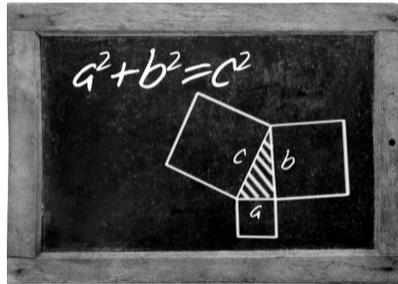
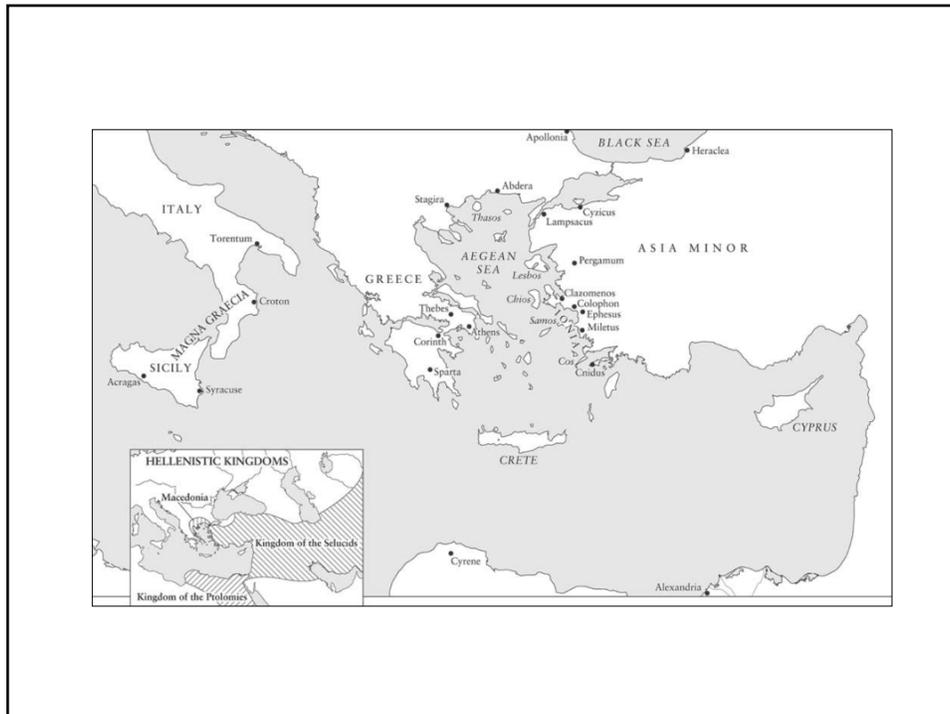


Early Civilizations: Science and Technology in Greece and Rome



Greeks and Romans

- Some broad generalizations
 - Greeks favored scientific thought
 - Romans introduced many technological innovations
- Greek Civilization
 - Hellenic (Classical) Period: 5th to 4th Centuries BCE
 - Hellenistic Period: 3rd to 1st Centuries BCE
- Roman Civilization
 - height: c. 1st Century BCE to 4th Century CE



Hellenic Science

- there was no institutional support for it
- individual Greeks interested in the “philosophy of nature”
 - detachment from the practicalities of life
 - natural philosophy was undertaken as play/recreation
 - self-consciously theoretical



The Cosmology Of the (Early) Greek World

- Thales of Miletus (fl. 585 BCE)
 - rejected divine explanations
 - the Earth floats on water
 - world composed of primordial watery substrate
 - claims based on a sequence of general principles



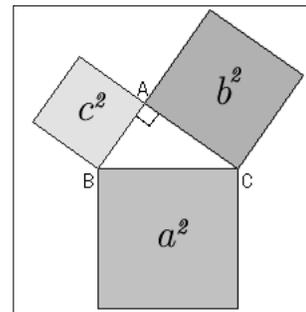
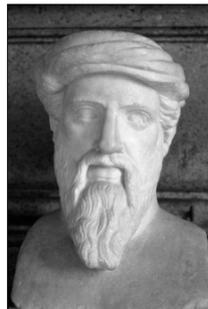
Statue of Thales,
Union Station,
Washington, DC



