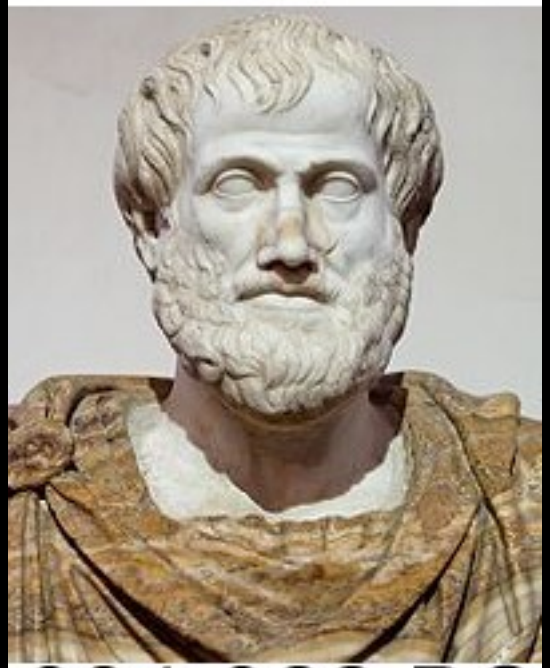
Aristotle



384-322 BC

ARISTOTLE’S SCIENCE

Aristotle on Scientific Knowledge

Scientific Knowledge is not just knowledge of the fact; it is also knowledge of the reason why. It is provided by a syllogism (called 'Barbara') of the form, AAA-1.

***Major premise*: All Cs are Fs.**
***Minor premise*: All Ks are Cs.**

***Conclusion*: All Ks are Fs.**

Major premise: All Cs are Fs.
Minor premise: All Ks are Cs.

Conclusion: All Ks are Fs.

The syllogism must contain exactly 3 terms, and each term must be used univocally. The 3 terms in this example are Cs, Fs, and Ks.

The syllogism:

All squares are rectangles.

All boring people are squares.

So all boring people are rectangles.

is invalid because the word 'squares' is not being used univocally.

Major premise: All Cs are Fs.
Minor premise: All Ks are Cs.

Conclusion: All Ks are **Fs**.

The **major term** is always the predicate of the conclusion.

The **major premise** is the premise that contains this term.

In an AAA-1 type of syllogism this term will also occur in the predicate position of the major premise.

Major premise: All Cs are Fs.
Minor premise: All Ks are Cs.

Conclusion: All **Ks** are Fs.

The **minor term** is always the subject of the conclusion.

The **minor premise** is the premise that contains this term.

In an AAA-1 type of syllogism this term will also occur in the subject position of the minor premise.

Major premise: All Cs are Fs.
Minor premise: All Ks are Cs.

Conclusion: All Ks are Fs.

The middle term is always the term that exists in both premises.

In an AAA-1 type of syllogism this term will also occur in the subject position of the major premise and in the predicate position of the minor premise.

To have scientific knowledge, however, more than this is required:

- To be knowledge of the reason why, both premises:
  - Must be necessary truths.
  - Must be primary, immediate, themselves indemonstrable, and prior to/more intelligible than the conclusion.
- There must also be no D such that C is a proper subset of D.
- In cases where the middle term “converts,” i.e., the two terms in the major premise can be flipped, two syllogisms can be constructed.
  - One of these will provide the reason why.
  - The other will provide knowledge of the fact.

Aristotle's Example:

Assumption: All near things are non-twinklers and all non-twinklers are near things.

Question: Are all the planets non-twinklers because they are near things, or are all the planets near things because they are non-twinklers?

SYLLOGISM 1	***SYLLOGISM 2***
***Major Premise*: All non-twinklers are near things.**	***Major Premise*: All near things are non-twinklers.**
***Minor Premise*: All planets are non-twinklers.**	***Minor Premise*: All planets are near things.**
***Conclusion*: All planets are near things.**	***Conclusion*: All planets are non-twinklers.**

According to Aristotle, *Syllogism 1* is a "demonstration of the fact that all the planets are near things." It would be wrong to say that they are near things because they are non-twinklers. *Syllogism 2,* on the other hand, is a "demonstration of the reason why all the planets are non-twinklers," namely, they are non-twinklers because they are near things.

SYLLOGISM 1

Major Premise: All non-twinklers are near things.

Minor Premise: All planets are non-twinklers.

Conclusion: All planets are near things.

SYLLOGISM 2

Major Premise: All near things are non-twinklers.

Minor Premise: All planets are near things.

