Apologetics and the Historical Deficit

Demarcation and the Philosophy of Science

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Introduction

Traditionally, the philosophy of science has been concerned with grounding scientific theories and determining their epistemic status. This is an issue because these theories make universal claims about the behavior of nature on a scale that exceeds possible observation. Philosophers have approached this question by establishing criteria that credible scientific theories are required to meet in order to be considered legitimate or by describing the logical ground of current scientific claims, in either case demarcating the boundaries of scientifically respectable discourse.

Yet this approach looks at ideas in abstract. If we begin with an historical approach instead of immediately abstracting to the problem of justifying scientific knowledge in general, we encounter the following dilemma: the historical grounds that determine a scientific theory and lead to its becoming generally accepted by scientists are not verification or demonstration. Instead, theories have typically won over their adherents before definitively proving themselves and would not have achieved their current level of development otherwise.

This conflicts with how science is traditionally viewed. For instance it is often claimed that scientific theories are justified <u>inductively</u>. If I say "all swans are white," I am making an assertion that is based on my observations of several cases and then generalizing it to every case. So one might say upon the discovery of a black swan: "We <u>used to believe</u> all swans to be white, but <u>now</u>

we know swans are in fact sometimes black." Science progresses by learning more of these kinds of facts about the world, thus continually "pulling the wool off our eyes." In doing science scientists make their "best guess" about the world and then try to confirm it through observation. If there are two competing theories they resolve the dispute by inference to the explanation that can explain the most facts with the least number of assumptions. Accordingly, scientific laws represent inductive claims about the relationships between classes of particulars, verified by a large number of repeated individual observations before becoming generalized into a theory.

This attitude might be the source of the kind of anachronistic prejudice which science textbooks often encourage, that treats ancient scientists as if they were shackled in a hocus pocus of hearsay and dogmatic doctrine and require modern rationality and pure scientific method to liberate them. This way of thinking prevents us from seeing how outdated systems used to work historically. We are blinded by what Kuhn calls *incommensurability*. For instance, we might scoff at Aristotle's idea that the heavens contained an element called "aether," thinking that he just made it up, but that is because we would not be aware of aether's logical place within his system and are unable to translate it into the vocabulary of our own.[1] Thus the concept of aether is incommensurable with the concepts found within the structure of our own worldview and therefore appears to us as an absurd fiction or mythology.

Next to this traditional view is *positivism*, a term that is used in a number of different ways within science but usually refers to Vienna school of *logical positivists* who believed that meaningful statements must conform to the *principle of verifiability* which requires that meaningful statements be reports of possible observations: if the observation is possible, then the statement has meaning; if it does not correspond to any possible observation, it is meaningless.

[1] See Kuhn, *Structures of Scientific Revolutions*, 148-51.

It is then the job of observation to determine whether or not these statements are true or false. Although the positivists do not seem to have a unified point of view on the epistemic status of a theory and many of them changed their point of view later in their lives, a recurring view borrowed from Wittgenstein was that scientific theories are a kind of “overlay,” like a coordinate system applied to a map, the components of which point to discrete observable variables.[2]

Karl Popper's *falsifiability criterion* opposes the positivists' view, arguing instead that if a theory is internally consistent, makes empirical rather than tautological claims and provides science with an opportunity for advancement, it is only necessary that it be falsifiable by empirical observation, that is, by observations that contradict its premises.[3] Falsifiability solves the problem of induction by making deduction the logical grounds of scientific inquiry. According to Popper, scientific theories are, by definition, claims from which individual observations may be deduced.[4] He holds that all statements in science should be in principle testable (but not that they must be tested before they are accepted) which means that as long as the theory is dynamic, it could be falsified and revised at any time.[5] Popper believed that when a scientific theory encounters a problem that it cannot solve, instead of working the theory around the problem, the theory should be rebuilt from the ground up.[6]

Currently many scientists, intellectuals and the general public believe – if I am not mistaken – that scientific claims either are in practice justified by induction or falsifiability, or at least should be. However, the historical record

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[2] See A.J. Ayer, *Language, Truth, and Logic* (New York: Dover Publications, 1952); cf. Ludwig Wittgenstein, *Tractatus Logico-Philosophicus,* trans. C.K. Ogden (New York: Barnes & Noble, Inc., 2003), 139-149.
[3] Popper, *Logic of Scientific Discovery*, 9-10.
[4] *Ibid.,* 25.
[5] *Ibid.,* 20; 26; 33-34.
[6] *Ibid.,* 59-66. It should be remarked that Popper later rejected falsifiability, as did the logical positivists verifiability.

does not show that this has been the case, nor does it suggest that it should be the case except in a highly qualified manner.