Pythagoras (fl. 525 BCE)

- Pythagorean theorem
- conception of *alolon*
- acceptance of notion of irrationality of knowledge

Pythagoras, Musei
Capitolini, Rome



Plato's Cosmology

- Plato (428-347 BCE)
- developed geometrical astronomy
- not based on any observation
- based upon idea that
 - heavens were divine
- must have ideal form (circles, spheres, etc.)
- closely tied to what we today call “astrology”



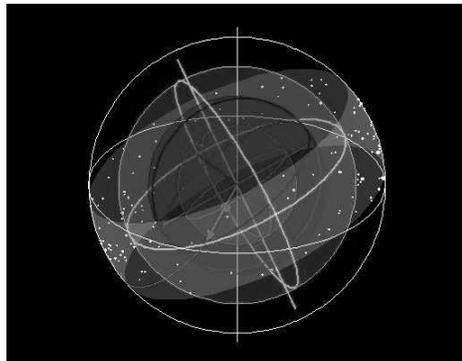
The Greek geocentric view:
Earth, circled by Sun, Moon, planets, and
starry zodiac

Main challenge for Greek Astronomy

- if the universe was based on concentric circles
- then how to account for those planetary bodies (esp. planets) which moved in irregular patterns in the sky?
- in other words: Plato believed that the planets moved in circles around the Earth; but if that were true, then they would move across the sky in much more regular motion

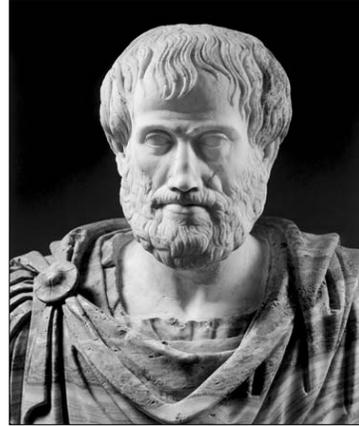
This problem first “solved” by:

- Eudoxus (fl. 365 BCE)
- developed model of universe with 27 nested spheres revolving in various directions



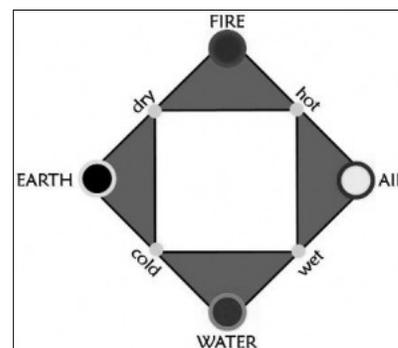
Aristotle (384-322 BCE)

- contributed to logic, physics, cosmology, psychology, history, anatomy, ethics, etc.
- founded Lyceum
- tutored Alexander the Great but had no institutional affiliation
- believed that the only route to knowledge: sensation and observation
- examples of how such a perspective can lead you astray?



