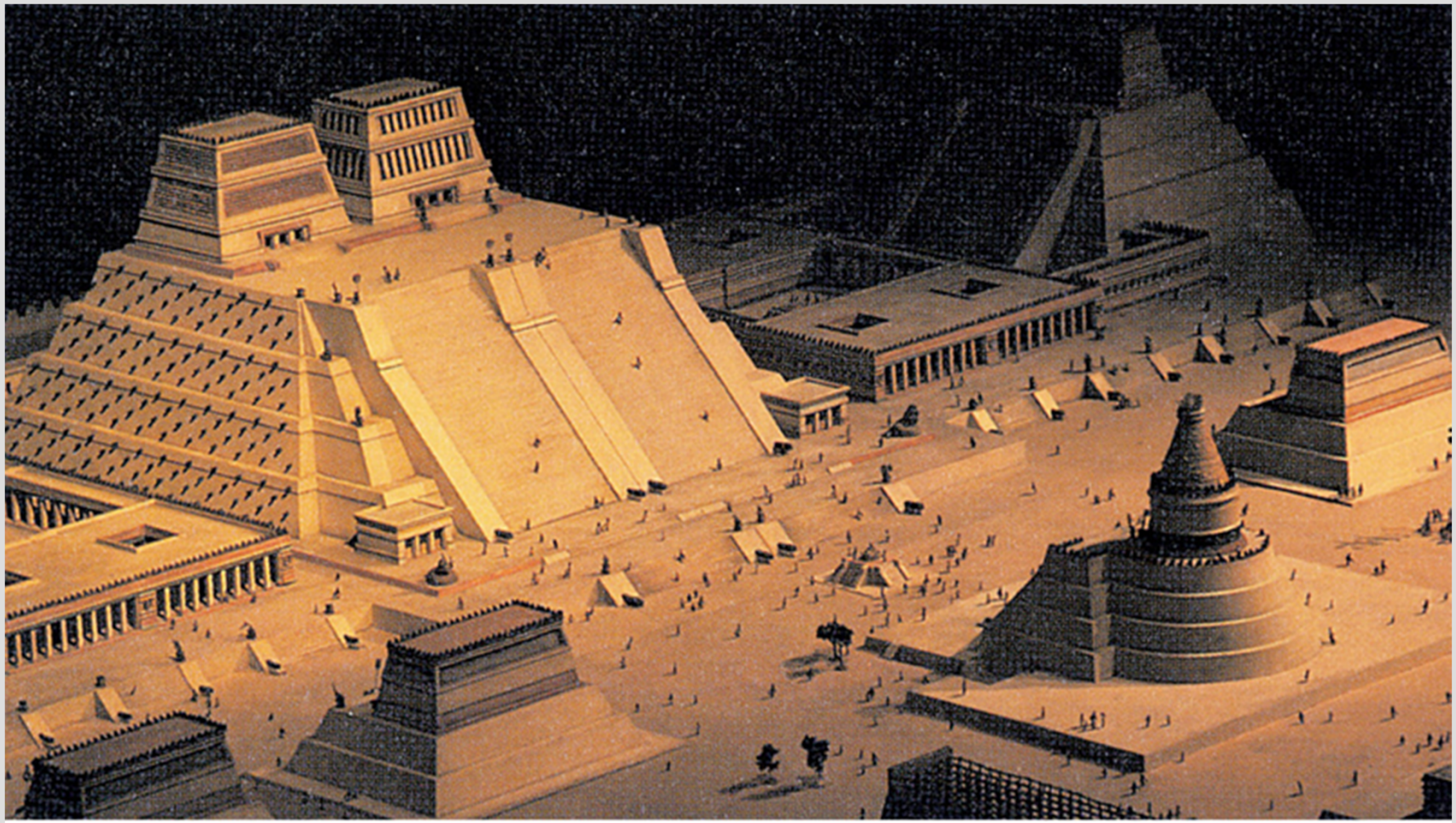


Mayans (fl. A.D. 400 – 1200)

the Observatory at Chichén Itzá

- lived in central America
- accurately predicted eclipses
- Venus was very important
- marked zenial passages
- Mayan mathematics
  - base 20 system
  - invented the concept of “zero”
- Most knowledge lost when conquistadors burned their writings.