In *Structures of Scientific Revolutions* Thomas S. Kuhn looked at particular examples from the history of science and drew general structuralist claims about the way scientific fields move in general. In the following essay we shall not be so bold. Instead of structural generalizations about how science operates, we will look at select examples from the history of science starting with the transition, or "paradigm shift," from the geocentric Ptolemaic-Aristotelian perspective to the heliocentric Copernican-Newtonian theory, described by Kuhn in his earlier work on the history of the subject, *The Copernican Revolution*.

The Copernican Revolution

The Ptolemaic theory states that the earth is a tiny sphere that stands still in the exact center of a much larger sphere. The much larger sphere rotates with the stars as fixed points of light on the interior of this rotating sphere. The Sun moves between the earth and the sphere of stars. The majority of philosophers and astronomers believed this from the 4th century on, as well as throughout the middle ages up until the early modern era.[7] This model was incredibly accurate. Kuhn points out that in his day (the 1960's) navigators were still taught to treat the earth as if it were a stationary sphere surrounded by a rotating sphere of stars as it is the basis for navigation by longitude and latitude. The theory remained practical until the invention of GPS in the mid 1990's.[8] On the basis of this theory Aristotle developed a theory of physics that provided a mechanical explanation of the motion of these two spheres.

The problem of the planets, that is, that the planets move at a different rate than the stars and occasionally make a retrograde motion, was not a

[7] Kuhn, *Copernican Revolution*, 27.
[8] *Ibid.,* 38.

falsification of the Ptolemaic description of the universe because the existence of the planets was accounted for within the model by epicycles (that is, the planets orbit around a fixed point and the fixed point orbits around the earth). The problem was that Ptolemy's system never quite reached the degree of accuracy needed although astronomers had full faith that the system could be made to work. It became one of the major problems for astronomers to work on; it was the problem Copernicus was working on.

What Kuhn points out about the Copernican revolution that is significant for our purposes is that the Copernican system did not present a better system than Ptolemy's epicycles and the idea of a heliocentric orbital system was not taken seriously by his peers who were more interested in the other astronomical content of his work. Yet, Copernicus' ideas began to be tried out and by the time of the Protestant Reformation there were enough Copernicans to cause a stir.

I wish to pose the following question: at what point did the Copernican revolution meet each of the aforementioned scientific criteria?

Kuhn cites a letter from Catholic leader Cardinal Bellarmine sent to the Copernican astronomer Foscarini in 1615. Bellarmine writes that "if there were real proof" of Copernicanism, the Catholic Church would be tasked with carefully interpreting the conflicting passages of Scripture or must even just simply admit that it does not understand these parts of Scripture, rather than to contradict a proven scientific theory. However, he said, "I shall not believe there are such proofs until they are shown to me" even though he was fully aware of Galileo's telescopic discoveries.[9] At what point in history might Bellarmine have been unequivocally convinced of his error? In Brecht's play *Life of Galileo*, Galileo sits his assistant Andrea in a chair and has him imagine that he is the earth. Then, he shows him that rotating the chair around the lamp and rotating

[9]*Ibid.,* 198.

the lamp around the chair puts the lamp in the same relative direction each time.[10] This demonstrates to his assistant a certain observational equivalence of the systems but does not prove it in a way that would satisfy Bellarmine. History has portrayed Galileo as a lone voice of reason and sound scientific method against a stubborn clericalism unwilling to let go of the past, and although his treatment most certainly was unjust and intolerant, his insistence characterized by the apocryphal phrase, “And yet it does move,” was not unequivocally scientifically justified at the time he uttered it.

If we apply the criterion of induction to the historical record, we would have to demonstrate that Copernicanism was an inference to the best possible explanation. In 1551, Reinhold published tables drawn on the basis of Copernicus' assumptions that more accurately predicted planetary orbits than Copernicus or Ptolemy. These tables and Copernicus' *De Revolutionibus* found their way into the hands of all students of astronomy with the effect that a new generation encountered major texts premised on heliocentricity. New astronomers started to see the mathematical harmonies allowed by Copernicanism as compelling evidence of the earth's motion.[11] The problem with accepting Copernicanism however was not only that it undermined the poetic and religious narrative of man's place in the universe but that heliocentricity also undermined the Aristotelian system of physics. This means that critics were perfectly justified in arguing that rejecting terrestrial and cosmological physics for more harmonious circles was not worthwhile. In 1609 Kepler was able to solve the problem of the planets and derive his laws by using elliptical orbits, and Galileo had pointed a telescope at the sky and revealed new stars, studied the surface of the moon, discovered Jupiter's moons, and noticed the rotation of

[10]See Bertold Brecht, *Galileo,* trans. Charles Laughton (New York: Indiana University Press, 1966).
[11]Kuhn, *The Copernican Revolution*, 187-8.

sunspots (thus demonstrating what had to be either the axial tilt of a rotating sun or the axial tilt of a rotating earth).[12] None of these was direct evidence of Copernicanism, although the most compelling evidence was the observations he made of Venus' orbit which demonstrated that the phases of Venus are not like the moon's geocentric phases but rather indicate its orbit to be heliocentric.