Conclusion: All planets are non-twinklers.

You might object here that the minor premise of *Syllogism 2* is not "prior to" and "better known" than the minor premise of *Syllogism 1*. But Aristotle responds to this as follows:

"Now 'prior' and 'better known' are ambiguous terms, for there is a difference between what is prior and better known in the order of being and what is prior and better known to man. I mean that objects nearer to sense are prior and better known to man; objects without qualification prior and better known are those further from sense. Now the most universal causes are furthest from sense and particular causes are nearest to sense, and they are exactly opposed to one another." [*Posterior Analytics*, Bk. I, Ch. 2.]

Note: The discussion above, besides hopefully indicating how foreign Aristotle's physics seems to us, was primarily designed to give you a feeling for how Aristotle's logic got incorporated into his physics.

Nine Theses in Aristotle's Physics

***Thesis 1*: Things that exist by nature have within themselves a principle of motion (e.g., change of place, alteration/decay, or growth/increase).**

***Thesis 1'*: Products of art have no innate principle of motion.**

Example:

A bed does not cause anything. It doesn't locomote. It doesn't grow. It doesn't decay (as a bed).

***Thesis 2*: With respect to things that exist by nature, the form (shape) is nature, rather than the matter.**

Example:

Man is born from man, but not bed from bed.

Thesis 3: There are four causes, viz., material, efficient, formal, and final.

"Knowledge is the object of our inquiry, and men do not think they know a thing till they have grasped the 'why' of it (which is to grasp its primary cause). So clearly we too must do this as regards both coming to be and passing away and every kind of physical change, in order that, knowing their principles, we may try to refer to these principles each of our problems. In one sense, then, (1) that out of which a thing comes to be and which persists, is called 'cause', e.g. the bronze of the statue, the silver of the bowl, and the genera of which the bronze and the silver are species. In another sense (2) the form or the archetype, i.e. the statement of the essence, and its genera, are called 'causes' (e.g. of the octave the relation of 2:1, and generally number), and the parts in the definition. Again (3) the primary source of the change or coming to rest; e.g. the man who gave advice is a cause, the father is cause of the child, and generally what makes of what is made and what causes change of what is changed. Again (4) in the sense of end or 'that for the sake of which' a thing is done, e.g. health is the cause of walking about. ('Why is he walking about?' we say. 'To be healthy', and, having said that, we think we have assigned the cause.)" [Physics, Bk. 2, Pt. 3]

Thesis 4: There is no void.

The Argument from Places

There are no places in a void because it is empty. So there is no place for anything to move to. If there were a void, then nothing could move in it.

Thesis 4: There is no void.

The Displacement Argument

When something is put in a medium, it displaces some of the medium. But in a void there would be nothing to displace.

Thesis 4: There is no void.

The Argument from Ratios

If a thing moves through a medium in a certain time, it will move through a medium half as thick in twice the time. But since the void contains nothing, there is no ratio. Where M = density of the medium, and T the time, and where other things are equal, if ½ M then ½ T, if ¼ M then ¼ T, etc. But the void is empty, so 1/0 M, but this is no ratio. (It would seem to follow that the thing would move infinitely quickly. But this violates the point that it takes some time for anything to move.)

Thesis 5: **Everything in motion must be moved by something. So all motion requires a continual application of force.**

Thesis 6: There must be a first (and unmoved) mover.

"There is something which is always moving with an unceasing motion, which is motion in a circle—this is clear not only to reason but also to observation. Hence the first heavens must be eternal. There is therefore something which moves them. And since what both moves and is moved has an intermediate status, there must be a mover which moves them without being moved, eternal and a substance of the actual." [Metaphysics, 1072a21-26]

Thesis 7: There can be no motion at a distance.

The argument for this:

***Premise 1*: All motion is either local motion, qualitative motion, or quantitative motion.**

***Premise 2*: All local motion is reducible to pushing and pulling.**

***Premise 3*: Pushing is local motion to something from something else.**

***Premise 4*: Pulling is local motion from something to something else.**

***Conclusion 1*: Pushing and pulling require contact.**

***Similar arguments are used to establish that the other kinds of motion require contact*.**

***Conclusion:* All motion requires contact.**

Thesis 8: Aristotle is a finitist with respect to the extent of the universe and the matter in it. He also denies that there can be an **actual infinite** set of things, including natural numbers.

But he maintains that a **potential infinite** does exist.

