

The Stuff of Matter in the Ancient World



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Matter unit

Overarching questions:

Is the stuff of the world unchanging or transmutable?
How have the institutions of science evolved?

I. Presocratics as
Proto-Scientists?

II. Plato & Aristotle,
Elements & Institutions

III. Why the Greeks?

Readings: Kirk, Raven, Schofield, *The Presocratic Philosophers*, 88-95;
Aristotle, *Physics*, 329-334;
Lindberg, *The Beginnings of Western Science*, 25-58.

Scientific Subjects are Old

Comic of the history of science removed due to copyright restrictions.

Scientific Subjects are Old



Chauvet cave paintings,
ca. 26,000 BCE



Great Pyramids of Giza,
ca. 2560 BCE

Photo of the [Pyramids of Giza](#)
courtesy of [wuji9981](#) on Flickr.



Stonehenge, ca. 2500 BCE

Photo of [Stonehenge](#) courtesy of
[nyaa_birdies_perch](#) on Flickr.



Babylonian math tablet,
ca. 1800 BCE



Egyptian math papyrus,
ca. 1650 BCE

Presocratics and Western Science

Why start with the Presocratics rather than the Babylonians or Egyptians?

1. “Took the gods out”

2. General classes of phenomena

3. Self-consistent theories

4. Critical debate

Some Caveats

We have *infinitely* more documents from the “prescientific” Babylonians and Egyptians than from the “proto-scientific” Presocratics!

There does not exist *a single* original document from the Presocratics. *All* of our information about them comes from (much) later commentaries.

"Others say that the earth rests on water. For this is the most ancient account we have received, which they say was given by Thales the Milesian, that it stays in place through floating like a log or some other such thing (for none of these rests by nature on air, but on water) -- as though the same argument did not apply to the water supporting the earth as to the earth itself." (*R*, 9)
-- Aristotle *de caelo* B 13, 294a28.

Constructing Legacies

The later commentators, such as Aristotle, arranged the Presocratics into neat and tidy genealogies: ‘A taught B, B taught C’ – at a remove of 300 years!

Moreover, the later commentators had a *stake* in reconstructing the past to make things appear to lead straight to them.

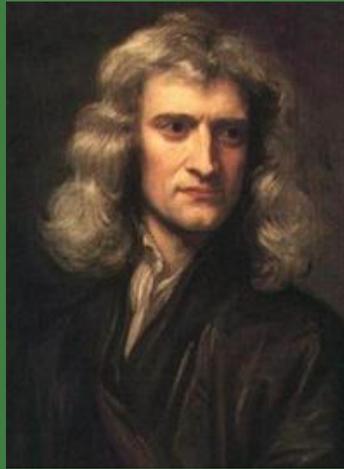


Image of "Newton's Principia For the Common Reader," S. Chandrasekhar, removed due to copyright restrictions.

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Ionians or Milesians

East coast of modern-day Turkey, fl. 580-530 BCE



Thales

Aristotle: “Thales, the founder of this type of philosophy, says that it [the original principle of all things] is *water*, perhaps taking this supposition from seeing the nature of all things (like seeds) to be moist.”

Thales attributed the unity of the cosmos to a substance of ordinary experience, rather than to the activity of the gods.

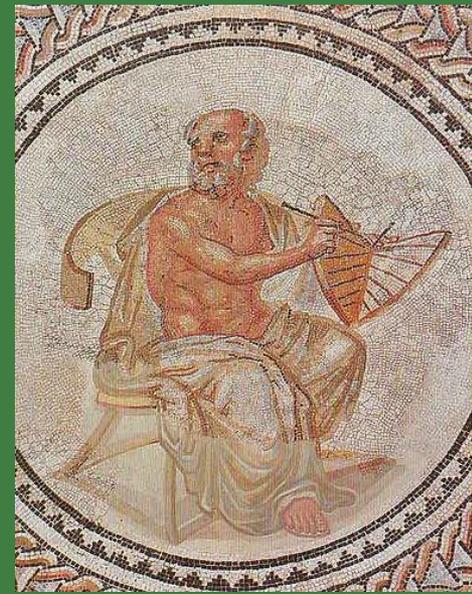
Perhaps he chose water because of its mutability: it can appear as a solid, liquid, or vapor.



