

Aristotle's Natural Philosophy

Waseda University, SILS,
Introduction to History and Philosophy of Science

The Hellenic World, 550–270 BCE

12 Greek and Phoenician Settlements
in the Mediterranean Basin, about 550 B. C.



The Atomists

- ▶ The early atomists, Leucippus & Democritus (5th c. BCE)
 - ▶ “Nothing comes to be at random (accidentally), but all things from reason and by necessity.”
 - ▶ There are some unarticulated **laws** that everything follows.
 - ▶ Reason and necessity are the same.
 - ▶ There can be no real chance or purpose.
- ▶ The later atomists, Epicurus (4th c. BCE) & Lucretius (around 1st c. CE)
 - ▶ The atoms swerve from their course by spontaneous chance.
 - ▶ Most things follow **laws**, but there is some underlying *chance*.
 - ▶ There is also **free-will**.

Plato (late 5th to mid-4th c. BCE)

The *Timaeus*:

- ▶ The universe is crafted by (1) a divine creator, The Craftsman, who is a purposeful being acting on an underlying (2) nature, which is brute.
- ▶ The Craftsman desires the good and brings order. He works with extant things, matter, to produce the best possible world. He makes the universe *a living being* in which there are other gods.
- ▶ The universe is the result of the combination of (1) Reason and (2) Necessity, the “errant cause.”
 - ▶ Reason provides the form, purpose and meaning to the universe.
 - ▶ Necessity is the material substance of the elements without any form, reason or purpose.
- ▶ There is *no omnipotent god*. There is *no real chance*, only Reason and Necessity, which are contrary to one another.

Aristotle of Stagira

A short biography of Aristotle:¹

- ▶ Born 384 BCE, medical family in Macedon.
- ▶ Athens: 367–347. [At the Academy.]
- ▶ Asia Minor and Macedon: 347–342.
- ▶ Macedon: 342–335. [Tutor to Alexander III (“The Great”)]
- ▶ Athens: 335–323. Founded the Lyceum.
- ▶ Fled Athens 323, died 322.



¹ Portrait of Aristotle: Pentelic marble, now in the Louvre, copy of the Imperial Period (1st or 2nd c. CE) of a lost bronze sculpture made by Lysippos.

Aristotle's World



Aristotle's Works

- ▶ Exoteric (external): Only Fragments. Dialogues in a highly literary style.
- ▶ Esoteric (internal): We have about 30 treatises. Very concise, often obscure. Edited and set in their current arrangement by Andronicus (c. 60 BCE).
- ▶ During the Hellenistic period (300–100 BCE), Aristotle was largely known through his dialogues, ever since by the esoteric treatises.

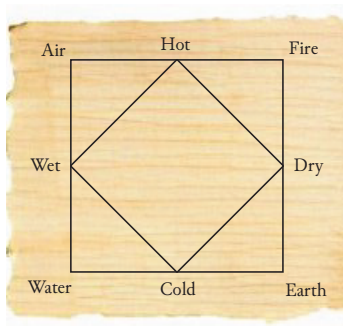
The Natural Works

- ▶ *Physics* (Nature): On change, and the causes of change, in natural things (esp. plants, animals, etc). Analogy between natural objects and artificial objects.
- ▶ *On the Heavens*: On the structure and function of the cosmos, particularly the superlunary regions.
- ▶ *Meteorology*: On phenomena in the sublunary realm. Weather, mineral and metal formation, etc.
- ▶ *On Coming to Being and Passing Away*: Matter theory, “chemical” change, etc.
- ▶ Biological works, mostly on animals.

- ▶ The natural world is *generally predictable* because things have an internal “nature” — that is, a tendency to fulfill their innate potential.
- ▶ The natural philosopher’s task is to observe the natural world and to discover the internal *nature of things*.
- ▶ We can only do this, when things are in their natural, uncontrolled state.
 - ▶ Hence, it will *not* do any good to perform experiments.
- ▶ For Aristotle, by and large, “nature” is a characteristic of individual objects, not some overall substrate that governs how things interact.

Qualities and Elements

- ▶ The material constituents of earthly things are made up of four “elements,” which are each composed of two “qualities.”
- ▶ Transformations from one material to another are explained by reduction to underlying qualities.
- ▶ All of the material objects that we experience are a mixture of these elements.
- ▶ There is another element, aether, above the sphere of the moon.