However, these observations do not give irrefutable evidence as this point of view is equivalent to the system developed by Kepler's mentor, Tycho Brahe, who argued that the earth is the center of the orbiting sphere of stars with the sun orbiting it and the planets orbiting the sun. This preserved both Aristotelian physics and the navigational utility of the two-sphere system and is mathematically equivalent to the Copernican system.[13] Before we could say that Copernicanism is justified as an inference to the best possible explanation of the most facts with the fewest assumptions, we have to wait for Issac Newton to develop his system of physics in 1685. Newton's theory also made unverified assumptions. Not only was absolute space and time posited axiomatically but the claim that the force of gravitation on earth is the mechanism of terrestrial motion is also axiomatic, and decried by many detractors as an "occult force" and Newton himself had to amend it in a later printing of the *Principia*. The fact that his theory did not yet offer explanations of terrestrial motion only further supports our point that the systematic abductive method fails to capture the dynamic nature of scientific discovery.[14]

Likewise, the mathematically equivalent Tychonic and Copernican systems fail to correspond to observable states of affairs as do the concepts of absolute space, absolute time, and the axiomatic positing of gravitational force, therefore the Copernican hypothesis fails to meet the criterion of verifiability

[12]*Ibid.,* 219-25.
[13]*Ibid.,* 200-09.
[14]*Ibid.,* 252-60.

and accordingly is from the positivist's point of view simply a change in the system of coordinates, which might be true but misses the essence of scientific transformation.

Lastly, the principle of falsifiability would require that the transformation be sparked by or settled by falsification yet no such event occurred as the problem of the planets had existed and been reckoned with since the time of Aristotle. Falsifications of the Tychonic version of the Ptolemaic system could not be observed until the 19th century when the Coriolis effect could be observed; eastern deviations in dropped weights could be detected (which Hooke had been unsuccessful in detecting in the 17th century) and Foucault's pendulum was devised in 1851.

The criteria suggested by philosophers of science were not responsible for the Copernican revolution.

La Verrier and the Planet Vulcan

It is one thing to point out that historically science has not used the criteria built by philosophers of science but what if they had been applied? If they had, we would run the risk of producing crises in the sciences too quickly; instead, the hesitancy of scientists to blame their theoretical presuppositions for anomalies has led to scientific discovery.

In the 19th century, for instance, a major topic in astronomy was the "n-body problem" involved in calculating the gravitational effects the planets had on each other.[15] Alexis Bouvard began calculations of Uranus' orbital positions and found a large deviation from what Newton's laws should have predicted, so he discarded all observations made before 1781 and found that an error of 30" remained. After continuous observations, by 1845 the margin of error had reached 2". Bouvard could not determine whether he had bad data or if there was some unperceived force at work but he was not prone to discard Newtonian

[15]Morando, "The Golden Age of Celestial Mechanics", 212.

mechanics. The existence of a foreign object was proposed and after a process of elimination this was assumed to be a planet.[16] John Couch Adams and Urbain Le Verrier each began calculations of where the planet should be as they would need to know where to point their telescopes to detect it. After Le Verrier published his findings in 1846, Johann Gottfried Galle observed Neptune from the Berlin observatory near the point predicted. Neptune had in fact already been seen twice by astronomers who mistook it for an undiscovered star – it took Le Verrier's faith in the infallibility of Newton's laws to deduce the existence of an unknown planet.[17]

Sometime after this success, Le Verrier calculated a discrepancy of 38” between Mercury's observed orbit and where Newtonian mechanics said it should be. He posited the existence of a planet orbiting between Mercury and the Sun that he called Vulcan, which of course does not exist.[18] (Instead, the orbit of Mercury represents an area in which Newton's laws are no longer accurate but can now be explained by Einstein's theory of general relativity.) This discrepancy was not seen as a falsification but rather as a problem for which the explanation must be sought. Given his success with the discovery of Neptune, Le Verrier was fully confident in Newtonian mechanics. What was valuable about the inferences Le Verrier made in the case of Neptune was that they led to a new discovery even though the same inferences elsewhere led to the discovery of a phenomenon that could not be explained at the time.

