Thomas Kuhn

The Structure of Scientific Revolutions

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Objectives

1. Explain Kuhn's theory of scientific change.
2. Explain the role of scientific paradigms in both periods of normal science and during revolutionary changes of theory.
3. Explain the various meanings of the term "paradigm" in *Structure*.
4. Clarify Kuhn's impact in the sociology of science.
5. Clarify Kuhn's legacy in the philosophy of science.

Reading Assignment

Kuhn, Thomas S. 1962/2012. *The Structure of Scientific Revolutions*, 4th edition. Chicago: University of Chicago Press.

Commentary

Thomas Kuhn's *Structure* was published in 1962 (see Kuhn, Thomas Samuel (1922–96) - Routledge Encyclopedia of Philosophy). In *Structure*, Kuhn provides a theory of the development of scientific knowledge, arguing that the growth of knowledge in a scientific field is punctuated by periodic paradigm changes. Each new paradigm provides scientists with a new conceptual framework for understanding the world. Further, each new paradigm is incompatible with the conceptual framework that preceded it. That is, each paradigm makes different assumptions about what the world is like. For example, the paradigm in physics developed by Descartes assumed that there was no action at a distance; everything moved was moved by something in contact with it. The paradigm that replaced Descartes' paradigm, the Newtonian paradigm, on the other hand, suggests that there is a gravitational attraction between all pieces of matter in the universe. Consequently, the Newtonian paradigm suggests that there is action at a distance. In virtue of these sorts of differences, Kuhn describes successive paradigms in a scientific field as incommensurable. (see https://www.rep.routledge.com/articles/thematic/incommensurability/v-1)

Kuhn argues that between changes of paradigm those working in a scientific field work in a normal scientific tradition, and they assume that the conceptual framework of the accepted paradigm is adequate for investigating the world. The accepted paradigm shapes how they see the world, and what aspects of the world they attend to.

Kuhn's book has two main parts. The first part is dedicate to normal science (Chapters II-VI), and the second part is dedicated to paradigm changes, or scientific revolutions, and their aftermath (Chapters VII-XIII). I will discuss the contents of the book in two parts, corresponding to these two themes. But first I will explain the notion of a paradigm, as it is one of Kuhn's principal conceptual innovations, and paradigms play a central role in both normal science and in periods of paradigm change.

Paradigms

Kuhn uses the term "paradigm" in multiple ways in his book and he does not always make clear which meaning of the term he is using. In fact, he was criticized for this shortly after the book was published (see Masterman 1970). It is worth distinguishing three principal ways in which the term "paradigm" is used in *Structure*.

First, a paradigm is a solution to a specific scientific problem that is then adapted as a template for solving other related scientific problems. For example, Johannes Kepler developed a mathematical model for the orbit of the planet Mars. He suggested that the planet has an elliptical orbit with the Sun occupying one of the two foci of the ellipse, and that the planet sweeps out an equal area of the ellipse in equal time. This model was subsequently used to model the orbits of other planets, as well as the orbits of the Moon, moons of other planets, and comets. But in solving these related problems various parameters had to be modified. Thus, modeling the orbit of each individual planet, moon, and comet required some ingenuity. Kuhn believes that much of scientific problem solving works in this way. Scientists appeal to an already solved problem and use it as a template to solve related problems. In using the term "paradigm" in this way, to refer to a paradigmatic example, Kuhn was reacting against a view of scientific problem solving that suggests that it is a more straightforward, almost mechanical, process. Instead, Kuhn claims that scientific problem solving involves reasoning by analogy, recognizing that one thing is like another in some respects. Kuhn came to refer to paradigms in this sense as exemplars. When young scientists-in-training do the exercises in their textbooks they are learning to work with paradigms.

Second, Kuhn often uses the term "paradigm" when he is talking about scientific theories; that is, a paradigm is a theory (see Theories, scientific - Routledge Encyclopedia of Philosophy). Thus, he refers to Lavoisier's paradigm in chemistry, Copernicus' paradigm in astronomy, and Newton's paradigm in physics. And a change of theory, the replacement of a long-accepted theory by a new theory, is described by Kuhn as a paradigm change. For example, the Ptolemaic paradigm in astronomy was replaced by the Copernican paradigm in the 17th Century, about 70 years after Copernicus published his book presenting his new theory of the cosmos, according to which the Earth orbits the Sun rather than the Sun orbiting the Earth, as Ptolemy had said.