Theory of Causation

- ▶ Aristotle's theory of causation is a reaction to those of his predecessors.
- ▶ He believed that a successful theory of causation will explain *change* in the natural world.
- ▶ The causes are answers to questions about the inner *nature* of things, and how things change. (Stuff, Structure, Agent, Purpose.)
- ▶ Each of his predecessors had focused on certain aspects of these explanations or answers — Aristotle claimed to cover them all.

Four causes of things

Aristotle:

“We think that we know the cause of a thing when we can answer the question ‘why?’”

1. **Material:** That *of which* it is made; stuff.
2. **Formal:** That *according to which* it is made; structure, pattern, model.
3. **Efficient:** That *by which* it is made; the agent of change.
4. **Final:** That *for the sake of which* it is made; the purpose, goal.

Four causes, an example

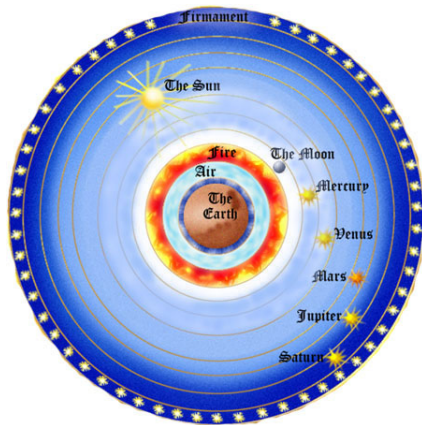
In the *Physics*, Aristotle presents the example of a bronze statue.

Example (What are the causes of a certain bronze statue)

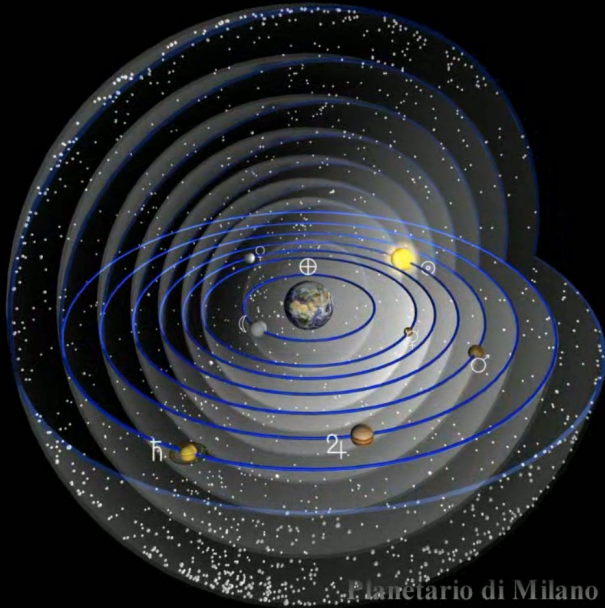
- ▶ The statue is made out of bronze (an alloy of copper and tin). This is its **material cause**.
- ▶ It is made in a particular shape, say of a person. This is its **formal cause**.
- ▶ It is made by a sculptor, using specialized techniques. This is its **efficient cause**.
- ▶ It is made to fulfill some function — to decorate a particular city square, or to honor a particular person, etc. This is its **final cause**.

Aristotle's Cosmology

- ▶ The cosmos is *eternal*. It has always existed in basically the same way.
- ▶ There are two fundamentally different regions, which have *different physical principles*.
- ▶ Sublunar (under the moon): earth, water, air, fire.
- ▶ Superlunar (above the moon): aither.



Aristotle's Cosmology



Planetario di Milano

Below the Moon

- ▶ Characterized by change and imperfection.
- ▶ The four elements are always shifting around, moving toward or away from the center, seeking their natural place.
- ▶ The elements form *mixtures*, such as all of the materials we actually experience in day-to-day life (even normal air, water, fire, “earth,” etc.).
- ▶ The changes of the mixtures account for observable phenomena. (Change in location, temperature, quality, heat, size, color, etc.)
- ▶ The elements, and mixtures of the elements, are *not made up of atoms*. They are *continuous* bodies that can be subdivided indefinitely.

Above the Moon

- ▶ Perfect and unchanging (although moving).
- ▶ No qualities.
- ▶ A single substance, *aither*.
- ▶ The aither is neither effected by, nor reacts with, the other four elements.
- ▶ These imply that there is a complete separation between the regions.
- ▶ Notice that there are various problems (anomalies) created by this division such as questions about how we explain solar heat, seasons, celestial light, effects of the moon, etc.

Theory of Motion

- ▶ There is no spontaneous motion. *There is no motion without a mover.* (So, no inertia.)
- ▶ All motion is either **natural motion**, produced by the internal nature of the moved object, or **forced motion**, produced by some object outside the moved object.

