

Ancient knowledge

ENG 151 · Lecture 2
Practical ingenuity
Mehmet Göktürk

How could people know?

Measure a field. Treat an injury. Predict a season. Explain why something moves.

Ancient people combined craft, observation, calculation, religious practice, and argument.

We will ask what each method could establish—and what evidence survives.

Our route through antiquity

Early urban societies: Mesopotamia, Egypt, and the Indus world.

Greek and Hellenistic inquiry: explanations, geometry, instruments, and measurement.

Chinese mathematical practice and the Roman world complete our comparison. These histories overlap.

Cities need organized knowledge

Fields, storehouses, building work, and calendars create recurring problems.

Records let knowledge outlive one person. Training allows someone else to repeat a procedure.

Mesopotamia was a changing collection of societies, not one uniform culture.



Mesopotamia and neighboring regions

Pottery, metals, plaster, and waterproofing depend on choosing and processing materials.

A craftsperson may recognize useful changes without a modern chemical explanation.

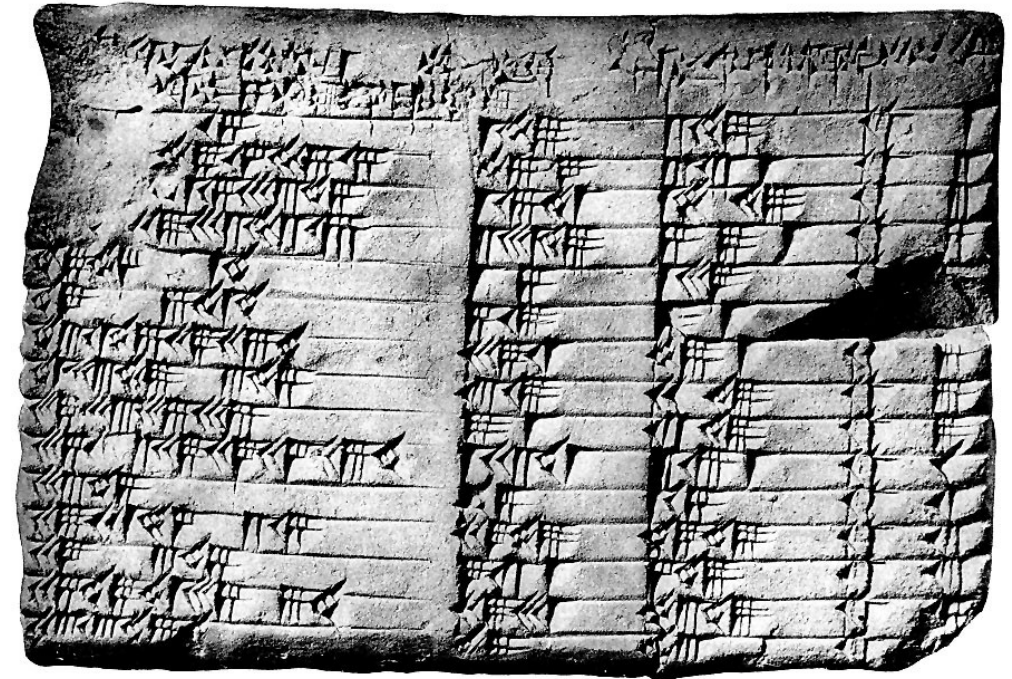
Practical aims and religious meanings could coexist. Neither tells us that people lacked curiosity.

Plimpton 322

This Old Babylonian tablet preserves numerical relationships in a four-column table.

Its numbers are related to right-triangle triples; its intended use remains debated.

The object survives. Reconstructing what its maker intended is a separate historical problem.



Plimpton 322 · early second millennium BCE

Calculation and proof

For sides 3, 4, and 5: $3^2 + 4^2 = 9 + 16 = 25 = 5^2$.

This checks one numerical relationship. A general proof must explain why a claim holds for every case in its stated scope.

This is our teaching example, not a transcription of a row of Plimpton 322.

The sky becomes a record

Scribes recorded celestial events on clay tablets over many generations.

Repeated observations made cycles available for calculation and comparison.

Astronomy served calendars and other purposes, including divination. Prediction did not require a modern model of the heavens.



A cuneiform tablet · exact object date unverified

Egypt: measurement and building

Surveying land and organizing construction required measurement and coordination.

Pyramids show what combined skill, materials, and organized labor could accomplish.

A finished structure is evidence of achievement; it does not reveal every construction procedure.



