Origins: Classical period

The first thinkers to seek natural or earthly explanations instead of divine explanations were ancient Greek scholars like Thales, Pythagoras and Democritus. But the first to really consider *how* to obtain knowledge were Plato and Aristotle, more than 2.300 years ago.

To **Plato** the external world and the objects in it are just imperfect reflections, or shadows, of *'ideal'* forms. These ideal forms are often portrayed as casting shadows on a wall.

Plato was a philosophical *realist*; he thought reality, in his case the world of forms, exists *independently* of human thought. To Plato these forms are not just abstract concepts in our mind, they really exist, but separately from the physical world.

Plato thought that since the physical world we see is an imperfect reflection of reality, we can't learn the true nature of reality through sensory experience. He insisted that knowledge about the ideal forms can only be gained through *reasoning*. Plato is therefore referred to as a *rationalist*.

Plato's student **Aristotle** was a *realist*, just like Plato. He thought that reality exists independently of human thought. But to Aristotle reality *is* the physical world. There is no separate plane of existence where abstract forms live.

Aristotle also disagreed with Plato on how we can gain knowledge about the true nature of things. Aristotle was an *empiricist*. He believed our sensory experience gives an accurate representation of reality, so we can use our senses to understand it. He believed that ultimately, knowledge comes through *observation*.

But that doesn't mean Aristotle was interested in observations only. He still saw reasoning as the best way to understand and *explain* nature; he in fact developed **formal logic**, more specifically the *syllogism*. Here's an example of a syllogism:

"All humans are mortal, all Greeks are humans, and therefore all Greeks are mortal". If the two premises are true, then the conclusion is necessarily true. By using this conclusion as a premise in a new syllogism, our knowledge builds.

Of course this only works if the premises are true. Consider this one: "All mammals are furry, all cats are mammals, therefore all cats are furry". The first premise is false, which means the conclusion is not necessarily true. Not a good basis for building knowledge!

So how can you be sure a premise is true? Well you can prove it using another syllogism, but of course you have to keep proving *those* premises, so there has to be a set of starting premises that you can accept as undisputedly true.

According to Aristotle these **fundamental premises** can be determined through *observation* of basic patterns or regularities in the world. Unfortunately he wasn't aware that some of his own observations were too selective, leading to fundamental premises that we know now are just plain wrong. For example, he thought, based on his observations, that insects have four legs, and that men have more teeth than women.

Aristotle probably came to these conclusions based on observations of the mayfly which walks on four legs, but like other insects actually has six legs; it's also likely that he examined his own teeth and those of male friends but only examined the teeth of servant-women who were more likely to be malnourished and have less teeth. He didn't realize it, but his observations were inaccurate.

Even so, Plato's and Aristotle's views remained dominant for almost 2000 years! It took until the end of the 16th century for people to realize that Plato and Aristotle's views were flawed.

How did the scientific method develop after Plato and Aristotle? Well, the ancient Greeks made many scientific advances. For example, **Ptolemy** described the movement of planets by placing the earth at the static center of the universe with the planets, including the sun, in a circular orbit, each moving in their *own* little cycle along their orbital path.

These cycles within cycles were necessary to explain the weird phenomenon of retrograde motion, where planets would sometimes move backwards. Ptolemy's model allowed for accurate predictions, but it's thought that people didn't really believe that it described the *actual* motion of the planets; it only *'saved the phenomena'*.

After the demise of the Greek city-states, during the rise and fall of the Roman Empire and the first centuries of the middle ages, very few scientific advances were made. Plato's and later Aristotle's philosophical ideas remained dominant until a new scientific revolution at the end of the 16th century, starting the age of enlightenment.

But, let's look at the developments that led up to that revolution. First, around the turn of the 10th century, Arab and Persian scholars such as **Ibn al-Hasan**, **Al Biruni** and **Ibn Sina** started using *systematic observation* and *experimentation*, emphasizing *unbiased observation* and not just logical reasoning.

Second, building on the work of their predecessors, the Englishmen **Grosseteste** and **Roger Bacon** advocated the use of both *induction* and *deduction*. Induction means using particular observations to generate general explanations. Deduction means predicting particular outcomes based on general explanations.

A third important development was the invention of the printing press. This created the perfect conditions for a scientific revolution. More scholarly works became available to a wider audience. Among these works was "*De revolutionibus orbium coelestium*" by **Copernicus**.

This was the fourth important development to lead up to the scientific revolution. In Copernicus' new model of planetary motion, the planets, including earth, moved in circles around the *sun*.

Now this didn't exactly agree with religious doctrine; the Church accepted Aristotle and Ptolemy's model with *earth* at the center of the universe. Many historians believe Copernicus was afraid to publish his work because he feared the Church would punish him for contradicting their doctrine.

He did eventually publish his new model. But he added a special dedication the pope, arguing that if *Ptolemy* was allowed to formulate a model with strange cycles that only *'saved the phenomena'*, well then he should be given the same freedom.

He was implying that *his* model was also intended, not as an accurate representation, but just as a pragmatic model. Whether he truly believed this is unclear. He died shortly after the publication, which actually did not cause an uproar until 60 years later.

Now according to many the scientific revolution and the age of enlightenment started with Copernicus. But others feel the honor should go the first man to refuse to bow to the Catholic Church and maintain that the heliocentric model actually described physical reality. This man of course, was **Galileo Galilei**.