Problem: How are non-wet things related to water? Over-specificity.

Anaximander

Simplicius: “Anaximander, the successor and pupil of Thales, said that the principle and element of existence was the *apeiron* [Boundless], from which come into being all the heavens and the worlds in them.”



The raw material (*apeiron*) is indestructible and everlasting.

(Iocane powder, anyone?)

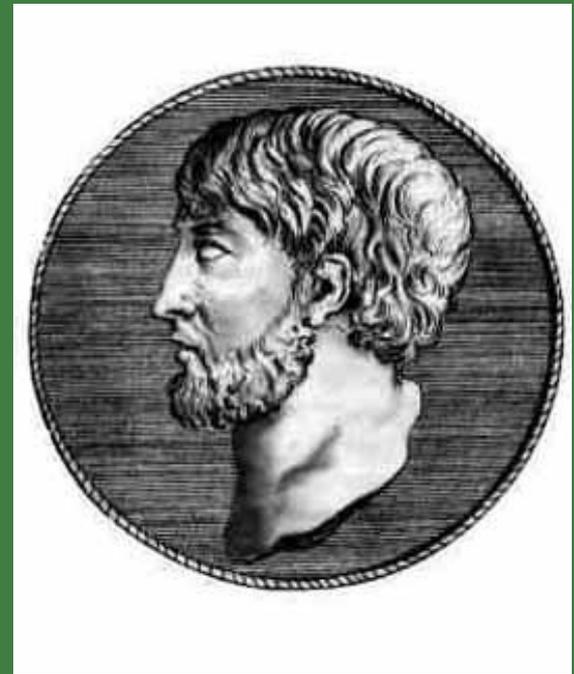
Image of Wallace Shawn as Vizzini in “The Princess Bride”

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Solved Thales’s problem of over-specificity by beginning with a non-ordinary substance. But he still left the nature of *apeiron* vague.

Anaximenes

Theophrastus: “Anaximenes, a companion of Anaximander, also says, like him, that the underlying nature is one and infinite, but not undefined as Anaximander said but definite, for he identifies it as air; and it differs in its substantial nature by rarity and density. Being made finer it becomes fire, being made thicker it becomes wind, then cloud, then water, then earth, then stones; and the rest come into being from these.”



‘Critical debate’: Anaximenes is presented as engaging with Thales’s and Anaximander’s ideas, trying to strengthen their weaknesses.