Motion below the Moon

Natural Motion: *Rectilinear* motion either toward or away from the center, seeking natural place. (Fire up, earth down, etc.)

- ▶ Speed is proportional to weight and inversely proportional to resistance ($V \propto W/R$).
 - ▶ What happens when there is no resistance? (Note: Aristotle did not believe that a vacuum can exist.)
- ▶ This means bodies will fall in times proportional to their weight.
 - ▶ Is this actually what happens?

Forced Motion: Impact by one object on another which forces it out of its natural motion. (Projectiles, a stone on a plant, etc.)

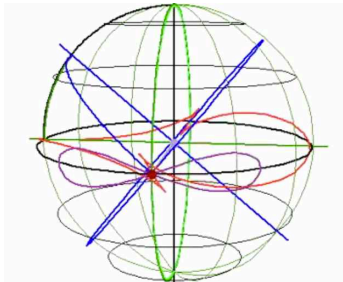
- ▶ Speed is proportional to force and inversely proportional to resistance ($V \propto F/R$).
 - ▶ Again, what happens in a vacuum?
- ▶ This means bodies will stop moving when they are no longer forced.
 - ▶ How do projectiles continue to move after they are put into motion?

Motion above the Moon

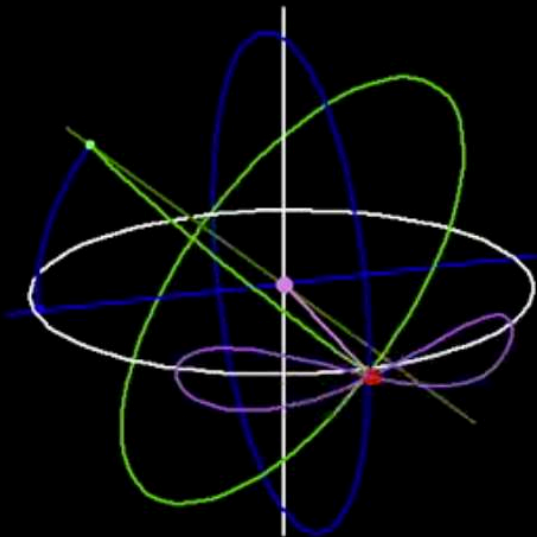
- ▶ **Natural motion:** The celestial bodies are *divine beings* which move themselves in circles according to rational thought.
- ▶ *There is no forced motion in the heavens.*
- ▶ They are moved by the prime mover as a final cause. (They are moved by love (*eros*)!?)
- ▶ Celestial motions are *circular, regular* and *continuous*.
- ▶ There is no contrariety, resistance, alteration or real change. All irregularities are merely apparent. (But, there must be motion from place to place.)

Concentric Spheres

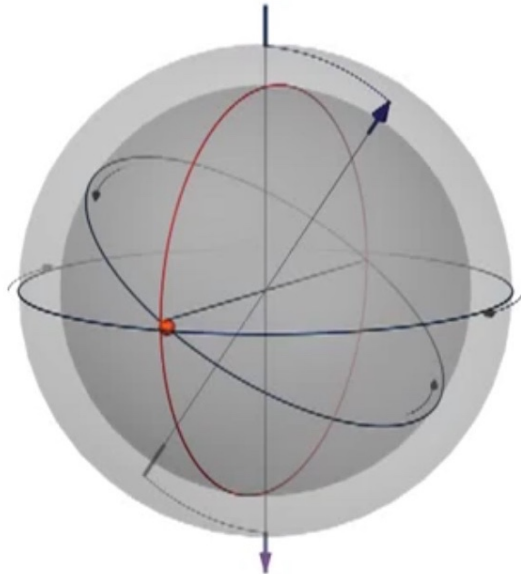
- ▶ Following Eudoxus and others, Aristotle supposed that the celestial bodies are carried on interlocking spheres.
- ▶ There are different ways of counting the total spheres.
- ▶ Aristotle gets 56.



