

Aristotle

Knowledge comes from experience

Aristotle

- 384 - 322 BCE
- Born in Stagira, in Thrace, near Macedonia.
 - The "Stagirite."
- Son of Nichomachus, prominent physician.
 - Aristotle was likely trained in medicine.



Plato's Student

- At age 17, Aristotle was sent to study with Plato at the Academy.
- He became Plato's most important student, remaining at the Academy 20 years, until Plato's death.



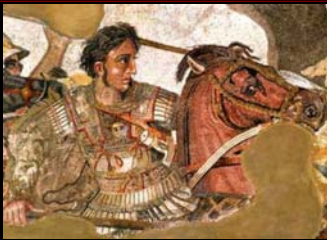
Aristotle becomes a royal tutor.



- When Aristotle left the Academy in 347, he settled briefly on islands near the Ionian coast, then accepted an invitation to teach the son of the Macedonian king, Philip II, whose father had been attended by Aristotle's own father.

Alexander the Great

- Aristotle tutored Phillip's son, Alexander, for 5 years until Phillip died and Alexander assumed the throne.
- Alexander went on to conquer much of the nearby world.



The Lyceum

- In 335 BCE, Aristotle returned to Athens and established his own school, in competition with the Academy.
 - Named the Lyceum, as it was adjacent to the temple to the god Apollo Lykaeos.
- Morning serious lectures
- Evening public lectures
- Inclusive curriculum
- Classification approach
- Aristotle associated with Alexander
 - After Alexander's death in 323, Aristotle fled Athens to prevent "a second sin against philosophy."

Aristotle's works

- What we have as Aristotle's works are about 30 closely written, terse, treatises on a full range of philosophical and scientific topics.
- These may have been his morning lectures, or even student's notes on those lectures.

...versus Plato's works

- In contrast, Plato's surviving works consist of about 20 dramatic dialogues that discuss philosophical issues in a Socratic, dialectical, questioning manner.
- Aristotle may have written such works as well, but they have not survived.

The foundation of western philosophy – and science

- Aristotle's works – more than Plato's – laid the groundwork for the systematic development of philosophy and the basic framework for the understanding of nature.
 - Logic, empirical evidence, systematic explanation.
 - Sound methodology, wrong conclusions.

The benchmark for the understanding of nature

- The standard view of the world for 2,000 years.
- To understand the development of science it is necessary first to grasp Aristotle's methods and his conclusions about nature.

Empiricism

- First, Aristotle grounds all knowledge on experience.
 - This is unlike Plato for whom knowledge came only when the philosopher escaped from the world of sense perception, which could mislead.
 - Reality, for Aristotle, was the world around us, not the objects of the mind, which could be just fantasy.

Aristotle, the biologist

- Students at the Lyceum collected specimens, dissected, and classified them.
- Analysis of life forms arose from examination of many real examples.
- Similarly every subject was examined and classified.

Contrasting World Views

A basic division in how the world is understood:

- Plato – (pointing up) true knowledge comes from contemplating the abstract ideas.
- Aristotle – (pointing down) true knowledge comes from close examination of the world around.



Plato and Aristotle from Raphael's *School of Athens*.

Contrasting World Views, 2

The ideal form, an example:

- For Plato, a geometric object, e.g. a triangle, circle, cube, etc.
 - The true object exists only in the mind. Actual representations are only approximate.
- For Aristotle, an animal or plant species, e.g. roses, trout, human beings, etc.
 - The species is what all the instances of it have in common.

Logic

- The way to knowledge beyond what is presented to the senses.
- Based upon Parmenides' principle of the excluded middle.
 - A statement is either true or false. Therefore, if it can be shown that a statement is not true, it must be false.
 - If valid reasoning leads to a false conclusion, one of the premises must be false.

Syllogisms

- The key component of Aristotelian logic is the *syllogism*.
- Typical format:
 - Major premise – a general truth, or observation
 - Minor premise – a particular fact, or specific observation
 - Conclusion – an inference implied by the two premises together

Syllogisms, 2

- The classic example of the syllogism:
 - Major premise: All men are mortal.
 - Minor premise: Socrates is a man.
 - Conclusion: Socrates is mortal.
- In other words, what applies to all members of a group applies to each and every member.