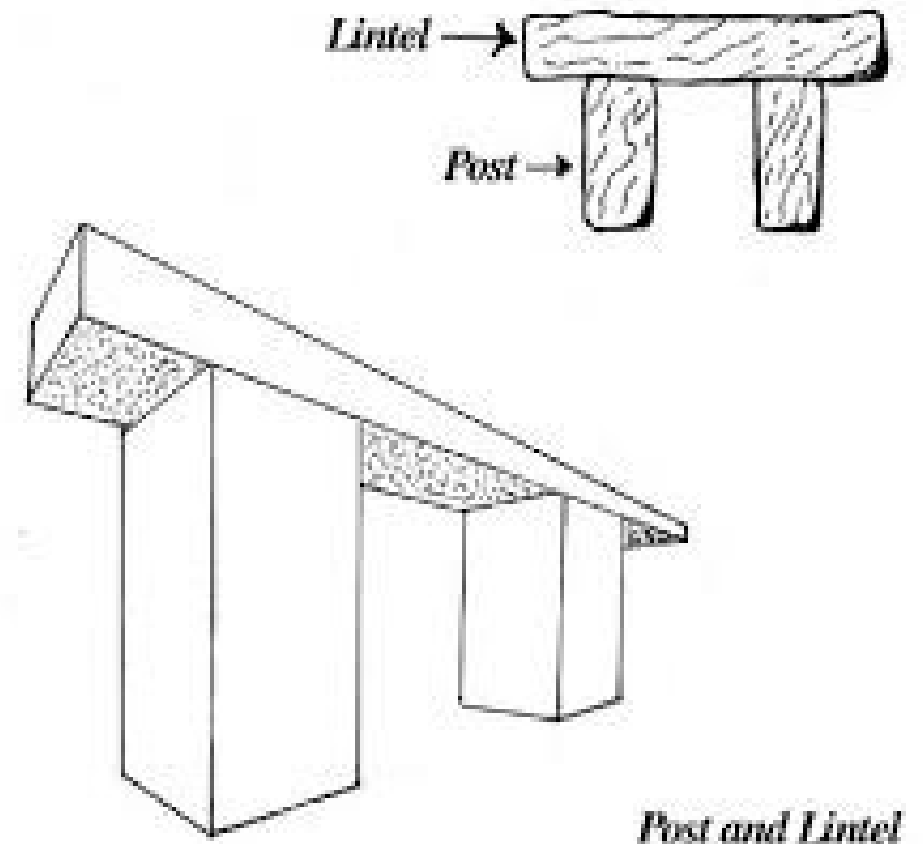
Pyramids at Giza

What does the structure tell us?

A post supports a lintel; the arrangement carries a load across an opening.

A drawing helps us discuss a construction principle. It does not prove how a particular building was designed.

The 3–4–5 example is useful mathematics. Its use by ancient Egyptian builders needs separate evidence.



Post-and-lintel construction · explanatory drawing

Healers used remedies, physical treatments, incantations, and ritual.

The terms *asû* and *āšipu* refer to kinds of practitioners; their roles should not be equated directly with modern professions.

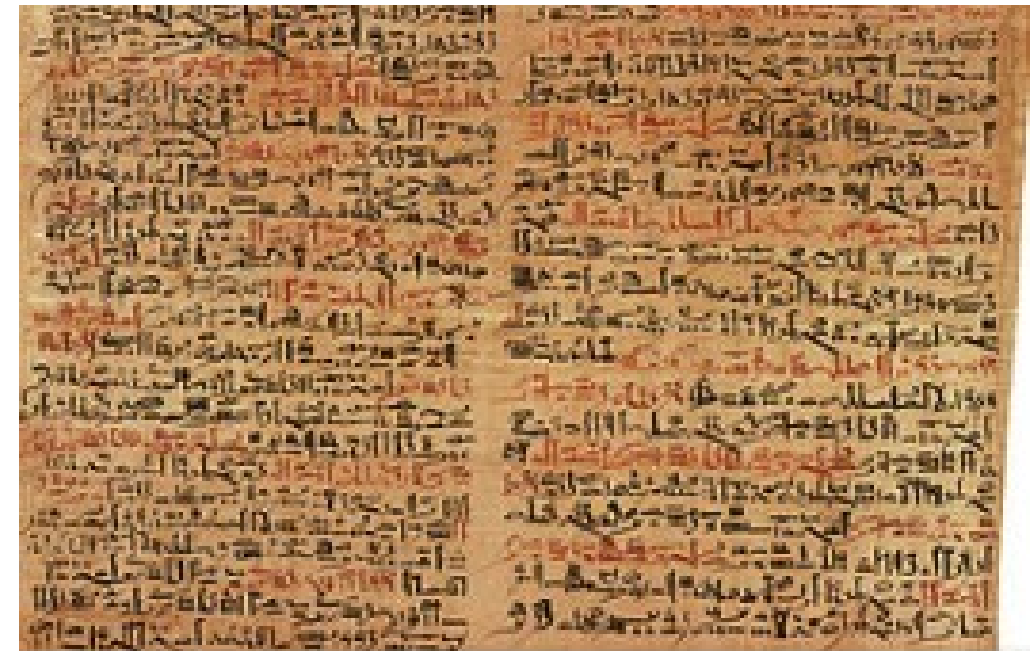
A remedy's presence in a text establishes that it was recorded, not that it worked.