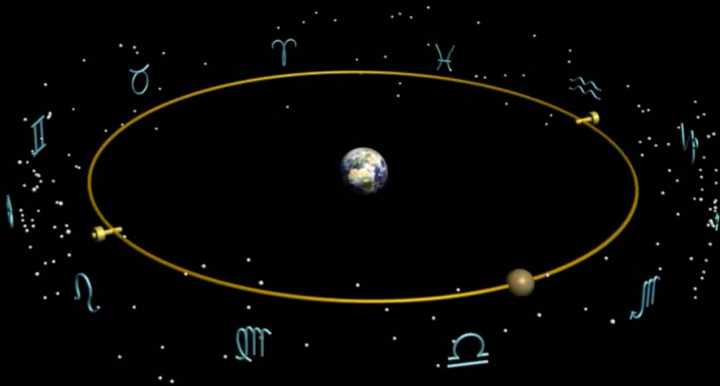
Concentric Spheres, the lemniscate



The leminscate, varying sizes



Eudoxus's cosmos, full model



- ▶ Is eternal, uncreated.
- ▶ There is no void space. The cosmos is a *plenum* – that is, everywhere filled with matter.
- ▶ A finite sphere, beyond which nothing exists. Divided into concentric spheres.
- ▶ Some things are *moved* by something else, others are *self-moving*.
- ▶ Rational beings are compelled (by love) toward a perfect rational being, which is *thought thinking about itself*.
- ▶ The existence and characteristics of this god can be derived on a purely rational basis.

Aristotle's Biology

- ▶ In terms of research in the natural world, Aristotle devoted the majority of his attention towards biological subjects.
- ▶ His biological studies seem to have had a deep impact on his entire system of thought.
- ▶ About 25% of his extant writings are on zoology – the first systematic comparative study of animals.
- ▶ *History of Animals*, *Parts of Animals* and *Generation of Animals*, and short specialized treatises.

Example, the development of a chick embryo:

History of Animals, VI 3

“Generation from the egg proceeds in an identical manner with all birds ... With the common hen after three days ... there is the first indication of the embryo ... the yolk comes into being ... and the heart appears, like a speck of blood, in the white of the egg. This point beats and moves as though endowed with life, and from it two vein-ducts, with blood in them, trend in a convoluted course ... and a membrane carrying bloody fibres now envelops the yolk, leading off from the vein-ducts.”

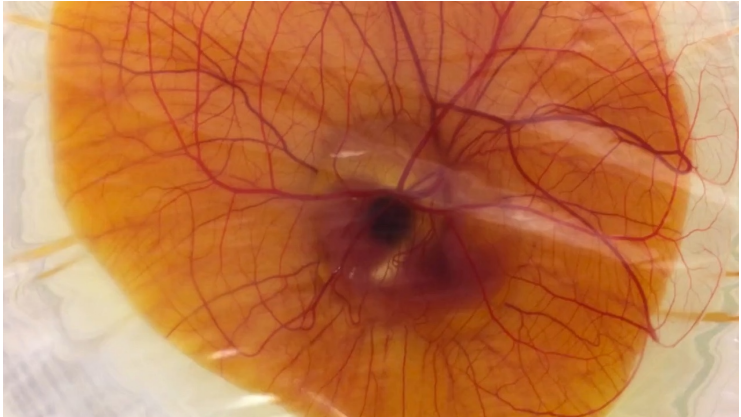
Chick embryo, 3 days after conception



History of Animals, VI 3

“A little afterwards the body is differentiated, at first very small and white. The head is clearly distinguished, and in it the eyes, swollen out to a great extent ... At the outset the lower portion of the body appears insignificant in comparison with the upper portion ... The life-element of the chick is in the white of the egg, and the nutriment comes through the navel-string out of the yolk. When the egg is ten days old, the chick and all its parts are distinctly visible. The head is still larger than the rest of its body, and the eyes larger than the head...”

Chick embryo, 9 days after conception



Intrinsic Teleology, I

- ▶ Aristotle applies his four causes to an explanation of natural organisms.
- ▶ In an organism, the plan (formal cause), the thing doing and carrying out the planning (efficient cause), and the end for which the plan is executed (final cause) are all *the organism itself*.
 - ▶ For Aristotle, this is the **defining characteristic** of *life*.
- ▶ An organism makes itself and it is its nature to do so.

Intrinsic Teleology, II

- ▶ The parts of animals are set up so as to fulfill the overall purpose of the individual organism.
- ▶ We should always ask, “What is the purpose of every part? What does it do? Why is it arranged thus?”
- ▶ Every living thing is arranged in *its own best interest*.
- ▶ Aristotle thought that what was most beautiful and noble about life was its purposefulness. (The individual purposefulness of the organism itself, not some overall, cosmic purpose.)

Overview

- ▶ A natural philosophy based on cause and deduction.
 - ▶ Four causes.
 - ▶ Systematic, rational explanation.
- ▶ A systematic cosmological system.
 - ▶ Geocentric — the earth is a sphere in the center of a spherical cosmos.
 - ▶ Four terrestrial elements and one celestial element.
- ▶ A rational account of the variety we see in the natural world.
- ▶ A rational account of intrinsic teleology in biological organisms.