Later in his career, Kuhn would characterize scientific revolutions in a different manner, suggesting that they involve changes to the scientific lexicon or vocabulary, changes that require us to rethink how various kind terms (terms that pick out kinds of things) are related to each other. Thus, for example, the kind term "planet" acquires a new meaning when one moves from the Ptolemaic theory to the Copernican theory. In Ptolemy's theory, a planet was a wandering star, a "star" that does not moved with the fixed stars. In contrast, in the Copernican theory, a planet is a satellite of the Sun. And, whereas the Earth is a planet according to Copernicus' theory, it is not regarded as a planet in Ptolemy's theory.

Third, Kuhn sometimes uses the term "paradigm" to describe a complex network of theory, values, and goals that guide a scientist in their daily work. This is the broadest notion of paradigm. Kuhn would later use the term "disciplinary matrix" to describe this complex.

When reading *Structure* it is helpful to try to keep these three notions of paradigm in mind.

Normal Science

Kuhn's book is a book about the development of knowledge in the natural sciences, that is, physics, astronomy, chemistry, biology, and geology. He believes that these fields develop in a patterned manner, a pattern that you do not see in the social sciences, like sociology and anthropology, or the humanities, such as philosophy and history. Interestingly, scholars in many fields outside of the natural sciences have found Kuhn's book insightful, and have reflected on the relevance of his analysis to their own fields. Thus, sociologists have asked whether there are paradigms in sociology, and whether the growth of knowledge in sociology is marked by periodic revolutionary changes of theory.

Before the developmental pattern that characterizes the natural sciences can be manifest, a group of scientists must first settle on a paradigm. This first paradigm unites the various scientists working on the same topics, providing them with a shared conceptual framework or theory. It is only once those working in a scientific field have accepted the same conceptual framework or theory that they can begin to work effectively. For only then can they set aside the differences that divide them and begin working on solving problems that the paradigm is especially well-suited to solve. As long as scientists are engaged in debates about the fundamentals in their field, they cannot embark upon normal scientific research. In another book Kuhn states that the field of astronomy settled on its first paradigm during the Hellenistic period in ancient Greece; the studies of magnetism, electricity and heat developed their first paradigms later, in the early modern period (see Kuhn 1976/1977, 46).

In this normal scientific phase, scientists assume the paradigm describes the world accurately, and is suited to solving the problems they seek to solve. And they generally work on the sorts of problems that they think the paradigm can aid them in solving. As a consequence, scientific knowledge tends to advance very rapidly in periods of normal science. Kuhn compared the work of normal scientists to puzzle-solving. It requires ingenuity but it is a highly constrained activity.

But scientists working in a normal scientific tradition inevitably begin to run into difficulties, or as Kuhn calls them anomalies. An anomaly is some sort of phenomenon that is contrary to what the paradigm suggests. Kuhn claims that when scientists initially encounter anomalies they often are able to just set them aside. But sometimes an anomaly will become quite pressing and attract the attention of many scientists working in a field. In their efforts to solve the anomaly or anomalies, the consensus about the accepted theory begins to breakdown. At this point, a scientific research community is open to the possibility of a scientific revolution.

Scientific Revolutions

When the consensus around the accepted theory breaks down, in their efforts to resolve anomalies, scientists begin to try things they would not have tried in a normal scientific phase. For example, Kuhn suggests that scientists will begin to interpret the theory in different, competing, and somewhat incompatible, ways. Alternatively, they may engage in philosophical reflections, or construct thought experiments, as Einstein famously did in the early 20th Century and Galileo did in the early 17th Century. And some scientists will even develop new alternative theories. The scientific community now begins to fragment, as they try various means to make sense of the anomalies that have led the field into a crisis state.

A scientific revolution occurs when the scientific community as a whole comes to accept a new competitor theory. They do so, usually, because the new theory can resolve a problem or set of problems that the older theory could not resolve. Kuhn suggests that this process involves much upheaval in a field, as those working in the field need to learn a new theoretical framework. In fact, scientists even need to rewrite the textbooks in such a manner that reflects the world view embodied by the new theory.

Kuhn suggests that at first there is often great resistance to a new theory. Scientists trained to see the world through the lens of the older theory are aware of the many past problems that the older theory confronted but was ultimately able to resolve satisfactorily. Consequently, many scientists are quite reluctant to abandon the old theory. In this respect, scientists are often quite conservative.