Syllogisms and Logic

- Aristotle worked out the forms of valid reasoning from premises.
- The principle is to combine known truths and deduce new knowledge that must be true if the premises are true.
- The method is sound.

However...

- The conclusions from syllogistic reasoning must be true only if the premises are true.
- Very often, Aristotle reasoned correctly from faulty generalizations and produced impressively argued, but nevertheless false, conclusions.
 - As Plato noted, the senses can deceive.

The Four Causes

- A *cause* for Aristotle is a factor that partly determines a result.
- Aristotle identified four causes as the explanation for anything (or event) that is.
- How and why something came to be is understood by examining its four causes.

The Four Causes, 2

- The causes are:
 - The Material Cause – basically the stuff out of which anything is made.
 - The Formal Cause – the form, size, and shape of the thing.
 - The Efficient Cause – what put the material into the form it is in.
 - The Final Cause – the purpose of the thing.

The Four Causes, 3

- An example: The causes of a knife.
 - Material: The metal, e.g. iron, steel.
 - Formal: The shape of a knife – sharp edge, long shaft, pointed end, rounded handle, etc.
 - Efficient: The tool maker that fashioned it.
 - Final: To cut or slice.

The Four Causes, 4

- Man-made things are easy enough to classify, but natural objects become more difficult.
 - What is the efficient cause of a tree?
 - What is the final cause of a rain shower? Or a human being?
 - What is the material cause of a thunderclap?
 - The formal cause of sunlight?

The Four Causes, 5

- For Aristotle, the most important cause was the final cause, that for which the thing exists. Anything is explained only by understanding its purpose.
 - Examples: a chair, a blackboard, a piece of chalk, a shoe.
 - Or, a planet, a drought, a mountain, a leopard.

Aristotle's logical analysis applied

- From the logical tools developed by Aristotle, and the careful observations made and generalized, Aristotle built a complete system that explained the world as it is.
- His system shows the power of reasoning *and* the dangers of premature generalizations.

Aristotle's Cosmos

- Classification: There are two different parts of the world.
 - There is the world all around, where things come and go; are born, live, and die; and motions start and stop.
 - There is the world up in the sky, where things happen over and over again: the sun rises and sets, the seasons reoccur, the planets repeat cycles.

The Sub-Lunar World

- The world around us includes the Earth itself, the seas, the atmosphere, and of course fire.
- It extends up to the moon, the first heavenly body.

Generation and Corruption

- The Sublunar world is the world of life.
- Everything in it came into being, had a period of existence, and died.
 - Even motions started and stopped.
- Even objects that did not appear to have a life span were subject to this process:
 - Rocks, mountains, etc., came into being and passed away, though over very long periods.

The Material of the Sublunar World

- Aristotle accepted the popular four elements of Empedocles as the material of the sublunar world:
 - Earth, Air, Fire, Water.
- Everything in the sublunar world is made up of these elements, in different combinations.

Natural Place

- The elements all have a natural place in the sublunar world
- Earth and water are “heavy” and so their natural place is at the centre of the world.
- Fire and air are “light” and their natural place is at the outer edge of the sublunar world.
 - Note: “Light” does not mean “less heavy.”

Natural Motion

- When unobstructed, the elements strive to reach their natural place. This is called natural motion, and requires no further explanation.
- Earth is heavier than water, so it will push past water seeking the centre.
- Fire is lighter than air, so it pushes further outward.

The Sublunar World



Forced Motion

- Objects on Earth are not always in their natural place, nor do they only have natural motion.
- They may be forced to move unnaturally, by, for example, being pushed or pulled.
- Or an object may be prevented from going to its natural place by being held back.

Everyday Forced Motions

- A heavy object may be pulled or pushed to a new location.
 - When it is no longer being forced, it stops.
 - If it is pushed off a cliff, it will resume its natural motion downward, seeking its natural place.
- A light object, e.g. a vessel containing air, may be pushed under water
 - If released will assume its natural motion upward.

