(2018) "Paradigm Shift: A 'Strange' Case of a Scientific Revolution." In: W. Irwin and M. White (eds), *Dr. Strange and Philosophy: The Other Book of Forbidden Knowledge. The Blackwell Series in Popular Culture and Philosophy.* (Hoboken: Wiley), 139-150.

A Strange Case of a Paradigm Shift

Brendan Shea, PhD (Brendan.Shea@rctc.edu)

In the 2016 film *Doctor Strange,* the title character undergoes a radical transition from successful neurosurgeon to highly skilled sorcerer. Unsurprisingly, he finds this transition difficult, in no small part because he thinks that sorcery seems somehow "unscientific." Nevertheless, he eventually comes to adopt sorcery as wholeheartedly as he had embraced medicine. Some of his reasons for making this transition are personal, such as his desire to fix his injured hands and, later, to help others. Strange also displays the same sorts of motivations that might drive any scientist: his intellectual curiosity drives him to understand how the Ancient One cured a paraplegic, and his desire to make a positive difference leads him to push the boundaries of sorcery.

This chapter will examine what Strange's transition can teach us about the nature of scientific inquiry. More specifically, we'll think about when it might make sense for scientists like Dr. Strange to *change* their approach. This will also allow us to explore what it means to practice science more generally. Some of what we learn might be surprising. For example, while it might seem *obvious* to us (and maybe even to Strange) that sorcery can't count as a science, there are reasons for doubting this quick conclusion, at least in the sort of world that Dr. Strange lives in. Finally, we'll consider what all of this means for science in *our* world, where things differ quite significantly.

1 BACK WHEN STRANGE WAS NORMAL

Our investigation starts with the ideas of the scientist, historian, and philosopher Thomas Kuhn (1922-1996). In his 1962 book *The Structure of Scientific Revolutions*, Kuhn argued against the widely held view that scientific progress was the result of the application of a universal "scientific method" that assured regular, incremental progress towards the truth.[1] Instead, Kuhn thought that "scientific revolutions" often looked quite a bit like Strange's experience, where scientists refused to change their fundamental ideas about how the world works, or their *paradigms*, until a series of crises forced them to. If and when they finally did change paradigms, they had to undergo their own version of Strange's conversion experience, which required them to relearn exactly what the "world" is.

While Kuhn's examples are chosen from this history of physics, astronomy, and chemistry, his ideas have much broader import. After all, if rival scientific paradigms really are as different as, say, neurosurgery and sorcery, it might seem that the objectivity of science itself is threatened. It's for this reason that the story of Doctor Strange—who has the ability to understand multiple paradigms—is potentially so interesting, even to readers in a world without sorcery.

Kuhn, like Strange, received his initial training in a discipline very different from that which would eventually make him famous. Kuhn earned a doctorate in physics from Harvard University but, in the early years of career, came to feel that many of his best, most original ideas were actually about the history of science. In particular, he thought that many people had wildly inaccurate views of how science had actually worked in the past, which led them to be confused about how it worked in the present.

According to one popular view of science at the time, the *falsificationism* advocated by philosopher of science Karl Popper (1902-1994), scientific theories (as opposed to, say, political theories) were defined by the fact

that certain sorts of observations could show them to be wrong, and scientists were the sort of people who were willing to change their minds on the basis of such evidence.[2] So, for example, Popper would be quite happy with the early picture of Doctor Strange as the heroic, risk-taking neurosurgeon, who was always willing to oppose the received wisdom in an effort to save patients. Most importantly, Popper would note that scientists like Strange are characterized by taking failure seriously and making changes to their theories and methods in response. If a patient dies, Strange would undoubtedly try something different the next time around.

Though Popper's falsificationism remains highly influential, Kuhn argues that it doesn't accurately capture the way "normal science" actually works. By this, Kuhn simply means the ordinary day-to-day activities of the physicists or biologists who are *not* the Newtons, Einsteins, or Darwins of the world. First, Kuhn notes that innovators like Strange are actually pretty rare. The vast majority of practicing scientists spend their lives working on a small, well-defined set of problems—or "puzzles," as Kuhn calls them—that could be answered using the theories and methods they learned through years of rigorous schooling, and which their communities had picked out as worth solving. They rarely propose entirely novel techniques or methods, and certainly don't consider something as outlandish as sorcery, even if they encounter severe problems. Second, absent special circumstances (more on this later), they almost never reject their most fundamental methods, theories, or values, even in the face of numerous, seemingly unsolvable problems (such as the many diseases and conditions that modern medical science hasn't been able to treat or cure). However, in the vast majority of cases, these failures have not caused biological researchers to abandon the basic ways in which they approach problems.