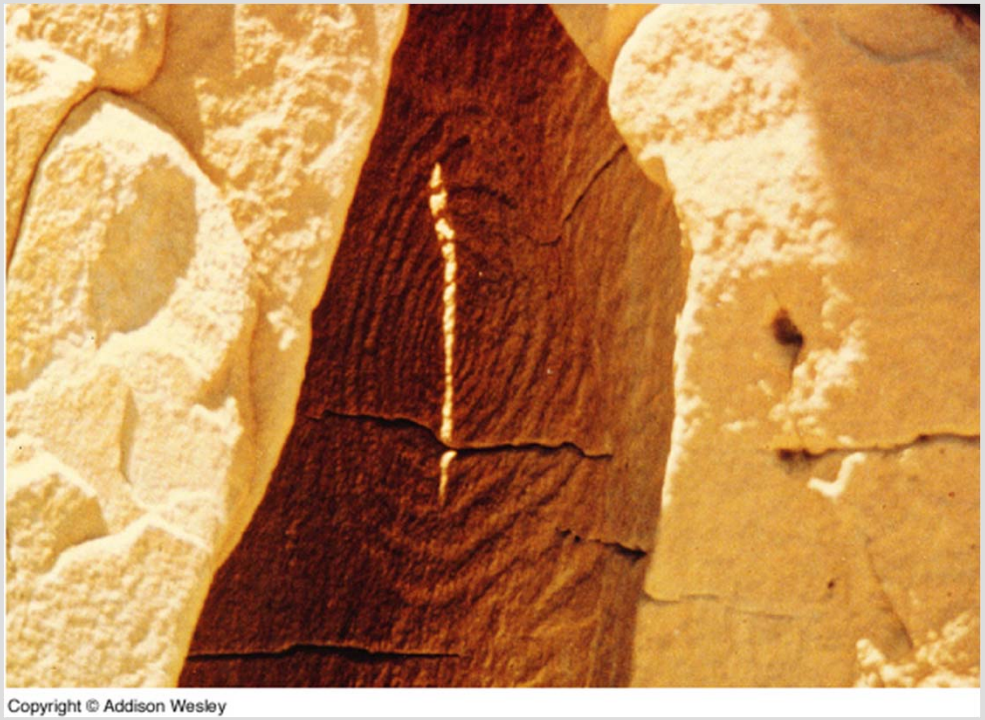
Templo Mayor in Tenochtitlan



Anasazi (ca. A.D. 1000)

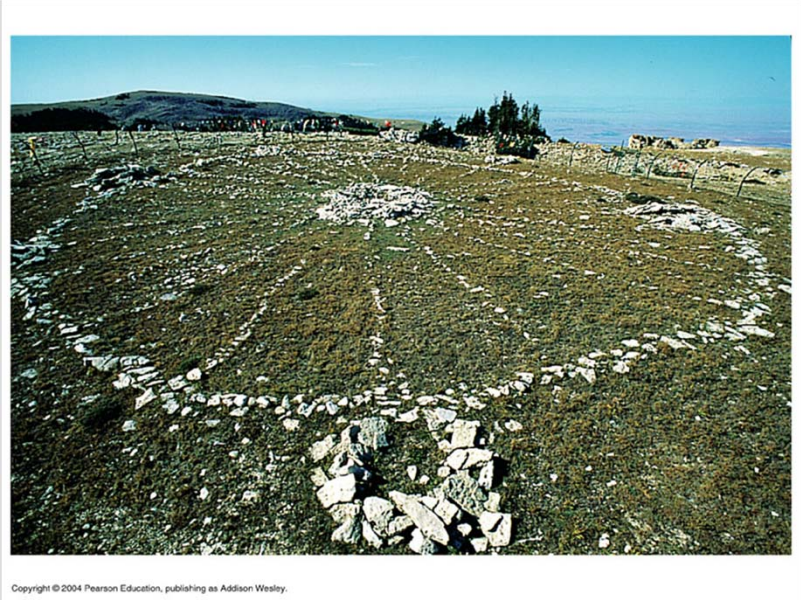
- lived in “four corners” area of SW USA
- built structures to mark solstices and equinoxes

Pueblo Bonita at Chaco Canyon, NM



Sun Dagger at Fajada Butte, NM

Plains Tribes of N. America



Big Horn Medicine Wheel, WY

- star maps and sighting circles were drawn on the ground to mark:
  - solstice rising points of Sun
  - rising points of bright stars
  - 28 spokes for 28 days of the lunar cycle (didn't count the new moon day)

Nazca lines -

800 lines stretching for miles

many aligned with Sun/star rise/set points

Why did they do it?