Reading an Egyptian case

The Edwin Smith papyrus organizes injuries as cases with examination, diagnosis, prognosis, and treatment.

This arrangement makes observations available for later readers.

Careful description can coexist with an incomplete explanation of the body.



Edwin Smith papyrus

Two papyri, different evidence

Edwin Smith is especially important for its descriptions of injuries.

The Ebers papyrus contains a broader collection of medical knowledge and remedies. It is a different document.

We can study recording practices without assuming that all ancient treatments were effective.

Standards in the Indus world

Many Harappan bricks follow an approximately 4:2:1 ratio of length, width, and height. Absolute sizes varied.

Shared proportions can help builders coordinate work and replace components.

The archaeological pattern supports standardization. It does not by itself establish a single ruler, rulebook, or motive.

Greek knowledge had many homes

Natural philosophers, craftspeople, healers, and religious communities asked different questions.

There was no single profession corresponding to the modern scientist.

Arguments about nature existed alongside practical work and religious life.



Mosaic traditionally identified as Plato's Academy

Calendars and seasonal work

Hesiod's Works and Days connects seasonal signs with agricultural tasks.

Parapegmata linked calendar sequences with recurring celestial or weather phenomena.

A calendar coordinates people as well as describing nature. Its usefulness depends on local conditions.



Later portrait associated with Hesiod; Greek architecture

Seeking causes in nature

Early Greek thinkers proposed different accounts of the world's order and change.

Water, air, the boundless, elements, and atoms were competing starting points.

These were diverse positions, not one doctrine shared by all “Presocratics.” Much evidence comes through later writers.

Plato and Aristotle

Plato gave mathematics and rational demonstration an important role in knowledge.

Aristotle also studied living things and treated observation as important to inquiry.

Plato emphasizes stable intelligible forms. Aristotle locates form in the things we encounter and investigate.



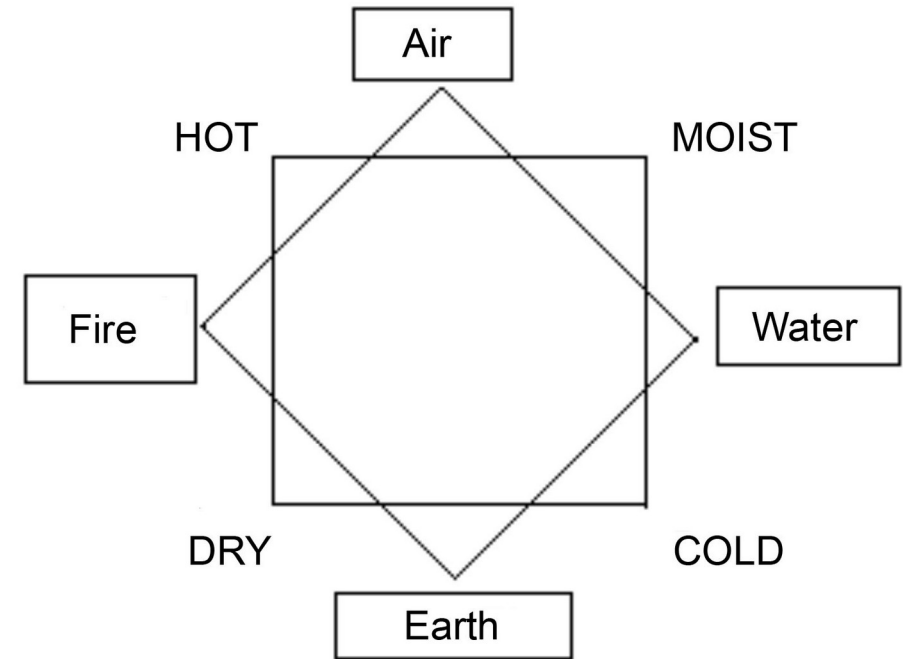
Plato and Aristotle in Raphael's School of Athens

Four elements and qualities

Earth, water, air, and fire were associated with combinations of hot, cold, wet, and dry.

The framework connected familiar changes into an ordered account of matter.

Its elements are historical explanatory categories, not the chemical elements of the modern periodic table.



Four elements and paired qualities

A divided cosmos

In an Aristotelian account, the region below the Moon was a place of generation and decay.

The heavens were associated with aether and regular circular motion. Earth occupied the center.

A coherent account can organize experience and still rest on assumptions that later inquiry rejects.

Schema huius præmissæ diuisionis Sphærarum.