2 FROM SCIENCE TO SORCERY: HOW SCIENTIFIC REVOLUTIONS HAPPENS

If Kuhn is right, then Doctor Strange's initial suspicion of sorcery is just what we should expect from a practicing scientist. After all, in normal circumstances, science is all about solving certain sorts of puzzles—identifying new pathogens, developing surgical techniques, designing new drugs, and so on—using all of the skills and knowledge acquired after years of formal education and professional practice. To abandon all of this in favor of some strange new idea, such as manipulating dimensional energy to fight mystical enemies, is almost to abandon science altogether. In fact, Kuhn argues that "mature" sciences like biology and physics weren't even possible until researchers agreed on a shared paradigm that made it possible for them to focus their time and energy on identifying and solving ever more specific sorts of puzzles, as opposed to having to continually make public arguments about which fundamental theories, methods, or values should be adopted.

At certain points in history, however, scientists have changed their paradigms, such as when they adopted the Copernican, sun-centered model of the solar system over the older Ptolemaic, Earth-centered model. In Strange's particular case, this same sort of shift occurs when he abandons his career as a surgeon for one as an aspiring sorcerer. Kuhn spends a great deal of time in *The Structure of Scientific Revolutions* thinking about why and how scientists make such revolutionary changes. He suggests that this process, at least at the level of the individual scientist, is both more mysterious and less prototypically rational, than scientists, historians, and philosophers have often thought.

Kuhn argues that scientific revolutions have their roots in the sorts of "puzzle solving" activity that Doctor Strange engages in as a scientist, which by its nature involves making ever more precise measurements and predictions. Over time, however, these sorts of measurements will reveal anomalies, or areas where the existing paradigm's predictions fail, no matter how many tweaks are made. So, for example, while the Earth-centered paradigm in ancient astronomy did surprisingly well for over thousands of years, astronomers

eventually found themselves needing to make more and more adjustments, such as positing that the planets moved in ever-more-complex epicycles in their orbits of the earth, just to keep their paradigm in agreement with their increasingly precise observations of the sky.

In the face of such anomalies, scientists are forced to entertain ever more radical ideas, until they reach the very limits of what their current paradigms allow. In Strange's case, this process takes place with extraordinary rapidity, as his quest to heal his injuries leads him first to the frontiers of medicine, then to the miraculously healed Jonathan Pangborn, and finally to the Ancient One and everything she shows him. Until the very end of this process, however, Strange never gives up on the core commitments of his paradigm: that the treatment for his condition will be explicable in terms of human physiology and the biological and physical theories on which this is based.

On Kuhn's view, Strange's reluctance to jump ship is entirely understandable. In fact, Kuhn argues that the mere existence of anomalies—even glaring, important ones—doesn't cause scientists to abandon a paradigm in which they've been trained. Instead, they will abandon such a paradigm only if they are presented with a new paradigm that they can adopt in the old one's place (and they won't always do so then!). Along with offering a solution to the troubling anomalies, this new paradigm needs to make novel predictions and to offer an attractive, elegant picture that leaves plenty of room for future work, in the form of unsolved puzzles. It is only when the Ancient One presents Strange with such an option that he is finally willing to leave his old life behind.

3 THE DARK DIMENSION? WHY UNDERSTANDING IS TOUGHER THAN IT SEEMS

Much of what we've said so far would fit pretty well with how many scientists, historians, and philosophers have often described the scientific method. Doctor Strange encounters a problem that he can't solve, formulates and tests a number of hypotheses aimed at producing a solution, and finally, finds one that works. Sure, sorcery is a bit different than the sort of scientific theories which work in our world, but that doesn't make Strange's approach any less scientific. For Kuhn, however, this misses the most interesting aspect of the story, which involves the transition between paradigms. When we look back at the history of science (or when the Sorcerer Supreme Strange looks back on his life), we might be tempted to think that the paradigm chosen in the moment of crisis was *obviously* closer to the truth than the old one was, and therefore we've made undeniable forward progress. Kuhn, however, argues that the history of science reveals a much messier process. In many cases, there simply are no clear, "objective" criteria that might allow adherents of one paradigm to rationally persuade adherents of another paradigm to convert and join their cause.