Atomists

Leucippus and Democritus,
fl. 440-400 BCE

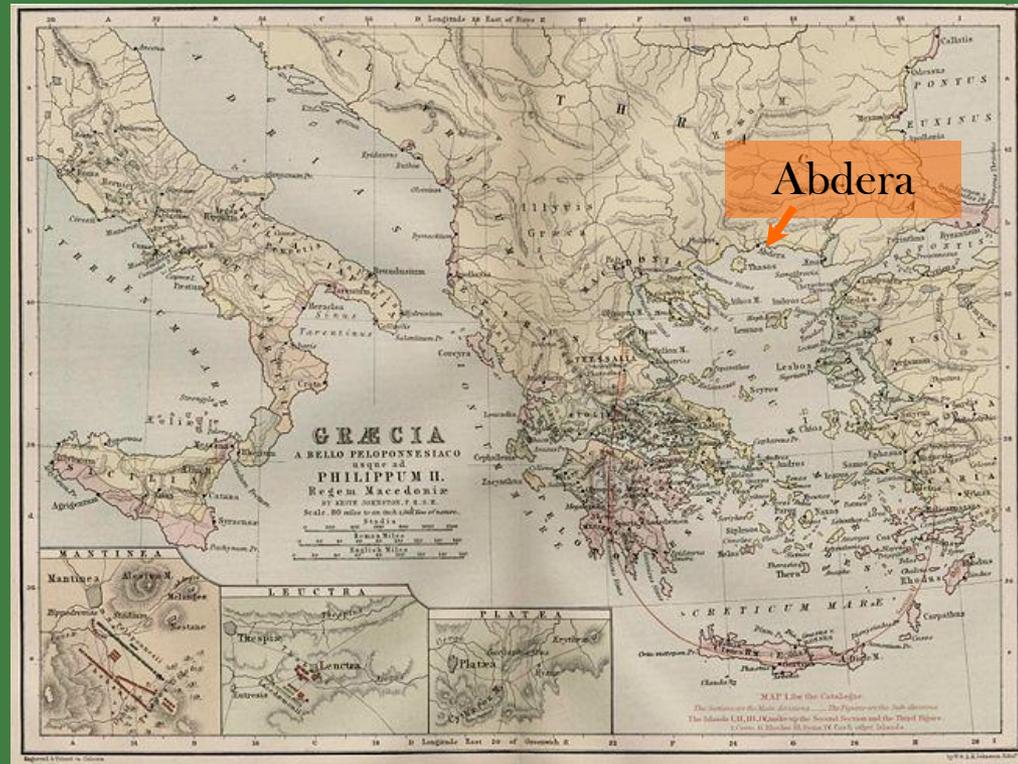
“atom”: indivisible

The variety of matter we see around us arises from changes in the *shape*, *arrangement*, and *position* of atoms. The atoms themselves are eternal and unchanging.

shape:
A vs. M

arrangement:
AM vs. MA

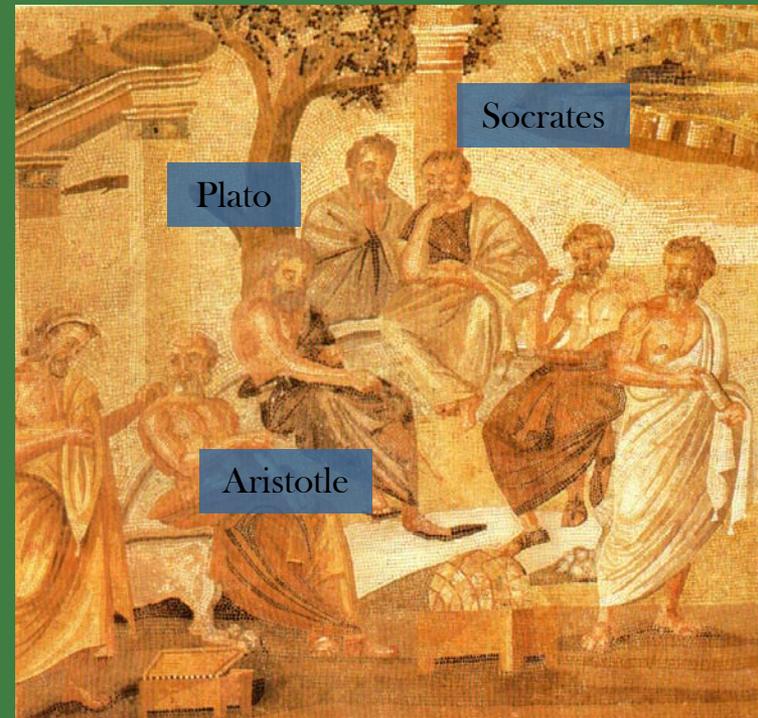
position:
M vs. W



Plato's Academy

Plato (428 – 347 BCE) was a disciple of Socrates, and the principal defender of Socrates's legacy following his execution for “impiety” in 399.

Plato's *Academy* in Athens (founded 387 BCE) became one of the first ‘static’ educational institutions, with regular faculty teaching a variety of subjects.



Not like today's universities: no degrees, no requirements, no ‘term limits.’ Aristotle arrived at age 17 and stayed for 20 years!