Dark Matter and Energy

Similarly, the current theory of gravitation in general relativity posits the existence of dark matter to account for unexplained deviations between the observable mass of large astronomical objects and their observed gravitational

[16]*Ibid.,* 216.
[17]*Ibid.,* 219-21. & Kuhn, *Structures of Scientific Revolutions*, 115-16.
[18]Morando, op. cit., 234-36. & Ley, *Watchers of the Skies*, 196-202.

effects. Just as the problem of the planets was generally well known at the time of Aristotle, the current gravitational problems in cosmology are known about and accounted for by dark matter which is currently estimated to comprise 95.1% of the total content of the universe.[19] Dark matter is deduced from general relativity just as Le Verrier deduced Neptune and Vulcan from Newtonian mechanics. Dark energy, the explanation for the accelerating expansion of the universe, is posited in an analogous way. Yet dark matter and dark energy give scientists problems to work on and many still hold out that an explanation consistent with general relativity will be discovered. However, by maintaining the theory we preserve the advantages general relativity offers in making accurate predictions required for near light velocities, electronic communication and stellar mass within the confines of our galaxy even if we can't explain dark matter and this leads to a paradigm shift sometime in the future. Just as the problem of the planets led the Greeks to posit epicycles, general relativity posits dark matter and dark energy to cope with one of its major predictive failures while preserving its predictive success.

Scientific Apologetics

Yet arguing for the truth of a scientific theory on the basis of its predictive power does not convince the skeptic nor does it win the confidence of the general public, nor is it useful when arguing the merits of one's own theory against a proponent of a rival theory. Thus, the usefulness of the aforementioned criteria is apologetic in nature. The scientific theories of today are not produced by utilizing induction, positivistic criteria of verifiability or the criterion of falsifiability, nor should they be. Yet science plays a crucial role in people's

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[19]Matthew Francis. "First Planck Results: the Universe is Still Weird and Interesting," *Arstechnica*, March 21, 2013, accessed December 6, 2014, <http://arstechnica.com/science/2013/03/first-planck-results-the-universe-is-still-weird-and-interesting/>

worldview. These "apologetic" arguments are useful, not for science qua science, but for the proselytizing of adherents, whether they be new scientists or the general public. It fosters belief in the predictive power of the sciences despite their susceptibility to revision and crisis.

The skeptic who wishes a demonstration of the scientific theory treats it as if it were in temporal stasis. Given the time slots for televised debates about heated public or political issues, demonstration by means of predictability is ineffective because the detractor can simply insist that the theory has explained some things but not everything, while the advocate would have to explain how the theory has a proven outstanding record of predicting new areas of discovery. To meet the time limit, an advocate might revise his apologetic into a claim about falsifiability even though the presence of falsifying data would not really be falsification but instead an unsolved problem requiring explanation. Likewise, the critic points to major anomalies or seeming anomalies as falsifications of the theory even though to the scientists they are simply areas where the data is insufficient, such as Uranus' orbit before the discovery of Neptune.

The idea of a "falsifying" experiment then is a useful rhetorical device for either side. In the debate between those who believed in abiogensis and the proponents of germ theory, Francesco Redi's experiments in the 17th century aimed at refuting spontaneous generation used sealed jars to demonstrate that the maggots entered the meat externally. Likewise, Karl Popper's experiment attempted to show that quantum mechanics was not falsifiable. The experiments involving the long-term observation of evolutionary changes in rapidly reproducing E. Coli at Michigan State provide a demonstration of evolution to those who do not wish to integrate it into their worldview – they will not convince any evolutionary biologists for whom evolution retains an incredibly accurate predictive power.

Yet these debates about truth, falsity, falsifiability and demarcation evoke a major ethical and political conflict: should scientific truth should be accepted provisionally or taken dogmatically? The crux of these debates in philosophy of science concerns the truth of scientific claims and their relevance to people's worldview. There are those who intrude into the world of the scientist, taking advantage of science's susceptibility to paradigm shifts and try to undermine it on the basis of the problems still remaining for scientists to solve. There are also those who make a career out of intruding into people's worldviews and declaring them unscientific and therefore irrational. The possibility of these attacks seems to be the reason that scientific theories do not have the flexibility of prediction that one finds within the humanities where one can utilize a variety of methods to analyze the same text each producing different results. Scientists must, in a way, sacrifice authenticity for credibility, otherwise predictions will be dismissed in the political and public realm when personally or politically inconvenient. As long as the possibility of attack and conflict continues, these criteria will be employed in defense of science while science will continue to predict, discover, calculate and measure nature on the basis of posited theoretical presuppositions that are not immune to foundational crisis.

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