"For motion..., although what is continuous contains an infinite number of halves, they are not actual but potential halves." (Physics 263a25-27). "...Therefore to the question whether it is possible to pass through an infinite number of units either of time or of distance we must reply that in a sense it is and in a sense it is not. If the units are actual, it is not possible: if they are potential, it is possible." (Physics 263b2-5).

According to the Internet Encyclopedia of Philosophy, this distinction allows him to respond to Zeno in the following way:

"Actual infinities, if they were to exist, would exist all at once. Potential infinites exist over time, as processes that can always be continued at a later time. Zeno made the mistake, said Aristotle, of conceiving of the continuous path taken by Achilles as being composed of an actual infinite aggregate of sub-paths, and Zeno envisioned the whole as dependent on these parts. That's the mistake, says Aristotle. Instead, the whole path is there, and then the analyst envisions a process of potentially dividing the whole into its parts. In reality, the path is given first, and it is continuous, whole, and finite. The potential infinity of sub-paths are created over time by the analyst, and at no time is there an actual infinity of sub-paths marked out in reality beyond the analyst's mind, yet Zeno needs this actual infinity in order to complete his argument. If we reject actual infinities, we have a way out of these paradoxes, claims Aristotle. Notice that Aristotle is using the word "potential" in a special sense because a potential president can later become an actual president, but a potential infinity cannot become an actual infinity."

Thesis 9: Principles of Proportionality.

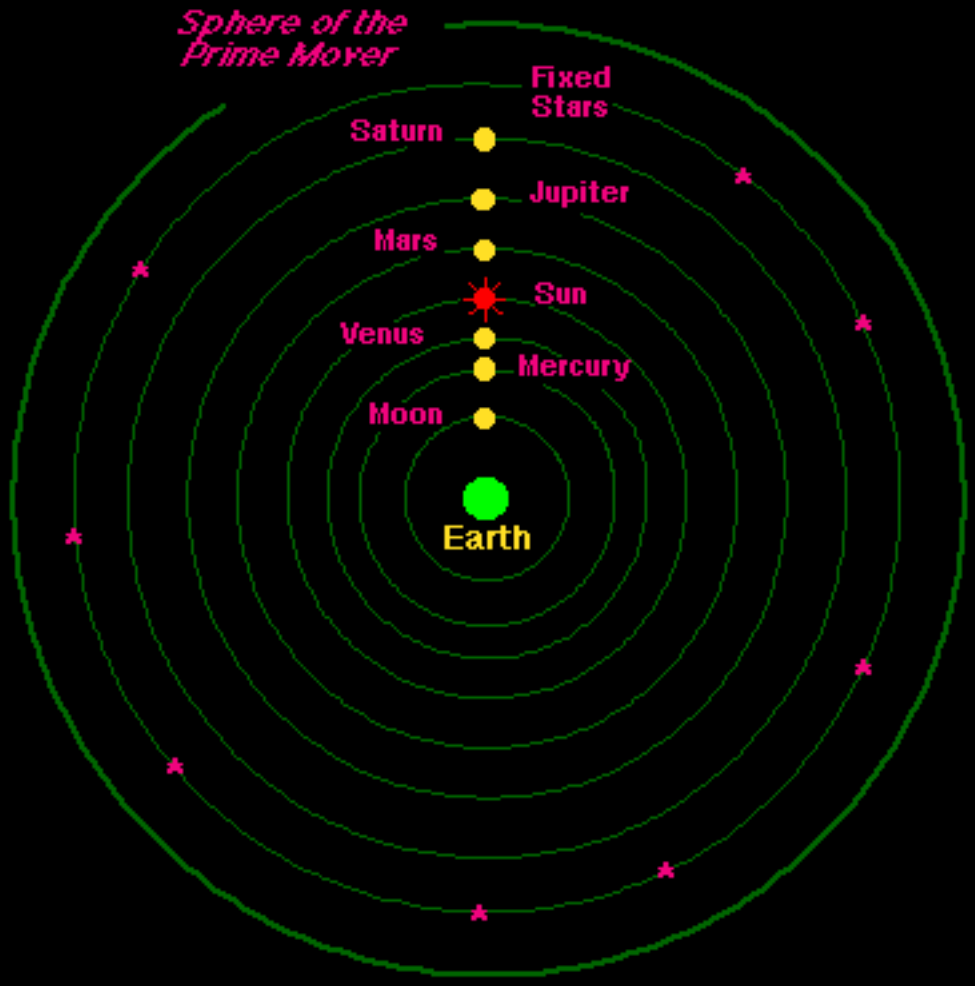
Different bodies move faster/slower for two reasons: Either there is a difference between the medium through which they move, or they have a difference in weight.

