Plato and Aristotle: Crash Course History of Science #3

Crash Course: History of Science
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Pop quiz: Are you a Platonist or an Aristotelian? An idealist or an empiricist? Do you think up neat rules to describe the universe and then try to fit data into your theory, or do you observe the world and draw conclusions from what you see? Do you trust math or your senses?

Before you decide, let's take a trip to urban Athens ca. 399 BCE.

[*Crash Course History of Science* intro]

Last week we met the Presocratics. Despite having by any reasonable standard invented science in Europe, these thinkers are lumped together today as simply "not Socrates". So, who was this smartypants?

Socrates didn't have a single clearly-formulated natural philosophy. He didn't even study nature. He studied politics and morality and prided himself on not claiming to know things.

But Socrates did two important things. He asked a lot of questions, which influenced how philosophers went about teaching their ideas, and he inspired the two rock stars of classical Greek philosophy.

Socrates held that knowledge comes from asking questions. So many questions. His name is attached to the Socratic Method, in which you constantly ask questions so that students can steadily break down a big problem into smaller parts – parts they can test hypotheses against.

It's okay if they realize that a hypothesis is wrong. In fact, it's good; it means they're moving away from falsehood. The Socratic Method is an example of negative hypothesis elimination, or proving that something is wrong to narrow down the possibilities of what might be right.

But Socrates's biggest legacy may be his student Plato and his student's student Aristotle. Both were inspired by Socrates's methods, but they arrived at some very different conclusions about the world.

We know a lot about Socrates thanks to his students. Chiefly, Plato founded a physical school called the Academy to train Athenians in how to think like Socrates.

Plato wrote down dialogues between Socrates and other thinkers, including Parmenides. He was the Eleatic philosopher who believed that nothing really changes and thus we can't trust our senses. This had a big impact on Plato, whose best-known works include *Republic*, in which Socrates defines justice and argues for rule by a philosopher-king instead of democracy, and *Timaeus*, in which Socrates talks about the nature of the universe.

Plato had a big impact on thinking about thinking. Today we still use Plato's name for a place of philosophical learning, "academy", to describe the concept of higher education in general.

At the original Academy, Plato emphasized training in how to think properly. Over the door of the Academy was inscribed the dictum "Let no one enter here who is ignorant of geometry."

Plato based his own philosophy on geometric laws. He taught a Pythagoras-inspired idealism, or a theory of nature based on perfect abstractions, rules of which real-world stuff could only ever be imperfect examples.

So Plato had to fit his observations to his theory. That idealism is one of the reasons people think of Plato as more of a philosopher than a scientist.

Plato built on the work of the Presocratic schools, but he developed a more complete way of looking at the natural world than they did. And his students took off in search of solutions, even as they changed his underlying theory. The only Greek who wrote more philosophy than Plato was Plato's own star student and rival, Aristotle.

Compared to Plato's idealistic abstractions, Aristotle's philosophy makes more common sense. His ideas are based on empirical evidence. He observed the world and then came up with a theory that explained it. This order of operations is at the heart of modern scientific practices.

Aristotle was from Macedonia in the north of Greece, but he studied at Plato's Academy in Athens for twenty years, until Plato died. Afterward, Aristotle took a lucrative gig. King Phillip II of Macedonia hired him as tutor to his son, Alexander.

And you know this particular Alexander. He decided to conquer the entire earth. Before age 30, he ruthlessly conquered much of Asia, Africa, and Europe, ruling over more area than anybody until Genghis Khan.

Aristotle's influence on Alexander "the Great" reminds us that science is always social. From the very beginning, scientists have served bad, heartless dudes. Aristotle, a man who literally wrote the book Ethics, pushed his most famous pupil to invade Persia, kill barbarians, and become a brutal warlord.

After Alexander died young, Aristotle went back to Athens to start his own school, the Lyceum. The Lyceum was pretty different from Plato's Academy. Because Aristotle liked plants and liked to walk and talk, his school wasn't in a building but a grove of trees outside the city. And his school was called the Peripatetic, meaning "walky" and thus informal, not like the Academy.

It was during the Lyceum years that Aristotle probably wrote many of his most famous works, including *Metaphysics*; *On the Heavens*; *On the Soul*, which is actually an amazing book of proto-biology meets psychology; and his school's highly influential set of textbooks on natural philosophy called *Physics*.

How did Aristotle answer our big questions about physics, such as "what was stuff?" and "where are we?" He posited a complete system joining the elements and the heavens. This became the basis for European thought about the physical for two thousand years.

Let's compare Aristotle's system to his mentor Plato's in this episode's Thought Bubble.

For Plato, the cosmos was perfect. It had perfect rules that could be studied, and all cosmic stuff was made up of atoms that were perfectly geometric platonic solids, each creating one element – tetrahedrons of fire, cubes of earth, octahedrons of air, icosahedrons of water – and dodecahedrons as the shape of the whole universe, like a giant celestial set of D&D dice.