In particular, Kuhn argues that paradigm change is far from the sort of slow, incremental process that one might expect if scientists were simply incorporating new evidence piece-by-piece into their existing paradigms. Instead, new paradigms emerge quite suddenly, and the initial evidence in their favor is often relatively minimal, especially when compared to the historical successes of the old paradigm. The first scientists to adopt a new paradigm do so because they believe that working in the new paradigm will allow them to move forward. However, to adherents of the old paradigm, this often appears as little more than blind faith, especially since the new paradigm almost always involves ideas and methods that are alien to the point of incomprehensibility. (Just think of how Strange's medical school teachers might react if he told them he'd become a sorcerer!) In Kuhn's terms, rival paradigms are *incommensurable*: there is simply no general method for translating the concepts taken from one paradigm into those of another. In a very real sense, scientists who adopt different paradigms literally experience different worlds, which contain very different sorts of things.

Kuhn's claim that paradigms are incommensurable is the most controversial and influential part of his book, but it's also a claim that is easily misunderstood. With this in mind, it will help to look more closely at Strange's experience. When Strange first encounters the evidence of sorcery, such as Pangborn's cured paraplegia and his own initial experiences with the Ancient One—he reacts with disbelief. He eventually changes his mind, though, when first, he becomes convinced that sorcery really is the best explanation for the anomalies he's observed, and second, he thinks that sorcery will allow him to solve the sorts of problems that interest him (such as his injuries). However, he doesn't commit to becoming a sorcerer until he finally realizes that he can genuinely make a contribution to the field, and help to solve problems that even Mordo and the Ancient One struggle with.

It is at this stage that Strange first encounters the problem of incommensurability. He wants to become a sorcerer, and can perhaps even explain some of the general ideas, such as the existence of other dimensions, that sorcery is based on. However, as it turns out, adopting a scientific paradigm requires more than memorizing lists of formulas. To truly understand things like the nature of dimensional energy, Strange has to master the methods for manipulating this energy, which requires long, tedious practice with simple spells. As it turns out, novice sorcerers—much like novice physicists—can't really understand their theories just by reading explanations of them in textbooks, or listening to wise old physicists or sorcerers talk about them. Instead, they have to learn how these theories are actually applied to standard sorts of problems, which Kuhn calls *exemplars*. The knowledge that Strange gains from this is much more of a "knowledge *how*" rather than a "knowledge *that*"—it is something he learns to do rather than some theory he has memorized.

Kuhn argues that scientists adopting a new paradigm learn to "see" the world in a new way through this process. So, by the conclusion of his training in sorcery, it's not simply that Strange has picked up a few new tricks, and memorized some complex chants and arm gestures. Instead, he finds himself in something like a different world, filled with very different sorts of things than his old world. He is in a world which demands that he respond in very different ways. Moreover, this is something that he will likely find difficult to explain to colleagues. And if Kuhn is correct, Strange shouldn't be too surprised if it proves difficult to convince his old colleagues of the correctness of his new ideas, even if he manages to get the idea across. After all, the sorcery skeptics might argue that contemporary medicine has solved lots of problems, and it would be foolish to let a few anomalies centered around one strange doctor cause them to give it up.

Somewhat surprisingly, Kuhn would also argue that a figure like Strange would be especially well-positioned to make paradigm-shifting advances in his new field of sorcery. Kuhn notes that, historically, most scientific revolutions were driven neither by the oldest, most experienced practitioners in a field, nor amateurs with little or no training. Instead, they were driven largely by people like Strange: newcomers to the field who have received enough training to understand how the paradigm works but who haven't yet become set in their ways. Like Strange, such innovators often come from other scientific disciplines and are often seeking the solutions to problems that the "normal" practitioners of the field had left unexplored.

4 PUZZLES ABOUT PARADIGMS

Kuhn, like Popper before him, fundamentally changed the way that many scholars looked at science. Where they once had seen a slow, orderly march toward ever-greater understanding, it now appeared as if scientific revolutions had more in common with political revolutions, or even with religious conversions, than with the dispassionate application of the "scientific method" taught in schools. While such methods have their place to play in normal science, revolutionary science is much closer to Doctor Strange's initial, baffling encounter with the Ancient One. Adopting a new paradigm requires scientists to radically rethink not just their theories and methods, but also their overarching view of what the world is fundamentally like and what their role in this world is.