The Allegory of the Cave

LUX VENIT IN MVNDVN ET DILEXERVNT HOMINES MAGIS TENEBRAS QVAM LVCEM. IO. 3. 19

ANTRVM PLATONICVM



Maxima pars hominum cecis immerga tenebris
 Volvitur assidue, et s' fultis letatur inani:
 Adspice ut oblect' tis obtutus in hercat umbras,
 Vt VERI simulacra omnes mirentur amantq;

Et s' solida vana ludantur imagine rerum.
 Quam pauci meliore luto, qui in lumine puro
 Secreti à s' solida' vrb'ba, ludibria cernunt
 Rerum umbras recusat, expendant omnia lauce:

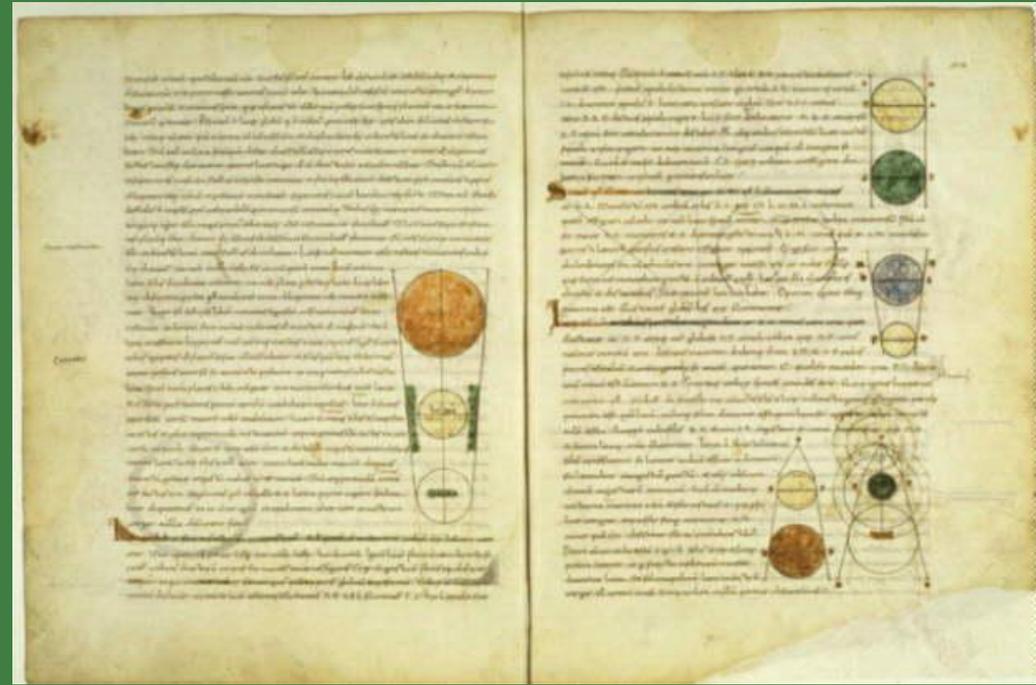
Hi posita erroris nebula' dignoscere possunt
 Vera bona, atque altos ceca' sub nocte latentes
 Extrahere in claram lucem conantur, at illis
 Nullus amor lucis, tanta est rationis eges' in.

CC. Harlemensis Inv.
 Saenredam Sculpsit.
 Henr. Hondius excudit.
 1604.

HL. SPIEGEL FIGVRARI ET SCVLPV CVRAVIT. AC DOCTISS. ORNATISS. OZDPET, PAAW IN LVGDVN. ACAD. PROFESSORI MEDICO DD.

Plato's World

Plato held that a god-like craftsman (*not* omnipotent) created all material things by (imperfectly) impressing the ideal forms into a kind of malleable clay: the “Receptacle of Becoming,” akin to Anaximander’s *apeiron*.