Kuhn describes the various fields in the natural sciences as in a perpetual developmental cycle, moving from (i) a period of normal science, (ii) interrupted by anomalies that give rise to (iii) a crisis state that is ultimately resolved by (iv) a change of paradigm or theory. He does not see an end to this cycle. But he also believes that it does not pose a threat to progress in science. Scientific knowledge grows as scientists work though the cycle of change, even if the growth is marked by periods of significant reconstruction.

Philosophical Significance

The key philosophical significance of Kuhn's view of the development of science is that it suggests that we will never settle on a final theory in a scientific field. Every theory will ultimately prove inadequate, as it is developed and extended in the normal research practices.

Some regard this as a pessimistic view of science, and suggest that there is no room for scientific progress in such a picture of science. Kuhn thought otherwise. He believed that scientists were developing a richer and more detailed understanding of the natural world, even as their theories are replaced by newer alternative theories that provide a radically different picture of the world.

So contrary to what many of his critics suggest, Kuhn did not doubt that scientists were successful in meeting their research goals and in advancing our knowledge of the world. But he did not think that his account of the growth of scientific knowledge supported the view that our theories are getting ever closer to the truth.

In fact, part of what motivated Kuhn to develop his theory of scientific change was the realization that scientific knowledge does not grow cumulatively, with no setbacks, as he had been taught in his science courses. Kuhn claims that he came to doubt what he was taught when he began to study the history of science. Instead of thinking of Aristotle as trying to develop a physical theory like Newton's, and failing or falling short, he came to see that Aristotle was involved in a very different sort of project. But Kuhn only learned to appreciate what Aristotle was doing when he tried to understand what the world must have looked like for Aristotle and his peers, working with Aristotle's theory.

The Aristotelian and Newtonian world views, he suggests, are fundamentally different. And if we are raised and trained to see the world one way, it can be challenging to see it another way. Kuhn compares the change in perspective to the change that occurs when one sees the ambiguous gestalt figure that is both a duck and a rabbit. One cannot see the figure as both a duck and rabbit at the same time. But, just as one who only initially sees the duck figure can be taught to see the rabbit figure, so can scientists be taught to see the world through the lens of a different theory.

The Legacy of *Structure*

Kuhn's book has had a profound influence on our understanding of science. In fact, many scholars in fields outside the natural sciences have examined the extent to which their own field, be it sociology or political science, follows the same developmental pattern that Kuhn describes in the *Structure*.

Further, Kuhn had a profound influence on the sociology of science. (see Sociology of knowledge - Routledge Encyclopedia of Philosophy) After the publication of Kuhn's book many sociologists of science began studying the normal research practices of science. These studies include both historical case studies and ethnographic studies of scientific laboratories. To many sociologists, it seemed that the practices of normal science are as problematic as the practices of science during periods of revolution, as Kuhn describes them (see Barnes, Bloor and Henry 1996). More recently, philosophers of science have turned their attention to everyday scientific practices, including scientific experimentation. (see Experiment - Routledge Encyclopedia of Philosophy) Though these studies move beyond Kuhn's concerns they clearly owe a debt to *Structure* (see Chang 2012; and Andersen 2016).

Philosophy of science has been affected in another way by Kuhn's book. In suggesting that the growth of scientific knowledge is punctuated by revolutionary changes of theory that make radically different assumptions about the world, Kuhn gave philosophers the problem of theory change (see Wray 2021, Chapters 2 and 10). Philosophers, it seems, must account for the fact that changes of theory are an integral part of the development of science. This is challenging to reconcile with many forms of scientific realism. (see Scientific realism and antirealism - Routledge Encyclopedia of Philosophy)

Questions for Self-Review

1. What are the three different senses of paradigm that Kuhn employs in his book?
2. Do you think that scientists solve research problems as Kuhn describes, using past scientific achievements as exemplars for solving other related problems? Can you think of examples where scientists seem to work this way?
3. What roles do paradigms play in normal science?
4. Do you think that Kuhn's theory of scientific change, that is, the cycle through normal science, to anomalies, crisis, and a revolutionary change of theory, describes the development of fields outside the natural sciences?
5. If Kuhn is correct, and the development of a scientific field involves periodic changes of paradigm, do you think we can really say science is progressing?

Works Cited & Supplemental Reading

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