What does this mean for science in the real world? Should we conclude that the paradigm of sorcery is just as trustworthy as that of medicine, and that they have equal claims to be counted "scientific," for good or ill? Kuhn's writing is a bit ambiguous on these sorts of questions. When *The Structure of Scientific Revolutions* first came out, many readers took it to be arguing that the revolutionary decision of a scientific community to abandon one paradigm for another was a fundamentally irrational process, driven by very different factors than those relevant to explaining normal science. On this view, the incommensurability between various paradigms prevented any and all comparisons between them that might allow for rational choice. For example, when working as a neurosurgeon, Doctor Strange is perfectly capable of identifying the best surgical techniques to use, and can even explain and defend his choice to interns and colleagues. When he is working as a sorcerer, he can do the same thing when it comes to spells. What he can't do, however, is present a rationally compelling argument to a neurosurgeon that they ought to become a sorcerer, or vice versa.

In later editions of his book, however, Kuhn put a greater emphasis on the existence of more general scientific norms that could be used to judge between paradigms, and on the possibility of "translating" between competing paradigms. In the end, Kuhn thought the scientists themselves were the ones best placed to see how and when it made sense to change paradigms, even if their reasons for doing so couldn't always be made explicit to outsiders. Kuhn even notes the importance of people like Strange—masters of multiple paradigms—in this process, since they can help scientists in rival paradigms understand what exactly their rivals are up to, and what it might mean to adopt their paradigm as one's own. While these translations would always be partial and incomplete—after all, no one but another sorcerer could fully understand Strange's explanation of sorcery—they provide a good starting point, at least to those who come with open minds.

Like most philosophers and historians of science, Kuhn himself offered little advice on how contemporary scientists ought to do their work. However, he did worry that people were too quick to see "paradigms" wherever they looked, and that this caused them to overlook the ways in which mature sciences like physics and chemistry really were different from other human activities. For Kuhn, mastering a paradigm required much more than simply agreeing on a general outlook on life. Instead, a scientific paradigm required a detailed agreements on both what sorts of problems mattered and on the precise manner in which they could be solved. It is only because scientists have these agreements that they can get down to the business of puzzle solving, which makes up their normal work life. Mature science, for Kuhn, was genuinely and fundamentally different from almost everything else humans did.

5 AFTER KUHN, THINGS GOT STRANGER

The Structure of Scientific Revolutions was among the most important and influential books on philosophy of science ever published, and it led to major changes in the way many people—philosophers, sociologists, historians, and even scientists themselves—saw science. However, rather than ending the debate about the nature of science, Kuhn's book started a number of new debates. To close, we'll take a brief look at two philosophers of science who followed Kuhn, and we'll consider what they might have to add to our account of Doctor Strange's transition from surgeon to sorcerer.

Some post-Kuhnian philosophers, such as Paul Feyerabend (1924-1994), embraced and expanded upon the idea there were no rational, objective criteria by which one might judge competing scientific theories as better or worse, or even for distinguishing "scientific" theories from religious or mystical ones. Feyerabend's *methodological anarchism* held that, when it came to science, the only rule was "anything goes." After all, he reasoned, once we try to set down rules for excluding certain theories from consideration, we will find that we have ruled out obviously legitimate scientific theories.[3]

For example, consider how sorcery must have originally appeared to Doctor Strange. It contradicted basic physics; it was based on "primitive" ideas that most people had given up long ago; and sorcerers didn't behave at all like contemporary scientists. They didn't publish their findings, present them at conferences, run randomized controlled trials, and so on. This might seem like more than enough reason to reject sorcery. However, Feyerabend argues that, if we look closely at the history of science, we'll discover that many scientific theories (such as the sun-centered solar system) started off in much the same way. Because of this, we ought to be very wary of claiming that certain theories just "can't" work, or that we can simply ignore them as possibilities.

If Feyerabend is right, then real-life neurosurgeons and researchers might benefit from some Strange-like openness to ideas from outside of mainstream science. In particular, Feyerabend argues that if science is to continue to progress, scientists must continually be open to the possibility that some very different ideas might be the source of the next medical or scientific advance, no matter how bizarre they might seem now. Moreover, the mere fact that these ideas seem superstitious or mystical is not itself a good enough reason to reject them. Even if the vast majority of these theories are flawed in one way or another, the attempt to grapple with them will help us better understand why and how the theories we do adopt actually work. Feyerabend's ideas have remained quite controversial among both philosophers and scientists. After all, it's one thing to claim that sorcery could be a science in an alternate world like the one Doctor Strange lives in. It's quite another to claim that scientists in the actual world should have to consider sorcery as a serious rival for government funding, or as a possible subject to be included in high school science classes.