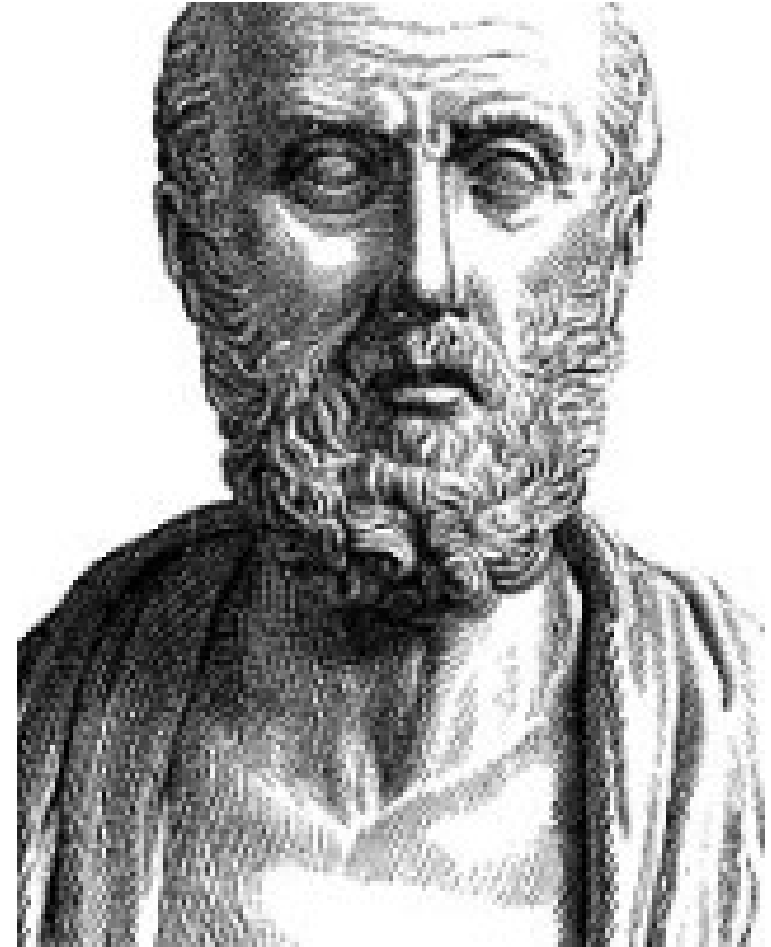
A geocentric arrangement of celestial spheres

Medicine and natural causes

Greek healing included several kinds of practitioners and traditions.

On the Sacred Disease explains epilepsy through natural causes. Its rejection of a supernatural cause does not make its own account correct.

The Hippocratic corpus is a collection of works, not simply the record of one author.



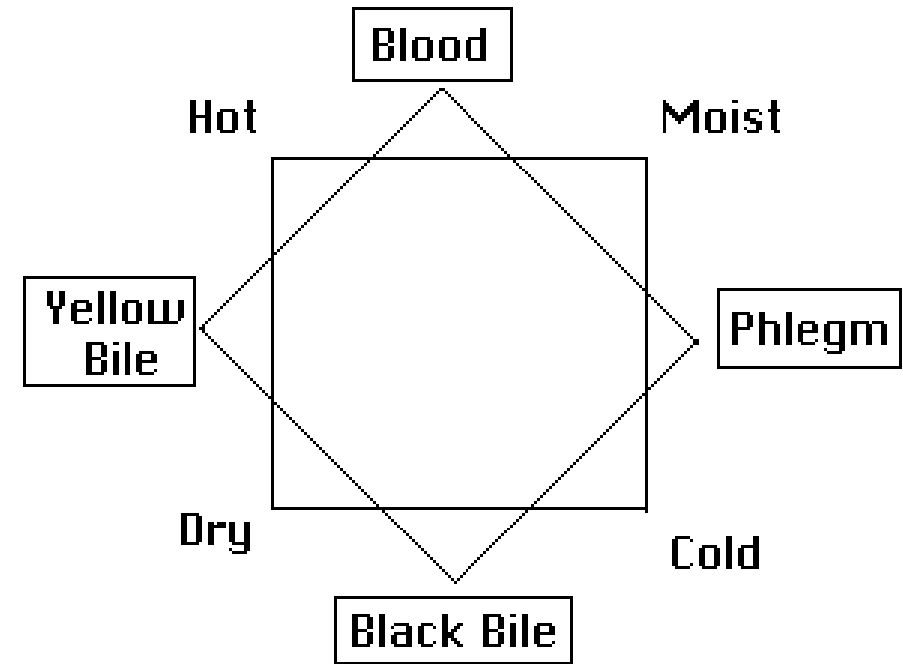
A later portrait associated with Hippocrates

Body, place, and balance

Airs, Waters, Places links health with environment and ways of life. Its claims must be read historically.

Humoral medicine relates health to the balance of blood, phlegm, yellow bile, and black bile.

These ideas mattered for later medicine; historical influence is not evidence of medical validity.



A diagram of the humoral framework

Alexandria and patronage

Alexander's conquests were followed by kingdoms connecting several regions and traditions.