- Velocity is directly proportional to the weight of the body in motion.

- If a force F can move an object of a given weight W a distance D in a given time T through a certain medium M, then F can move W distance D through a medium M*, where M* is n times as dense as M, in T/n. (So the more dense the medium the longer it takes the thing to get through it.)

- If a force F can move an object of a given weight W a distance D in a given time T, then, assuming the same medium, *where n is any fraction*, n*F can move n*W in T. (E.g., half the force can move half the weight in the same time.) However, it is not necessarily the case that, *where n is any whole number*, F/n can move the same W n*T. (E.g., half the force won't necessarily move the same weight in twice the time.) Forces have thresholds.

Aristotle's Astronomy



Aristotle's Universe

The earth is spherical in shape, stationary, and is located at the center of the universe.

The universe is spherical because that is the most perfect shape.

The universe is finite because it has a center (viz. the earth) and a body with a center cannot be infinite.

There were 5 fundamental elements:

4 elements below the sphere of the moon in the terrestrial region were:

earth

water

air

fire

1 element above in the celestial region was:

aether

The appropriate motion for the elements below the sphere of the moon is rectilinear.

The appropriate motion for ethereal objects is circular.

Things have potentials (due to their form) which, if they are not defective, they strive to actualize. And some things—those that are more perfect--have more potentials than other things.

Thus, for example, a rock, because it is made mostly of earth, seeks its proper place, which is toward the center of the planet.

In addition to this, all non-defective living things also have the potential to grow and reproduce.

While all non-defective animals also have the potential to sense. And some of these also have the ability to locomote. Some even have the potential to imagine.

And all non-defective humans also have the potential to reason.

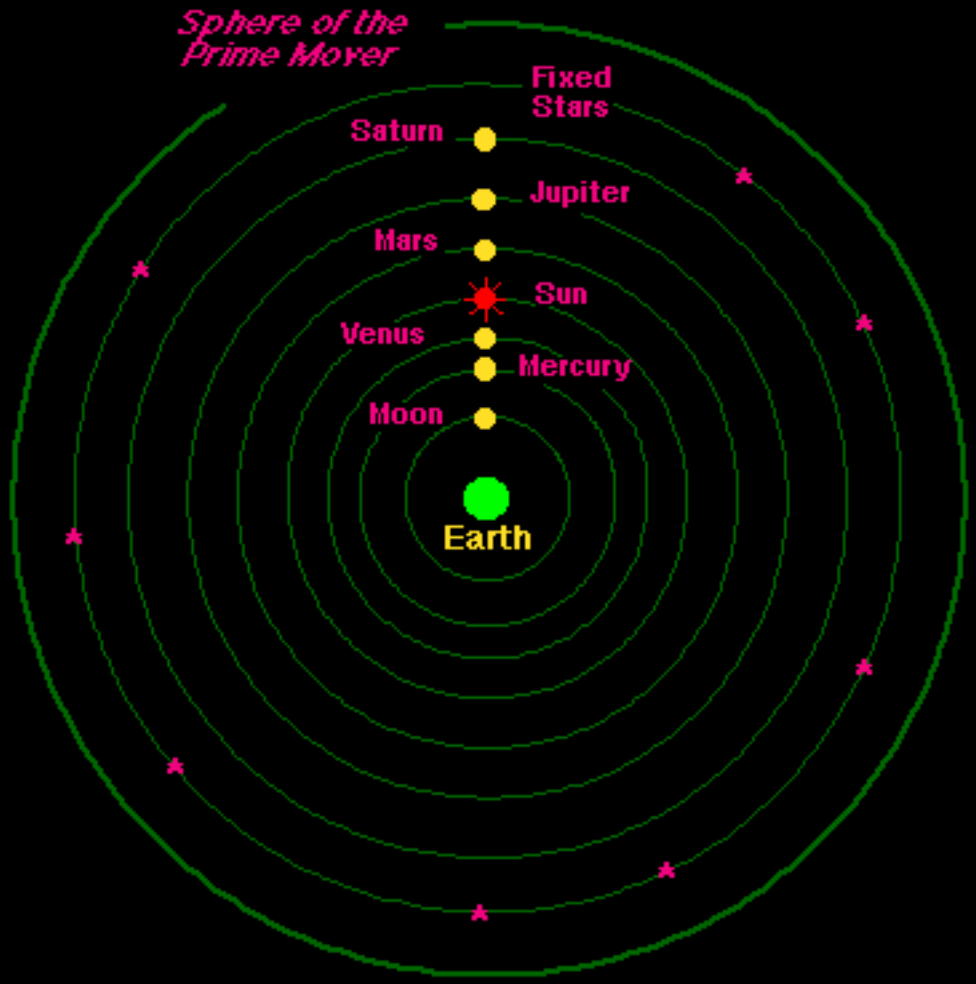
While all non-defective male humans also have the potential to engage in theoretical reason.