- archeologists & anthropologists surmise:
  - to keep time
  - for agricultural purposes
  - for religious purposes
- As far as we can tell, none of these ancient cultures tried to build a physical model based on their observations.
- Instead, they created myths to explain the motions of the objects in the sky.

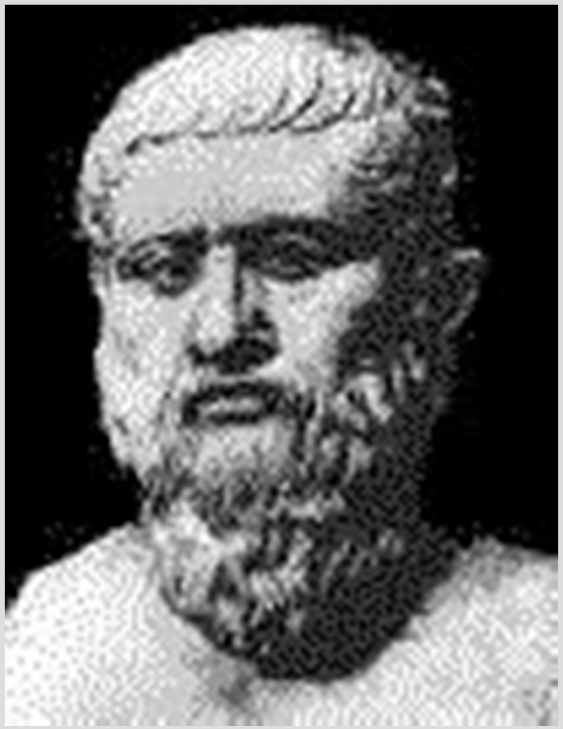
3.3 Ancient Greek Science

Our goals for learning:

- How did the Greeks lay the foundations for modern science?
- What was the Ptolemaic model?

Plato (428 - 348 BC)

- All natural motion is circular
- Reason is more important than observation



Aristotle (384 -322 BC)

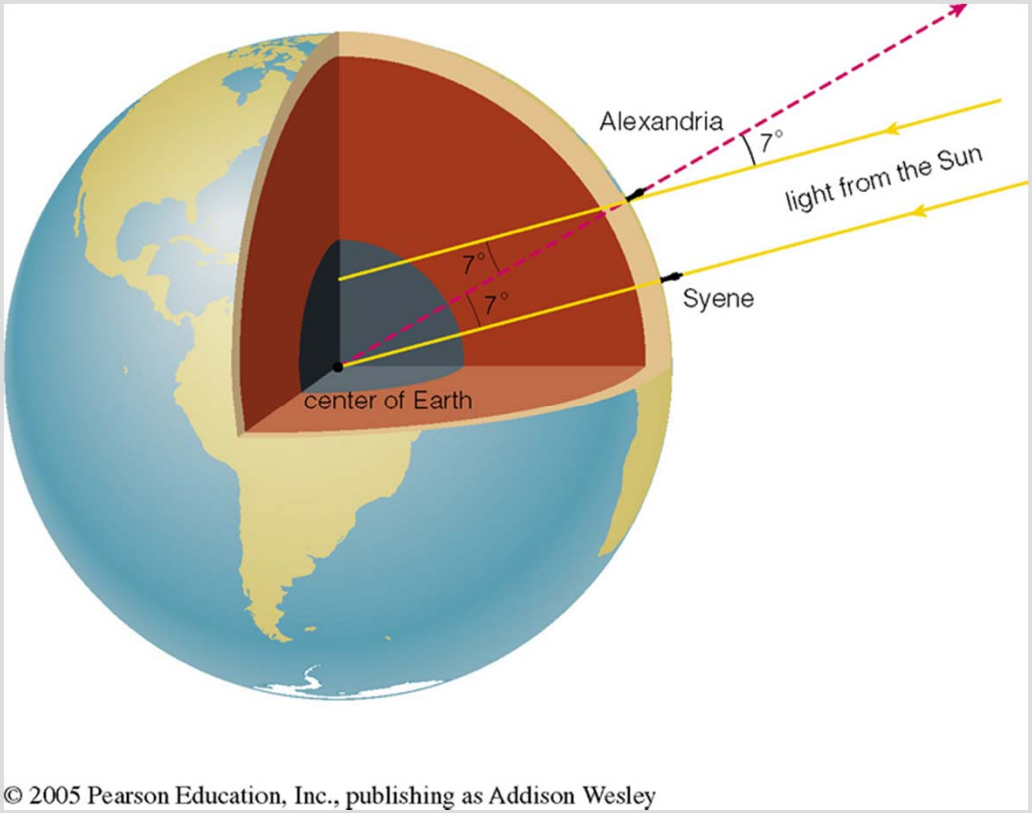
- *Physics*
- Geocentric universe
- elements
  - *earth*
  - *water*
  - *air*
  - *fire*
  - *quintessence*

Eratosthenes (276 - 195 BC)

• He measured the circumference of the Earth.