Alexandria became an important center of scholarship under the Ptolemies. Rulers supported collections and learned work.

As in Lecture 1, leadership and resources can create conditions in which knowledge grows.



Alexander in a surviving mosaic

Euclid: arranging an argument

The Elements organizes geometry and number theory through definitions, assumptions, and demonstrations.

A proof makes the steps of an argument open to inspection. It depends on its starting assumptions.

Copies, translations, and teaching kept the work available to new readers.



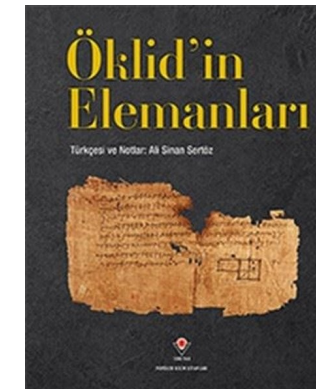
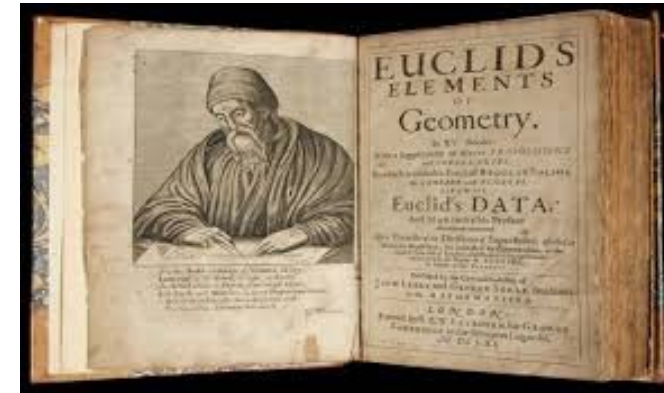
An ancient papyrus fragment of Euclid's Elements

A book across centuries

The Elements reached readers through many manuscripts, translations, and printed editions.

These English and Turkish editions show continued interest in its structure of reasoning.

Transmission preserves a text through active work: copying, translating, explaining, and correcting.



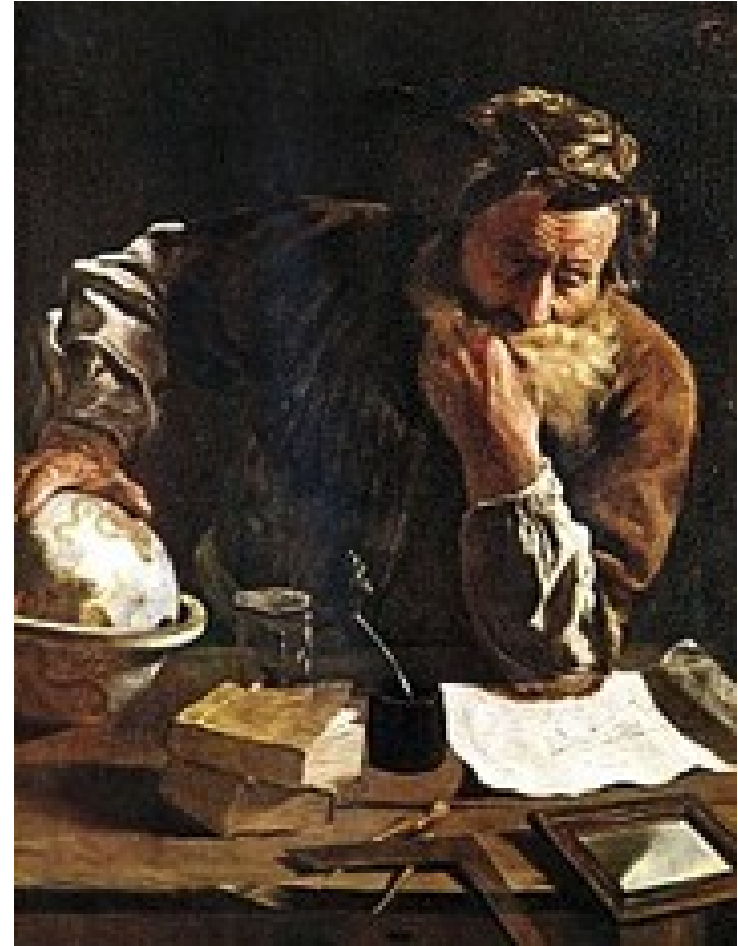
Editions of Euclid's Elements

Archimedes: reasoning and machines

Archimedes investigated areas, volumes, levers, and floating bodies.

His mathematics and mechanics show several ways to connect a problem with a reasoned solution.

Buoyancy relates the upward force on an immersed body to the weight of the fluid it displaces.



A later artistic depiction of Archimedes

A lever makes a comparison

For an ideal balanced lever: force $\times$ distance from the pivot is equal on both sides.