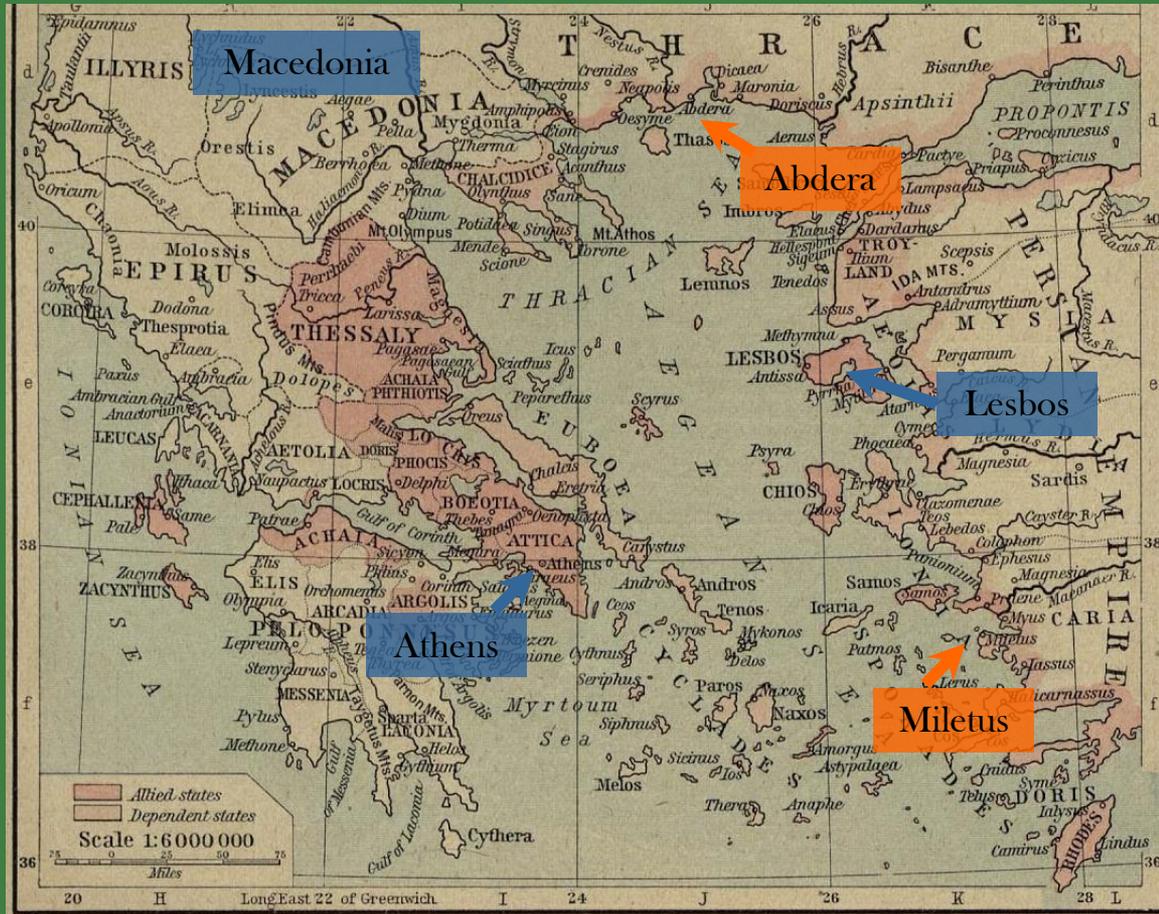
Medieval manuscript, translation and commentary on the *Timaeus*, ca. AD 900

Philosophers should only concern themselves with the ideal forms: only those are perfect and unchanging.

“The Peripatetic”

Aristotle (384 - 321 BCE) hailed from Macedonia. He studied at Plato's *Academy* from 367 - 347. After Plato died, Aristotle fled Athens for the island of Lesbos.

In 343, the king of Macedonia asked Aristotle to tutor his son, Alexander (the Great).



Aristotle returned to Athens ca. 335 and founded his *Lyceum*, which flourished until Alexander's death in 322. Aristotle again fled Athens, and died one year later.

“The Philosopher”

Aristotle’s works defined what it meant to be a scholar for nearly 2000 years. He wrote on everything from logic, rhetoric, and aesthetics to natural philosophy, metaphysics, politics, ethics, and more.



Medieval Latin translation, ca. 1400



ARISTOTLE'S COMPLEAT MASTER PIECE.

In Three Parts :

*Displaying the Secrets of Nature
in the Generation of Man.*

Regularly digested into Chapters and
Sections, rendering it far more useful
and easy than any yet extant.

To which is added,

A Treasure of HEALTH;
OR, THE
FAMILY PHYSICIAN;

Being Choice and Approved Remedies for
all the several Distempers incident to Hu-
man Bodies.

The Twenty-fifth Edition.

Printed and Sold by the Bookfellers, 1753.