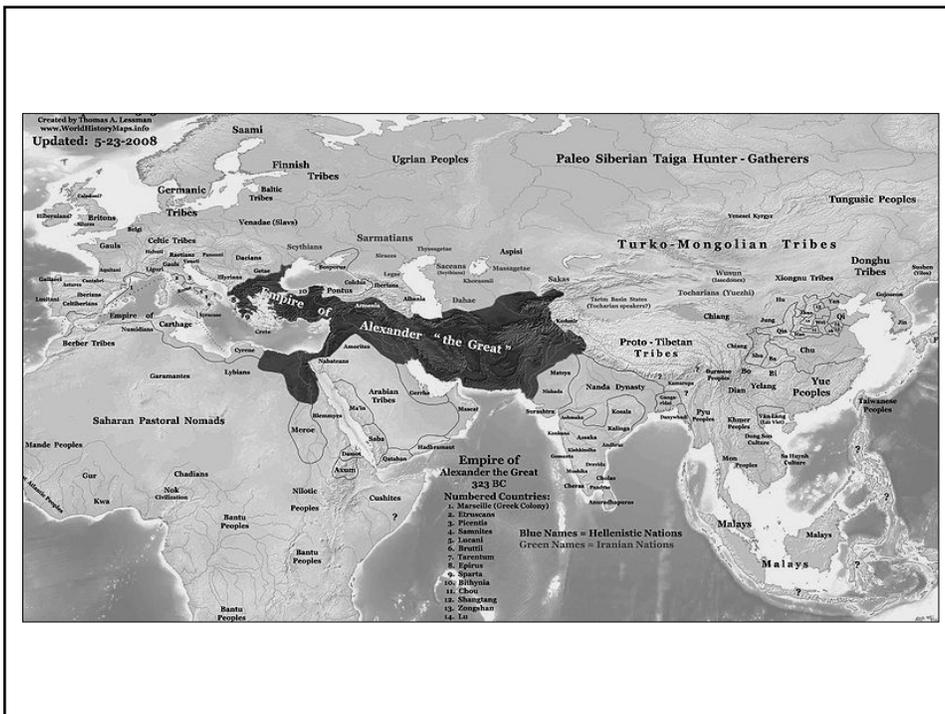
Aristotle's contributions

- four elements: earth, air, fire, water
- each element made up of combination of: hot, cold, wet, dry
 - provided a theoretical basis for alchemy—how?
- He confirmed the sphericity of the Earth by watching the shadow it cast on the Moon during lunar eclipses
- heavens made up of fifth element: *aether*
- read quote on p. 75 on “dual physics”:
The heavens above...



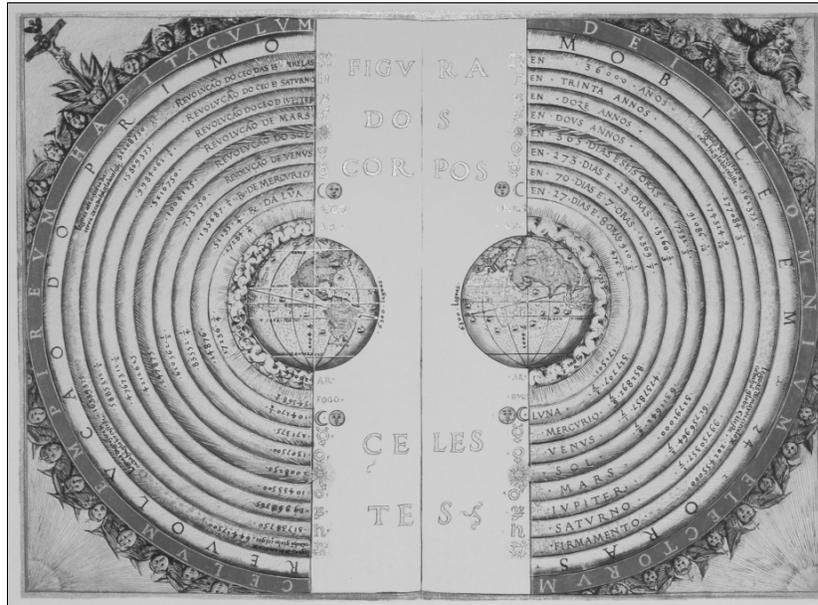
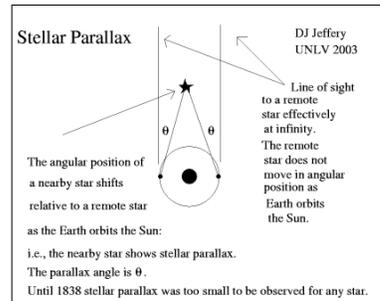
Hellenistic Science

- began 4th century BCE
- “Golden Age” of Greek science
- offered state support for scientific research
 - Why?
- Ptolemaic Egypt became center of learning
 - Museum at Alexandria
 - The Royal Library of Alexandria