A load of 100 units at distance 1 balances a force of 25 units at distance 4.

The example neglects the lever's weight and friction. Moving the force farther also makes it travel farther.

Antikythera: cycles in gears

This Hellenistic mechanism represented the Sun and Moon, lunar phases, calendar cycles, and eclipse predictions.

Its surviving fragments connect mathematical knowledge with skilled metalworking.

It is often called an ancient analog computer: motion represents relationships, rather than executing digital software.



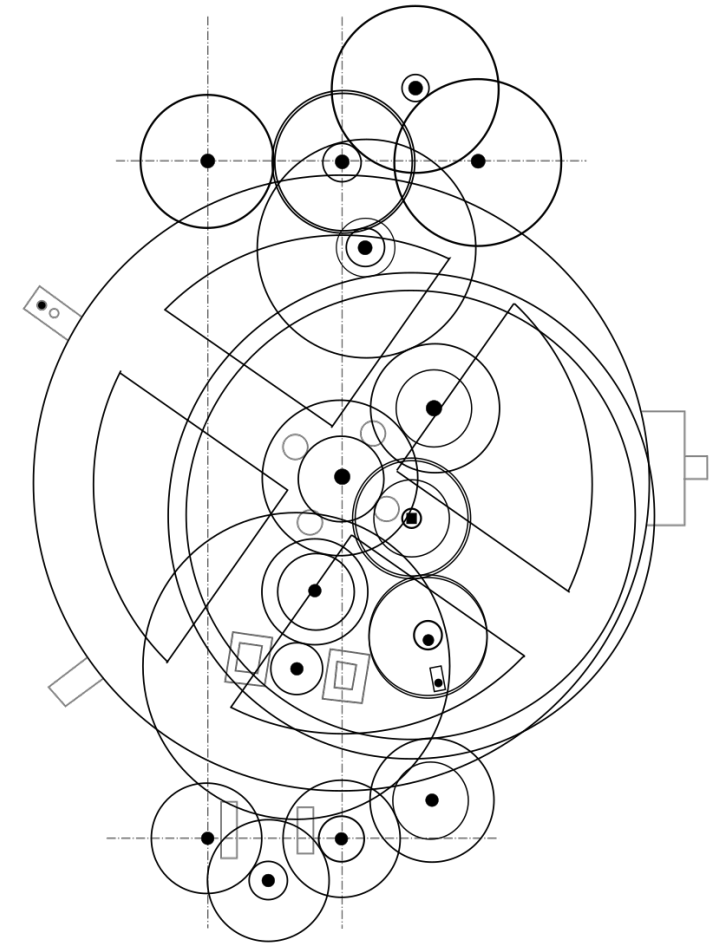
Surviving fragments of the Antikythera mechanism

Reconstructing a mechanism

A gear arrangement can translate one rotation into a different repeating motion.

Researchers compare fragments, inscriptions, imaging, and working models. Surviving parts are not the complete machine.

A reconstruction is an argument constrained by evidence. A precise total gear count depends on that reconstruction.



A schematic reconstruction of the gear arrangement

Measuring the Earth

Eratosthenes worked in Alexandria in the third century BCE.

The account associated with him compares a noon shadow at Alexandria with the Sun's position at Syene.

A local angular difference can be related to a fraction of Earth's circumference.



Later portrait associated with Eratosthenes

The circumference calculation

Idealized values: angular difference = 7.2° ; distance between sites = 5,000 stadia.

$7.2^\circ / 360^\circ = 1 / 50$, so circumference = $50 \times 5,000 = 250,000$ stadia.

The reasoning assumes a spherical Earth, nearly parallel sunlight, and a suitable north–south distance.

What limits the answer?

Angle, distance, alignment, and the historical length of a stadion affect the result.

The original treatise is lost; later accounts preserve the method. A precise modern percentage error would hide these uncertainties.

Ask how a result was obtained and transmitted, as well as whether its number looks impressive.

China: procedures for problems

The Nine Chapters on the Mathematical Art brings together problems involving fields, exchange, and other practical calculations.

Its text developed over time; later commentary explained and extended its methods.

It offers another setting in which systematic procedures and reasoning supported practical mathematics.

A small problem of proportion

Illustrative exchange: 3 baskets of one grain have the same value as 5 baskets of another.

At a fixed rate, 12 baskets of the first exchange for $(12 \div 3) \times 5 = 20$ baskets of the second.

What must remain fixed? The exchange rate and the measures used for a basket.

Knowledge in the Roman world

The empire connected regions through administration, travel, and trade, while access remained unequal.

Engineering, medicine, astronomy, and learned writing continued in Greek and Latin settings.

Pliny compiled natural knowledge; Ptolemy developed mathematical astronomy; Galen wrote extensively on medicine.



Map of the Roman Empire at its greatest extent

Three ways to support a claim

Record and compare: celestial observations or descriptions of injuries.