London edition, 1753

Ancient sources credit Aristotle with writing about 150 books, totaling about 6000 (modern) pages. About one-third of his works have survived.

Convolutd Provenance



Photo courtesy of [ImagesFromBulgaria.com](https://www.imagesfrombulgaria.com).

After Aristotle's death, his student Theophrastus gathered the manuscripts and gave them to his nephew, who *buried them in a cave* in Scepsis (modern-day Turkey) — to keep them out of the hands of angry Athenians.

They remained there for *two centuries* until they were re-discovered; transferred to Athens and then to Rome. The philosopher Andronicus prepared an edition ca. 50 BCE.

“Our” Aristotle is almost entirely the product of Andronicus's filtering, editing, and compiling.

“Like Eating Dried Hay”

Aristotle’s writings seem particularly strange to modern eyes. They were likely lecture notes from the *Lyceum* (his own plus some of his students’), not meant for broad circulation.

- skips steps in arguments
- repetition or minor variations
- outright contradictions



Archimedes Palimpsest: 10th century manuscript
overwritten with 12th century religious text.

Everything in its Place

Terrestrial sphere: everything is made of 4 elements. Compound bodies always undergo change and decay, as the proportions of the 4 elements change.

Photos of Vincenzo Coronelli's terrestrial and celestial globes removed due to copyright restrictions.

Celestial sphere: everything is made of just 1 element, “quintessence.” Since there is only one type of stuff, there can be no change: the heavens are eternal and unchanging.

The Four Elements



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Photo courtesy of [kevindooley](#) on Flickr.



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Clear lineage from the Milesian school;
and some borrowing from the Atomists.

Why the Greeks?



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Egotism? Later Greek philosophers attributed the birth of natural philosophy to the “miracle of the Greek mind.”

Wealth? Maybe they could afford a group of people whose job it was to speculate all day. *But* others at the time had “leisure classes,” too.

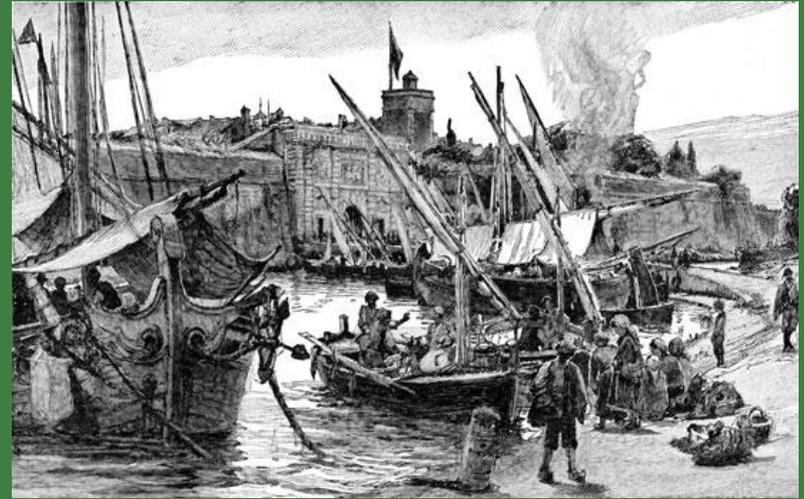
Image of "Nice Work If You Can Get It" by George Gershwin and Ira Gershwin (1937) removed due to copyright restrictions.



Literacy? Written texts permit critical inspection of ideas. *But* others had earlier alphabets, and most Presocratic communication was oral, not written.

The Role of Politics

International trade made Miletus a leading city by 700 BCE. Mercantile wealth broke the political power of the landed aristocracy. Merchants, in turn, needed laws to guarantee contracts: first Milesian constitution ca. 594 BCE.



Images of "Adversaries and Authorities: Investigations Into Ancient Greek and Chinese Science" and "The Ambitions of Curiosity: Understanding the World in Ancient Greece and China," both G.E.R. Lloyd, removed due to copyright restrictions.

These societal changes created an atmosphere of reasoned debate; they created a culture of critique and discussion.

“Reason” was invented in politics, and then applied to nature. What we call “science” might have its earliest roots in politics.

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STS.003 The Rise of Modern Science
Fall 2010

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