

## Origins: Enlightenment

**Galileo** is considered the father of modern science because he set in motion the separation of science from philosophy, ethics and theology, which were all under strict control of the Catholic Church.

Others had already quietly advocated a scientific approach based on observation and experimentation, instead of using theological reasoning. But Galileo was the first to do this very explicitly.

He also opposed several of Aristotle's theories, which were accepted by the Catholic Church as doctrine. For example, he disproved the Aristotelian view that heavy objects fall to the earth more quickly than lighter objects. Galileo did this with a thought experiment, showing that besides observation, he also valued logical reasoning.

Of course he is most famous for disputing the Aristotelian and Ptolemaic view that the earth is the center of the universe. He supported Copernicus' heliocentric view, where the sun is the center of the universe. Galileo made systematic observations of the planet Venus that could only be explained if the planets revolved around the sun, instead of earth.

Now, to Copernicus the heliocentric model just '*saved the phenomena*', meaning that the model accurately predicts our observations of planets, but that it doesn't actually correspond to physical reality. In contrast, Galileo had no problem claiming that the earth really revolves around the sun.

The Catholic Church did not appreciate Galileo's disruptive ideas. They brought him before the inquisition and put him under house arrest until his death.

**René Descartes**, of the Cartesian coordinate system, was a contemporary of Galileo. Although Descartes also rejected many of Aristotle's ideas, Descartes did agree with Aristotle that knowledge should be based on first principles.

Because he felt our senses and mind can be easily deceived, he decided to discard every notion that is even the least bit susceptible to doubt.

And once he had removed everything that he doubted, he was left with only one certainty, namely that he thought and therefore he must exist. '*Cogito ergo sum*'. This eventually led him to conclude that we only know the true nature of the world through reasoning.

**Francis Bacon** thought, just like Descartes, that scientific knowledge should be based on first principles. But in contrast to Descartes, Bacon maintained that this should happen through *inductive methods*.

Induction means that observations of particular instances are used to generate general rules or explanations. Suppose every time I've encountered a swan, the swan was white. I can now induce the general rule that *all* swans are white.

Bacon believed that all knowledge, not just the first principles, should be obtained only through this inductive method, generating explanations based on sensory experiences. This is why he is considered the father of **empiricism**, where empiric means relating to experience or observation.

Now, David **Hume** took empiricism to the extreme, accepting *only* sensory data as a source of knowledge and disqualifying theoretical concepts that didn't correspond to directly observable things.

This led him to conclude that the true nature of reality consists only of the features of objects, not of the physical objects themselves. This extreme form of empiricism is called **skepticism**.

I'll give you an example. Let's take as a physical object a cat. Now what makes this cat a cat? Well its properties: its tail, whiskers, coloring, fur and body shape... If you take away all the properties that make it a cat you are left with... well, nothing. The essence of the cat is in its features.

Hume also showed us the **problem of induction**: even though you've consistently observed a phenomenon again and again, there is no guarantee your next observation will agree with the previous ones.

For a long time, from the perspective of Europeans at least, all recorded sightings of swans showed that swans are white. Only after Australia was discovered did we find out that there are also black swans.

In other words, no amount of confirmatory observation can ever conclusively show that a scientific statement about the world is true. So if you require that all knowledge must be based on observations alone, that means you can never be sure you know anything!

Partly in reaction to Hume's skepticism, at the start of the 19th century a philosophical movement known as **German idealism** gained popularity. The idealists believed that we mentally construct reality. Our experience of the world is a mental reconstruction. Scientific inquiry should therefore focus on what we can know through our own reasoning.

Now, the Idealists concerned themselves mainly with questions about immaterial things like the self, god, substance, existence, causality. They were also criticized for using obscure and overly complicated language.

On the eve of the Second Industrial Revolution around the turn of the 19th century, scientists started to lose patience with the metaphysics of the idealists. Their musings on

the nature of being had less and less relevance in a period where scientific, medical and technical advances were rapidly being made.

At the start of the 20th century a new philosophy of science, came on the scene that proposed a radical swing back to empiricism. This movement is called logical positivism.