• The Sun is at the zenith in the city of Syene at noon on the summer solstice.

•But at the same time in Alexandria, it is 7° from the zenith.



• Eratosthenes inferred that Alexandria was 7° of latitude north of Syene.

• The distance between the two cities is 7/360 times the Earth's circumference.

• His result of 42,000 km is very close to the right number: 40,000 km.

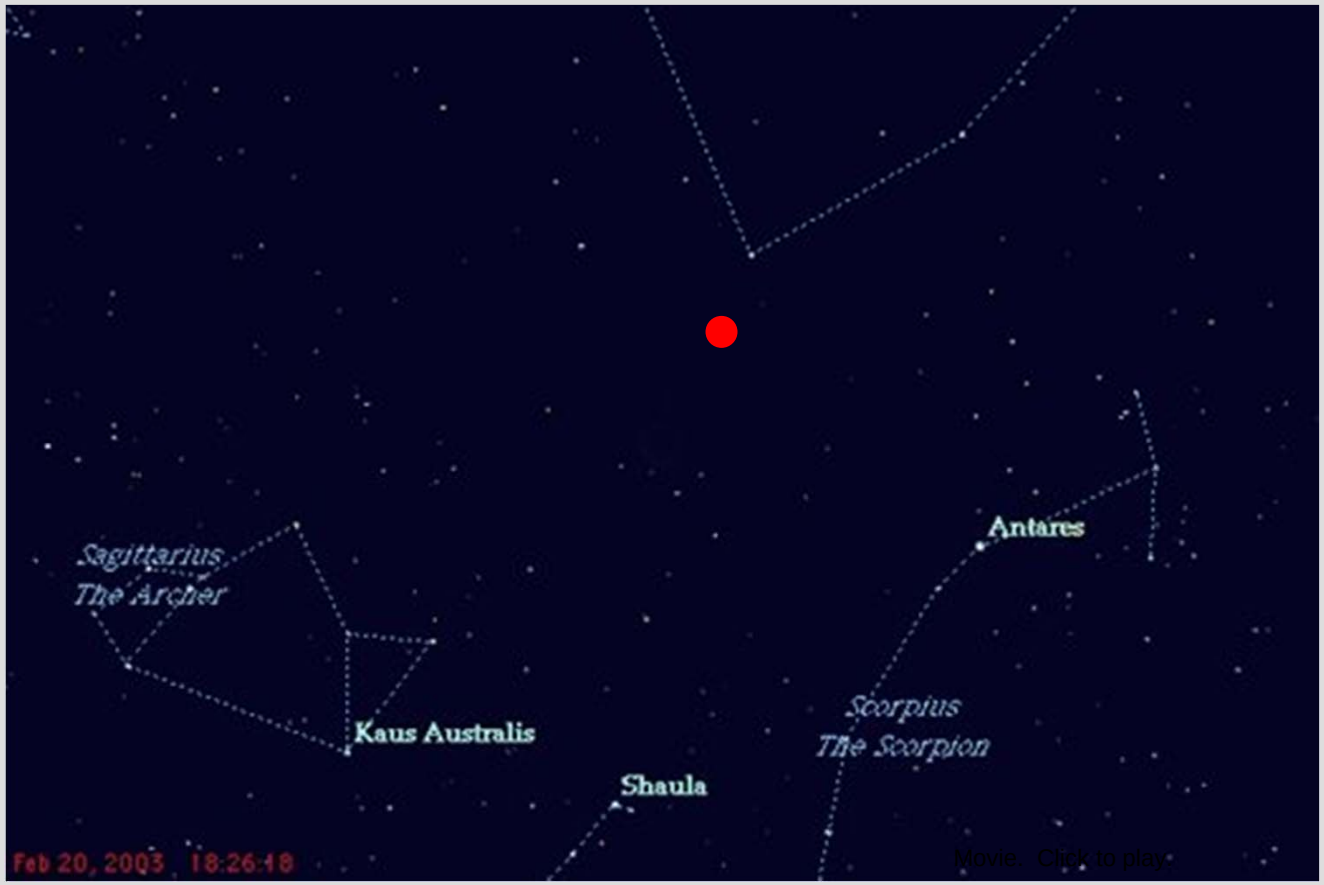
Claudius Ptolemy (AD 100-170)

Almagest

- star catalogue
- instruments
- motions & **model** of planets, Sun, Moon

His model fit the data, made accurate predictions, but was horribly contrived!