Legacies of the Science Under Alexander

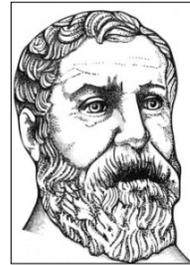
- Euclid's geometry
- Ptolemy's conception of the universe
 - most enduring model of the universe
 - not overturned until Copernicus
- alternative model proposed by Aristarchus
 - heliocentrism
 - seemed to be countered by experience



Ptolemy's model by Bartolomeu Velho, 1568

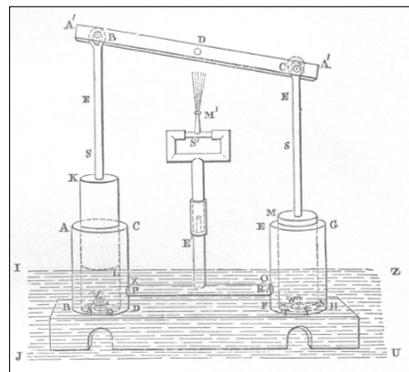
Technologies in the Late Greek Era

- A number of important innovations but:
 - a few were adopted into use
 - Pergamum water delivery system [10:45-15:14]
 - Archimedes' screw
- But most were simply novelties
 - e.g. inventions of Hero of Alexandria (10-70 CE)
 - fire engine
 - steam engine [33:40-35:40]
 - automatic sliding doors
 - slot machines



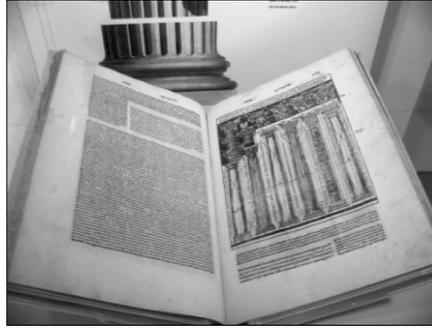
Fire Engine →

← Aeolipile



Roman Technology

- Romans were more practically inclined
 - related to imperial expansion
- Roman Civilization impossible to understand without accounting for technologies
 - military
 - transportation
 - water
- class of professional “engineers” (*architectons*)
 - most anonymous
 - Vitruvius wrote *De Architectura* (15 BCE)
 - principal source of information on Roman technology
- inherited many technologies from others
 - many through conquest
 - Etruscans (7th to 2nd century BCE)



16th Century Italian
Manuscript

- Technology under Greco-Roman rule (c. 800 years) did not significantly change “technological base of production”
 - things produced individually and locally
 - as outcome of crafts and trades
- However, what was produced affected all aspects of life
 - living conditions, transportation, fighting, urban life,

- Circulation and Consolidation [11:30-17:15]
 - transportation (Via Appia, finished in 312 BCE)
 - Gnomon
- City Construction [15:30-18:10]
 - concrete
- Water management [19:50-27:00]
 - Aqueducts
 - goal: to bring water from remote sources into cities
 - importance of the **arch**
 - how did it work? remote sources into cities
 - *Aqua Claudia, Anio Novus, Pont du Gard*
 - Claudius (1 BCE-54 CE)
 - Roman Emperor from 41-54 CE
 - roads, aqueducts, canals
 - what kind of social ramifications?

