

## Lecture #2 Tues Feb 2, 2010 A Brief History of Science

A whirlwind tour of the development of science

### The epochs:

**Ancient Greeks**

**Rise of Christianity as**

**State Religion**

**Beginning of modern science**

### The Players:

Pythagoras, Plato, Aristotle

The Scholastics

Francis Bacon, Galileo, Isaac Newton

*Central theme:* development of science is balancing *argument and logic* against *external evidence*

### Ancient Greek philosophers

**Pythagoras** (569-475 BC) “father of numbers”

discovered pleasing musical notes in small number ratios

believed everything related to mathematics

argued orbits of planets must be circles (most perfect geometric figure)

**Plato** (427-347 BC)

“dualism:” perfect, ideal (but imperceptible) “forms”

vs. accessible but imperfect “shadows”

believed knowledge of external world is innate

(hence only have to look inward, through reflection or logic)

**Aristotle** (384-322 BC) Plato’s student very influential

- straddled both argument and empirical observation

- made endless observations about the natural world and human institutions. Some observations very keen, others sloppy.

- also made many statements about the world not grounded in observation.

- wrote influential treatises on rhetoric (methods of arguing) and logic, most famously the *Organon* (“Instrument”). Most famous method is deductive logic using syllogism (“All humans are mortal + Socrates is human, thus Socrates is mortal”).

### Rise of Christianity

In 2nd-6th centuries A.D., Christianity became an ideological religion:

what you *thought* mattered. Different factions argued fiercely over different theological beliefs (nature of Christ, grace, etc.). The winning side declared the other heretics.

This imported philosophy and rhetoric into Christianity. Around the same time Christianity became state religion of Rome; St. Augustine used Platonic dualism to justify Christianity’s acceptance as a state power (previously Christianity had been hostile or indifferent to government). This remained even after fall of Roman empire.

Scholastics 1100-1500 AD. A school of philosophy in the late middle ages. Scholasticism was a mode of argumentation, based in part upon Aristotle. Used to: discern correct beliefs from false+ used to resolve apparent contradictions e.g. between different statements in Bible, or between Bible and Aristotle. Used deductive logic and syllogisms borrowed from Aristotle.

### **Rise of Modern Science**

During Renaissance and Enlightenment we have (1) a culture intensely engaged in *ideas* as seen in the Scholastics, who in particular emphasized ideas of Greek philosophers such as Aristotle and also Ptolemy; + (2) an intensely materialistic culture due to expansion of trade, exploration, and so on.

-- The knowledge of the ancient Greeks is found to be flawed.

1492: Columbus accidentally discovers the New World, it contradicted Ptolemy's *Geography*. At the same time Copernicus questions Ptolemy's geocentric cosmos.

1572: Tycho Brahe discovers a New Star (nova) which contradicts Aristotle's statement that the celestial sphere is perfect and unchanging.

Francis Bacon: (1561-1626). Wrote *Novum Organum* (New Instrument) as a response to Aristotle. Rejects pure deductive reasoning in favor of inductive reasoning: making hypotheses from observed examples.

Galileo (1564-1642): Made methodical, deliberate investigations into mechanics and astronomy. Was able to show through such investigations

-- Aristotle was wrong about mechanics and gravity (more later)

-- Ptolemy was wrong about astronomy

His main contribution was deliberate and exhaustive experimentation. He also began to make quantitative measurements.

Finally, Isaac Newton (1643-1727): Invented calculus, made full combination of mathematics with physics. Also did experimental observations into optics. Importantly, suggested universal laws of nature (which differs from Aristotle).

#### *On the way to modern science*

The search for "truth" is difficult in particular it is difficult to get people to agree on any "truth." Logic and argument (beloved of the Greek philosophers, adopted by the medieval Scholastics) are useful but they are *not enough*

Over history **natural philosophy** (which became modern science) evolved in two important ways: Science narrowed its scope of inquiry from *all* truth to investigations of reproducible phenomena and the external, material world; and logic and argument were *supplanted* by empirical and reproducible observation and experiment.

A description (not a definition):

“Modern science is an efficient method to discover *reproducible and reliable* causal relations in the natural, external world.”

Key elements:

(1) Natural, external world: an focus on thing and events that affect our *material* life (food, health, transportation, physical defense, etc.).

(2) Causal relations: when I know **if...then**, I can control the *material* life.

(3) *Reproducible and reliable*. If it is not reliable, it's not very useful

(4) Efficient. We have stripped away everything not necessary to affect everything else.

### **What is science?**

Science is not *the* search for truth. Science is *a* search for “truths” which are *overwhelmingly* convincing. How does science accomplish this?

Two kinds of knowledge or discourse

“Irreproducible” knowledge: revelation or authority; looks to the *past*

“Reproducible” knowledge: recipes; looks to future.

The trouble with science: science is hard! Science is often treated *as if it were* irreproducible (e.g. from authority figure).

*The culture of science: An economy of novelty.* The combination of *novelty, convincing,* and *reproducible recipes* means scientists often cultivate *skepticism*

Outward directed skepticism: Skepticism towards authority and peers. Scientists are rewarded if they can *convincingly* overturn old theories or facts or find new theories/facts

Inward directed skepticism: To ensure convincing peers, scientists need to be self-policing.