Calculate and demonstrate: a numerical procedure or a geometrical proof.

Build and test a use: a load-bearing structure or a mechanism. The evidence answers different questions.

Discussion: what survives?

A tablet, a machine fragment, a copied text, and a later portrait reach us in different ways.

Choose one. What can it establish directly? What would require another kind of evidence?

Consider whose work becomes visible—and whose skill may leave no named author.

Review questions

1. Why is a successful numerical example different from a general proof?
2. What assumptions support the Eratosthenes calculation?
3. Why can a natural explanation still be wrong? What does the Antikythera evidence show?

1. A numerical example checks a case; a proof establishes the claim within its stated assumptions.
2. Spherical Earth, nearly parallel sunlight, appropriate site alignment, and usable angle and distance estimates.
3. A natural cause still needs evidence. The mechanism shows skilled construction and calculation; its missing parts leave room for competing reconstructions.

The next part of the story

Knowledge survives when people preserve, teach, translate, use, and challenge it.

Lecture 3 follows these activities through Byzantine, Islamic, Indian, and Latin contexts.

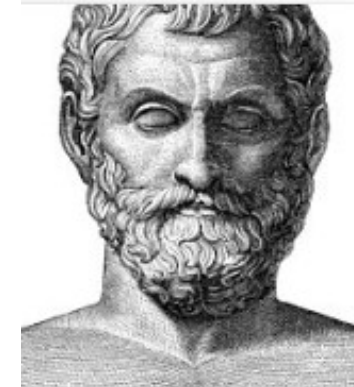
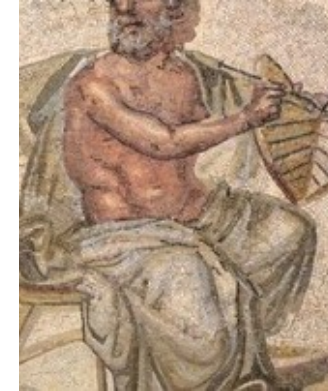
The next lecture will take up Aryabhata, Brahmagupta, and the medieval material in its chronological setting.

Reference: early explanations

Thales is associated with water; Anaximander with the boundless; Anaximenes with air and changes of density.

Heraclitus emphasizes change and order. These accounts differ in what they seek to explain.

The surviving record is fragmentary and often indirect. Avoid treating these summaries as complete doctrines.



Later representations associated with Anaximander and Thales

Reference: elements and change

Anaximenes connects changes of air with condensation and rarefaction.

Empedocles proposes four roots, with Love and Strife joining and separating them.

Empedocles also connects his thought with living beings, reincarnation, and opposition to animal sacrifice.



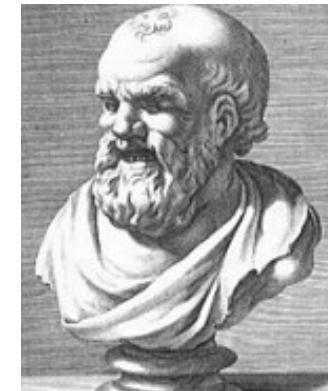
Later representations of Anaximenes and Empedocles

Reference: atoms and number

Leucippus and Democritus explain bodies through atoms and void. This is a philosophical model, not modern experimental atomic theory.

Pythagorean traditions give number, proportion, and harmony a central role.

An orderly pattern can suggest an explanation; evidence is still needed to assess it.



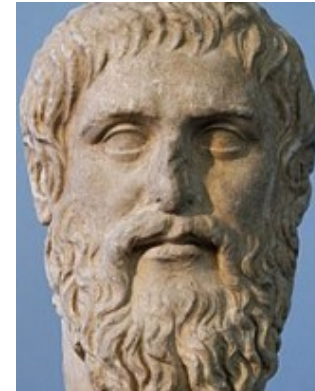
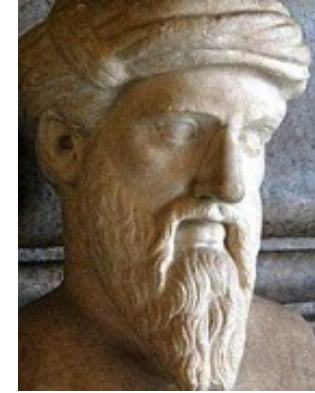
Later depictions associated with the atomist tradition

Reference: mathematical order

Pythagorean traditions connect numerical relationships with music and the cosmos.

Plato gives geometry and rational demonstration a prominent place in knowledge.

The famous geometry inscription at the Academy is a later story, not secure contemporary evidence.