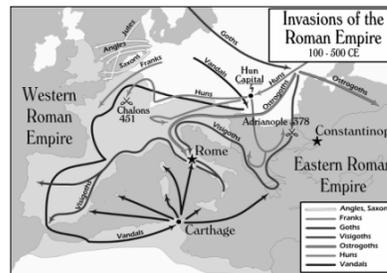


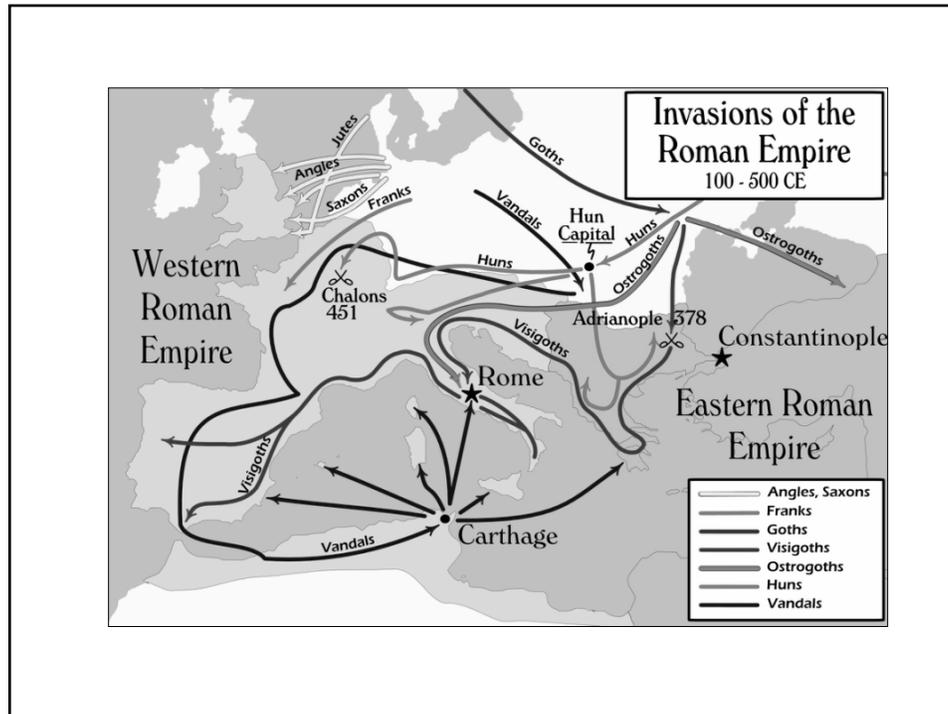
Some General Themes about Roman Technology

- Circulation
 - appropriation from predecessors/conquered
 - improvements for empire
- Technology and Imperial Control
- Bureaucracy of maintenance
- Daily Life

Decline and Fall

- Roman decline occurred over a period of 4 centuries
 - Western and Eastern Roman Empire (approx. 3rd Century CE)
 - Eastern Roman Empire → Byzantium
 - official end of Western Roman Empire: 476 CE
 - Romulus Augustus deposed by a Germanic chieftain (Odoacer)
- Causes
 - Barbarian incursions (Germanic Tribes)
 - “Migration Period”
 - intense circulation of people from 400-800 CE
 - Gothic Wars (Emperor Justinian’s attempts to gain back what was lost to the invaders) in 6th Century CE
 - population decreases
 - separation and decentralization
 - ruled by multiple emperors after 3rd Century CE
 - movement of center of gravity to Byzantium (later known as Constantinople)
 - severe decline in West as multiple invasions by Visigoths, Vandals, etc.





Did technology cause/hasten/impede decline?

- Some argue that technology had nothing to do with it
 - intrinsic economic problems
 - “plunder economy” thesis
 - mismanagement
 - slavery
 - empire of conquest is unsustainable
- technology probably played a part
- complex technologies need maintenance, upkeep, innovation
 - complex society → problems
 - short term solution → more complexity (more conquest, more bureaucracy)
 - becomes untenable
- More proximate role of technology
 - hydraulic technologies
 - disease
 - massive epidemics around 165 CE (smallpox, measles)
 - technological complexity not matched by medical knowledge

What happened to science & technology during the decline?

- in Late Roman era, shift from finding new knowledge to preserving new knowledge
 - we see this particularly in the Byzantine Empire
 - “science” as a profession was not valued in Rome
 - with rise of Christianity (and other parallel cults), science came into conflict with Christian precepts
- Christianity’s position on “secular” knowledge
 - read p. 94: “Official...”
 - destruction of Alexandria
- technical solutions to problems were unsustainable in the face of:
 - slavery
 - labor solutions to large-scale problems
- Too much discontinuity among successors to Western Roman Empire
 - destroyed much of knowledge base
 - scientific and technical knowledge unsustainable through discontinuities
 - eventually knowledge lost → severe decline
- Some continuities
 - Byzantine Empire
 - Islamic Empire