Plato's theory of the heavens stated that the wandering stars – that is, the planets – followed a path of uniform circular motion. You see, the wandering stars must move in perfect circles since the cosmos is orderly. Ah, but this one is moving backwards.

Plato's students could see that Mars, for one, seemed to jump backwards, showing retrograde motion. Plato didn't really have an explanation. European astronomers would spend the next two thousand years meticulously trying to solve this problem, and they would end up learning a lot in the process.

How did Aristotle build on Plato's system? Aristotle's cosmology was abstract too, but he attempted to make sense of observations about the world. He crossed those same four elements, plus a new anti-void called the aether, with four physical sensations – hot and cold, dry and wet – and used these to explain everything.

Earth was the heaviest element, so it was the center of the cosmos. Water was lighter than earth, so oceans rested on top of the Earth. So far, so good. Air's natural state is above water. That also checks out. Fire is on top of air, which is a little weird, but it does go up, I guess.

And way out past these four terrestrial spheres, out past the Moon, spun the stars, acting according to their nature as aethereal, or perfect circle-moving, objects. And nowhere anywhere in this theory was a void. Nature abhors a vacuum.

In Aristotle's cosmos, all of the elements were actively trying to get back to their natural states. Why did flames rise? They were just trying to get back to the fiery celestial realm above the air.

Thanks, Thought Bubble.

From the Presocratics to Plato to Aristotle, we've ended up with a bunch of spheres inside spheres, each with a natural tendency. This confirmed the average Bronze Age farmer's experience, and ours. The Earth seems to stand still, water sits on earth, air isn't very heavy.

Aristotle recognized that elements didn't always exist in their pure forms. A tree, for example, was a combination of earth, water, and air. Roots go down into the earth, and branches go up into the air. His theories also worked for comparisons. Why does a book fall faster than a piece of paper? Well, because it has more earth in it.

Aristotle could even explain natural phenomena. Why does rain fall from the sky to the ground? Why do volcanoes shoot fire up? Obviously, this isn't how I think gravity works, but it's a way of explaining it that made sense to the ancient Greeks.

Where Plato saw a world of ideal shapes, Aristotle had a theory that acknowledged that we're all kind of a hot mess. Things are naturally jumbled up but always trying to get back tot heir essential place.

Aristotle also loved looking at living things, and he looked closely. He noticed, for example, that the octopus can change color, which is awesome, and that male octopi have a special arm called a hectocotylus, which is something you should google, because it's weird and kind of awesome, and it wasn't confirmed by scientists until the 1800s.

Aristotle trusted that knowledge proceeded from the experience of the senses. In his works such as *History of Animals*, among others, he wrote down observations like these about all kinds of organisms. He also tried to classify the world into an orderly system, giving rise to taxonomy.

When he attempted to answer one of our questions, "what is life?" the taxonomy he created relied on a system of souls. Plants have a vegetative soul, responsible for reproduction and growth. Animals have a vegetative and a sensitive, or animal, soul, responsible for mobility and sensation. And humans, and only humans, have a vegetative, a sensitive, and a rational soul, capable of thought and reflection.

This led Aristotle to further theorize that all things can be placed on a line from simplest/least soulful to highest/most soulful. On one end, he placed plants then worms and so on. These low animals bore their offspring cold, dry, and in thick eggs. The higher animals made warm and wet babies.

So of course, at the other end of the line, Aristotle placed men, meaning not humans but dudes. According to him, cold, maternal blood produced inferior humans, girls, while hot, paternal semen produced boys.

Aristotle was maybe not someone we would want to elect as our philosopher-king today, but Aristotle's system of classification again seemed to confirm his classical and medieval readers' daily experiences.

His proto-biological ideas stuck around in various forms until Darwin, getting lumped under the heading of the "great chain of being", that all creatures on Earth stand somewhere on a ladder of perfection up toward God. You may have already guessed that this concept has been particularly troublesome when it comes to scientific racism, but that's a story for later.

The creepier effects of some of his ideas aside, Aristotle had an answer for everything. For the most part, these ideas were based on observation and conformed to his common sense. His answers were able to explain how the world worked, most of the time.

Not only did Aristotle come up with a complete theory of everything, he wrote it down. He was a prolific author, and a significant percentage of his texts have survived thanks to our Arabian scholars.

Then again, Plato's transcendental ideas about the cosmos, even if wrong in their particulars, inspired centuries of scholars to think about the universe as having underlying laws, ones that hold regardless of what our senses can show us.

So, are you a Platonist or an Aristotelian? Or, taking a page from Socrates, is that a trick question?

Next time, we'll follow Alexander the maybe not-so-great into India to witness the rise of the Maurya Dynasty, set the Earth spinning on its axis, and found a science of life.

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