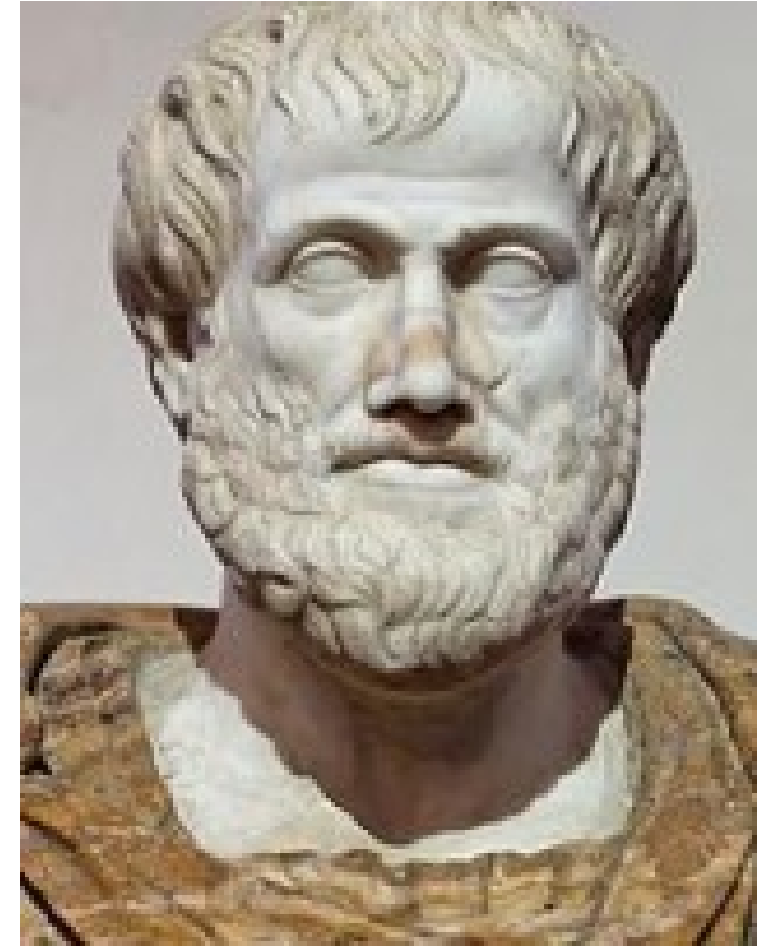
Later portraits associated with Pythagoras and Plato

Reference: observing nature

Aristotle investigated animal structure and behavior, including marine life.

His natural philosophy connects accounts of matter, motion, change, and explanation.

Observation matters, but observations alone do not guarantee that the larger explanatory framework is correct.



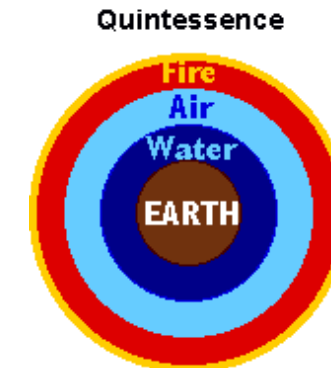
A portrait of Aristotle

Reference: picturing the cosmos

These images present the ordered Earth-centered universe and the region below the Moon.

They illustrate a historical framework; they are not photographs or direct observations of its proposed structure.

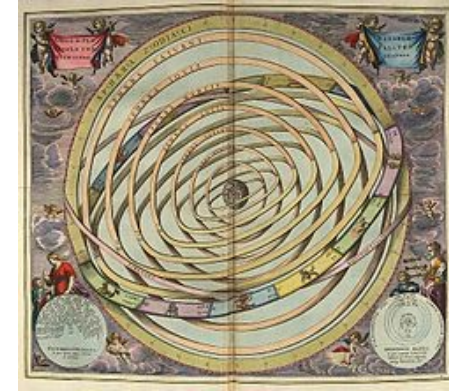
Later diagrams can help explain ancient ideas, but their date must not be confused with the date of those ideas.



Illustrations of the terrestrial and celestial order

Reference: later representations

This celestial scheme is from Harmonia Macrocosmica (1661), many centuries after antiquity.



The library scene is also a later representation, not a surviving view of ancient Alexandria.



Both are useful for discussing how later people pictured the past.

Later images of a geocentric cosmos and an ancient library

Reference: Archimedes in detail

Areas and volumes: circles, spheres, a parabolic segment, and other geometrical solids; methods of exhaustion support rigorous comparisons.

Other work includes bounds for π , the spiral, and ways of expressing very large numbers.

Levers, hydrostatics, the screw, pulleys, and defensive machines connect his mathematical legacy with accounts of practical work.

Sources for further reading

Objects and medicine: Columbia's Plimpton collection; the British Museum; the National Library of Medicine; Leipzig University Library.

Ideas and calculation: Stanford Encyclopedia of Philosophy; MacTutor histories of Eratosthenes and Chinese mathematics.

Objects and standards: Greece's Ministry of Culture on Antikythera; J. M. Kenoyer on Harappan measurement. Links are in the reading and slide notes.