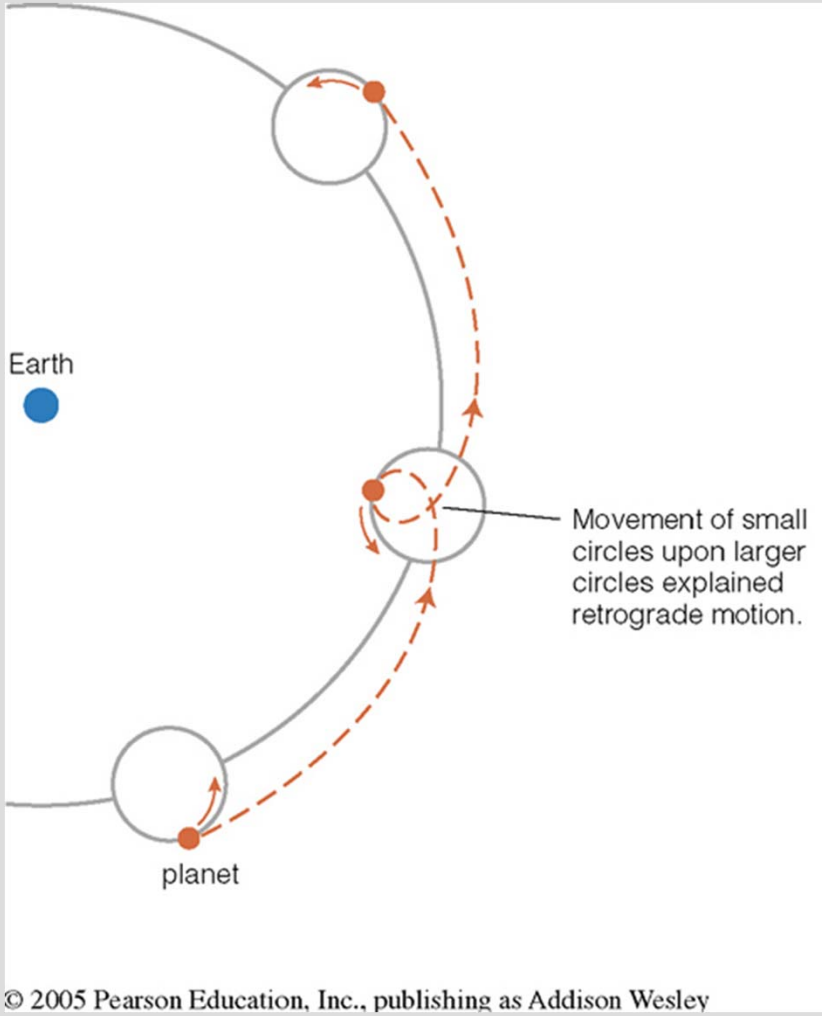
How does one explain *retrograde* motion?



Over a period of 10 weeks, Mars appears to stop, back up, then go forward again.

Ptolemy's Geocentric Model

- Earth is at center
- Sun orbits Earth
- Planets orbit on small circles whose centers orbit the Earth on larger circles
  - [the small circles are called **epicycles**]



Ptolemy's Geocentric Model

- This explained retrograde motion
- Inferior planet epicycles were fixed to the Earth-Sun line
- This explained why Mercury & Venus never strayed far from the Sun!
- Orbital order: Moon, Mercury, Venus, Sun, Mars, Jupiter, Saturn

3.4 The Copernican Revolution

Our goals for learning:

- Briefly describe the roles of Copernicus, Tycho, Kepler, and Galileo.
- What are Kepler's three laws of planetary motion?

Nicolaus Copernicus (1473-1543)

He thought Ptolemy's model was contrived

Yet he believed in circular motion

De Revolutionibus Orbium Coelestium

Copernicus' Heliocentric Model

- Sun is at center
- Earth orbits like any other planet
- Inferior planet orbits are smaller
- Retrograde motion occurs when we "lap" Mars & the other superior planets