The Problem with Logic

- Aristotle's view of the world is complete and consistent. It is based on direct observation, and logical analysis.
- When something cannot be observed (e.g. a cause), Aristotle endeavours to discover what it *must* be, by reasoning from what he has already determined.

Not so obvious forced motions

- The weakness of Aristotle's view of the cosmos is revealed most clearly in his analysis of forced motions.
- Aristotle believed that an object would only move *unnaturally*, if it was pushed or pulled – i.e. was in direct contact with the cause of motion.

What about something thrown or shot?

- Consider a rock being hurled, or an arrow shot from a bow.
- The motion of the object fits Aristotle's analysis, only so long as it is in contact with the cause of motion – the throwing arm or the bowstring.

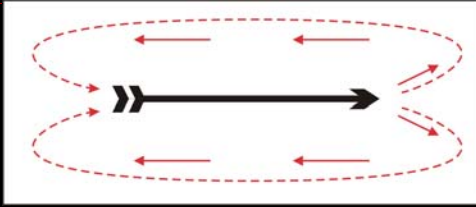
Why does the object move through the air?

- According to Aristotle, the object resumes its natural motion (i.e. straight down) as soon as it is no longer in contact with whatever was forcing it.
- But this is obviously not so; it keeps going.

Aristotle's Answer:

- Since the world is full (no empty spaces anywhere), a rock or arrow flying through the air must be pushing the air out of the way as it flies.
- That air has to go somewhere. It goes behind the moving object and continues to push it forward.

Antiperistasis



- This is the principle of *antiperistasis* – “against remaining in the same place.”

The weakest point in Aristotle's physics

- Aristotle's antiperistasis argument was the most obviously contrived explanation in his physics.
- It attracted the attention of later philosophers almost immediately as a problem.

The Super-Lunar World

- The heavens were obviously different.
- Motions there repeated over and over again.
- Generation and corruption did not apply.
 - Heavenly objects seemed to always be there.
- What needed explaining were the cycles.

Natural Motion in the Super-Lunar World

- In the sublunar world, objects moved to their natural place (and then stopped).
- In the superlunar world, they cycled.
- Therefore natural motion in the superlunar world must be *circular*.
 - The circle moves, but stays in the same place.

The Material of the Super-Lunar World

- The materials of the sublunar world have built in tendencies to go to their natural places.
- Therefore the material of the superlunar world must be different.

The Quintessence

- There are no forced motions or contrary tendencies in the heavens, so there is only one material there.
- It is an additional and different element.
- Aristotle called it the "Fifth Element."
 - In Latin, that is the *Quintessence*.

The Crystalline Element

- The heavens must be full (no empty space), but they look like they are empty.
- Solution: The fifth element must be invisible, like glass, except for the few bits that show up, the planets and the stars.

The Problem of the Planets, again

- All the natural motions of the fifth element are circular.
- Since there are no forced motions, everything in the heavens must be moving in combinations of circular motions.

Eudoxian Spheres

- Aristotle adopted the scheme of Eudoxus with spherical shells nested inside each other, all turning different ways.
- But with a difference:
 - Eudoxus was happy to describe the motions geometrically.
 - Aristotle required a cause of motion.

Solution: More spheres

- Eudoxus thought 27 spheres were enough to account for the motions of the celestial sphere and the seven planets (which include the sun and moon). But their motions were independent.
- Aristotle required that motion be communicated from one to another.
 - He needed 55 spheres in total.

The Unmoved Mover

- The ultimate cause of motion in the universe is what turns the celestial sphere.
- The celestial sphere rubs up against the spheres of Saturn, which rub up against Jupiter, etc.
- That ultimate cause is the *Unmoved Mover*.

The Aristotelian Cosmos

An illustration from an edition of Aristotle's *On the Heavens*, published in 1519.



A Philosophy for 2000 Years

- Aristotle's scheme provided a logically consistent explanation for the motions of the heavens and life on Earth.
- It combined most of the preconceptions of his time into a grand system.
- His view remained the standard conception for nearly 2000 years.