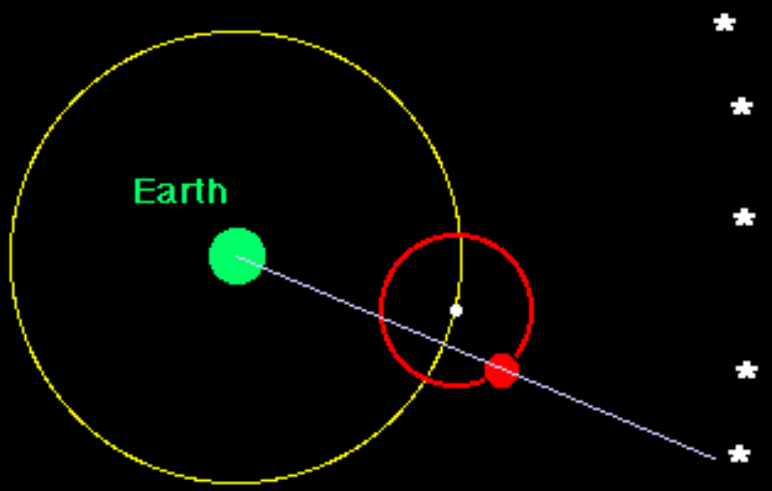
NAILS IN ARISTOTLE’S COFFIN

1. Problems with Aristotle's Astronomy

a. Epicycles and the Spheres

Epicycles needed to be postulated to account for the movement of the planets, but this entailed that some spheres overlap. How could this be?





b. The celestial realm was supposed to be unchanging but:

A new star appeared in 1572.

A new comet appeared in 1577.

And in 1609 Galileo saw sunspots, and satellites of Jupiter.

2. A Problem with Aristotle's Physics

When an arrow leaves the bow, it should head down. But it doesn't.

To overcome this problem it was supposed that as the arrow travels air is displaced. This threatens to cause a vacuum at its rear end, and vacuums are impossible. So, the hypothesis was that air rushes in and this propels the arrow forward.

But why, then, wouldn't the arrow continue forever?

And if it eventually falls to earth, which we know it does, wouldn't its fall be instantaneous?

Until you know that the arrow's path is parabolic you are going to have problems hitting targets in war!

The Theory of the Impetus

Revised from medieval times, Galileo suggested that motion functions like heat.

This theory was an ancestor to the concepts of inertia, momentum and acceleration in classical mechanics.

3. Neo-Platonism

Marsilo Ficino (1433-1499) translated all of Plato's dialogues into Latin.

This was important because it provided a set of contrasting theories to Aristotle's, perhaps the most important of which was that Plato had argued for the view that the sun was at the center of the universe.

It seems likely that Copernicus was aware of and sympathetic to the Neo-Platonist movement.

Nicholas of Cusa (1401-1464) expanded the Platonic argument that mathematics was a form of certain knowledge to the radical thesis that mathematics represented divine ideas. This extreme position, accepted by many Neo-Platonists, eventually became the basis for a new form of science.

4. The Corpuscular Theory

This theory had been around since ancient times, but was reintroduced in the 17th Century. In our reading, it is proposed by Galileo, who did much to popularize the new science. Galileo says that:

"Now, whenever I conceive of any material or corporeal substance, I am necessarily constrained to conceive of that substance as bounded and as possessing this or that shape, as large or small in relationship to some other body, as in this or that place during this or that time, as in motion or at rest, as in contact or not in contact with some other body, as being one, many, or few--and by no stretch of imagination can I conceive of any corporeal body apart from these conditions. But I do not at all feel myself compelled to conceive of bodies as necessarily conjoined with such further conditions as being red or white, bitter or sweet, having sound or being mute, or possessing a pleasant or unpleasant fragrance." [Ariew, p. 9]

Two points about this theory are especially worth noting:

- As we will see, not everyone held that these corpuscles were indivisible atoms.
- It marked the beginning of a distinction between primary and secondary qualities. The primary qualities were size, shape, and motion. The secondary qualities included color, taste, sound, etc.