In contrast to Kuhn's emphasis on the agreement of the scientific community and Feyerabend's call for methodological anarchism, Imre Lakatos (1922-1974) argued that there were clear, objective criteria for distinguishing between *progressive* and *degenerating* scientific research programs. Interestingly, Lakatos argued that the distinction had to do with how the scientists dealt with failure. Like Kuhn, Lakatos argued that scientists almost never abandon the "hard core" of ideas that made up the heart of their approach to the world. So, the Ancient One doesn't abandon sorcery after one failed spell, and Doctor Christine Palmer doesn't abandon medicine after the death of a patient. Instead, scientists make modifications to the *protective belt* of ideas around their hard core: the Ancient One might try a new pronunciation for a word and Palmer can modify the dose of a drug. Lakatos held that research programs were progressive when these modifications to the protective belt led to new predictions and discoveries. By contrast, a program is degenerating when the modifications to the protective belt are merely defensive maneuvers intended to prevent falsification. That is, in a progressive program, the changes made by the Ancient One and Palmer really should lead to better results, as opposed to simply serving as "excuses" for their failures.

Lakatos emphasized that there was no foolproof way in which philosophers or scientists could determine whether a particular, contemporary scientific research program would make progress in the future. After all, the history of science is full of examples of promising programs that ran into unforeseen problems, as well as of old, abandoned theories finding "new life" in the light of experimental results. Lakatos might not have much advice to give to Doctor Strange, other than to remind him of the importance of keeping a careful, honest record of his successes and failures, both with respect to medicine and to sorcery. However, Lakatos would insist that, when it came for philosophers and historians to tell the story of how Strange came to abandon medicine for sorcery, they should be able to explain why his choice was a rational one, based on objective criteria. Lakatos thought that both Kuhn and Feyerabend, by playing up the sociological and nonrational aspects of the history of science, failed to do just this.

6 OF SCIENCE, SORCERY, AND PHILOSOPHY

For Thomas Kuhn and his rivals, the story of a figure like Doctor Strange might have most value when we focus on the contrast between our world and his. Strange provides us with a clear picture of what it would it take for a seemingly outlandish idea like sorcery to become a scientific paradigm. Importantly, Kuhn argues that this would require much, much more than the mere inability of contemporary medical science to solve some problem or other. Instead, we would need to discover, as Strange does, both the existence of significant anomalies within current science and the sorcerous solutions to such anomalies. We would need not only to present a theoretical justification for thinking that spells might work, but develop a rigorous education program for young sorcerers on the precise techniques for various spells. Finally, and most importantly, we would need assurance that the paradigm could be extended to new problems through the use of methodical, puzzle-solving techniques, and that we, like Dr. Strange, could eventually find our ways to new dimensions.

More broadly, one might wonder: Why bother with the philosophy of science at all? After all, many scientists seem to get along quite well without considering such matters, and their work doesn't appear to suffer. However, this sort of quick dismissal misses some important benefits. First, as Kuhn emphasizes, the mere fact that scientists *usually* don't need to worry about philosophical issues hardly means that they never do. After all, when scientists like Doctor Strange find themselves in the midst of a scientific revolution, they have no choice but to consider the big, philosophical questions about reality, knowledge, and the relationship between the two. Second, even for those of us who don't aspire to be scientific revolutionaries, philosophy of science can help demystify the "scientific" approach to the world, even when it comes to theories as magical as those adopted by Doctor Strange.

---

[1] Thomas S. Kuhn, *The Structure of Scientific Revolutions: 50th Anniversary Edition*, ed. Ian Hacking (Chicago: University Of Chicago Press, 2012).

[2] For a short, very readable introduction to the ideas of Popper, Kuhn, and the other philosophers of science we'll be discussing, see Alan F. Chalmers, *What Is This Thing Called Science?*, 4th ed. (Indianapolis: Hackett Publishing, 2013).

[3] Paul Feyerabend, *Against Method* (London: New Left Books, 1975).