Paradigm Shift [1]

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A paradigm shift, a phenomenon explored by Thomas Kuhn [4], is not just a small modification to an existing scientific theory. Rather, it completely changes the scientific theory itself and radically alters the way in which it seeks to understand reality.

A paradigm shift is not limited to academics alone, but its effect ripples out into the public consciousness, too. For example, Darwin's theories [5] were intensely debated by scientists and theologians. This debate spilled over into the public discourse, and newspapers became filled with cartoons and caricatures of Darwin and his extraordinary new suggestions.

A paradigm shift [6] is often the result of scientists working at the fringe [7] of that paradigm, performing research [8] that most other researchers feel is a little misguided, or a dead end. In fairness, this is an understandable stance to take. But every so often, a scientist has a revelation. The weight of scientific and public resistance to material that challenges a paradigm may mean that fringe ideas are initially ridiculed.

Kuhn believed that paradigm shifts are instigated by accumulated evidence within a paradigm – "anomalies" – that are not adequately supported by current theories. When these anomalies can no longer be ignored, the shift can be quick and total.

For example, Feigenbaum's explorations of chaos theory took a long time to take root, and his ideas were originally marginalized, because they lay outside the established classical paradigm of physics. Early chaos theorists had difficulty securing funding [9], finding supervisors, or getting journals to publish their research.

"Normal science" continues for a long time, until some experiments begin uncovering inconsistencies. A certain amount of error [10] is accepted, and it can be absorbed by slight changes in the paradigm. However, eventually the basic and fundamental principles may be shown to be inadequate and there is a paradigm shift, i.e. "revolutionary science." While normal science entails gathering more data, revolutionary science entails looking at the same data but in a completely different way.

Roman mathematician and astrologer Claudius Ptolemy's fixation on the paradigm of his time created problems. Ptolemy, in common with most Ancient Greek philosophers, believed that the earth was at the center of the universe (geocentrism), and that the sun and other planets revolved around it. Unfortunately, the empirical observations [11] did not entirely fit this view. Some planets, when their positions were measured, appeared to move backwards relative to others, a retrograde motion.

Ptolemy's response fits Kuhn's idea of a paradigm dictating the very nature of the reasoning within it, before the inevitable paradigm shift. Ptolemy explained the anomalies by saying that the planets moved in epicycles, or circles within greater circles.

The problem with *that* view came when Ptolemy, and later observers, made more accurate observations. More epicycles had to be added, making circles within circles. It was not until Copernicus that this view was directly challenged. Copernicus postulated that the sun was at the center of the solar system (heliocentrism), which was regarded as the center of the universe at that time.

This is an example of how fringe science [7] slowly builds evidence against an established paradigm. Copernicus did not completely find the answer, because his model still required epicycles, and he had no inkling that orbits were elliptical, and not the perfect circles that convention dictated.

However, his mathematics and theory was cleaner, and supported by Occam's razor [12]. With Galileo [13], and the invention of the telescope, the model fell more neatly into place, and the first fairly accurate model of the universe emerged. The paradigm shifted, and it was only the resistance of the church that prevented immediate adoption. It was onto this foundation that Newtonian physics was built.

Poor Ptolemy is often used as a metaphor for bad science and irrationality, but this is unfair, and a fallacious argument from superiority. Using the equipment he had available, with no telescopes and limited mathematics, there was little wrong with Ptolemy's theories or methods.

His measurements were supremely accurate and were used for measuring the motion of the planets until the time of Copernicus. His rigorous and meticulous approach was faultless, and he was a good empirical scientist. Copernicus, Galileo and Newton had a lot of respect for him, so the modern world must be careful not to judge Ptolemy harshly, or assume that paradigm shifts imply some sort of judgment passed on work that preceded it.

Unfortunately, this is one of the downsides of paradigm shifts, with scientists who performed good work within the confines of the previous paradigm enduring a degree of scorn. Much of the problem is if they stubbornly cling to their theories, and succumb to confirmation bias [14]. However, criticism for outdated science does force us in the modern age to closely question our own assumptions. What will be the paradigm shift that catches the leading scientists of today by surprise?

Links

[1] https://verify.explorable.com/paradigm-shift
[2] https://verify.explorable.com/users/martyn
[3] https://explorable.com/users/Lyndsay%20T%20Wilson
[4] https://explorable.com/history-of-the-scientific-method#Kuhn
[5] https://explorable.com/darwins-finches
[6] http://en.wikipedia.org/wiki/Paradigm_shift
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