Scientonomy
Journal for the Science of Science

Sarwar, A. & Fraser, P. (2018). *Scientonomy* 2, 55-66
https://www.scientowiki.com/Sarwar and Fraser (2018)
https://doi.org/10.33137/js.v2i0.31275

Scientificity and The Law of Theory Demarcation

Ameer Sarwar
Department of Philosophy and IHPST,
University of Toronto
ameer.sarwar@mail.utoronto.ca

Patrick Fraser
Departments of Philosophy, Physics, and
IHPST, University of Toronto
p.fraser@mail.utoronto.ca

An earlier version of this paper was awarded the 2018 IHPST Award for the Best Essay on the Theory of Scientific Change.

Keywords

theoretical scientonomy, demarcation, scientificity, epistemic stances, the law of theory demarcation, theory assessment, assessment outcome

Abstract

The demarcation between science and non-science seems to play an important role in the process of scientific change, as theories regularly transition from being considered scientific to being considered unscientific and *vice versa*. However, theoretical scientonomy is yet to shed light on this process. The goal of this paper is to tackle the problem of demarcation from the scientonomic perspective. Specifically, we introduce *scientificity* as a distinct epistemic stance that an agent can take towards a theory. We contend that changes in this stance are to be traced and explained by scientonomy. Thus, we formulate a new *law of theory demarcation* to account for changes in scientificity within the scientonomic framework.

Introduction

The problem of demarcating science from pseudoscience and non-science has long been a concern of the philosophers of science (Hansson, 2017). This problem has both theoretical and practical implications: differentiating science from pseudoscience is important in areas such as healthcare, science education, and environmental policy, among many others (Hansson, 2017). Philosophers of science have proposed various criteria of demarcation that range from analysis at the level of individual theories (Popper, 1963) to that of whole-scale research programmes (Lakatos, 1970). It is also undeniable that this problem features prominently in discussions concerning scientific change (Derksen, 1993). For example, astrology was once considered an important part of mainstream science (Rutkin, 2008), but it is now regarded as unscientific (Thagard, 1978). In short, it is uncontroversial that the problem of demarcation is relevant to the theory of scientific change.

It is currently accepted in theoretical scientonomy that the methods employed by an epistemic agent at a particular time can have at least three types of components: demarcation criteria, acceptance criteria, and compatibility criteria (Barseghyan, 2015, pp. 9-10). Briefly, *demarcation criteria* are employed by an epistemic agent to determine if a theory is scientific or unscientific (Barseghyan, 2015, p. 10). The *criteria of acceptance* are employed to ascertain if a theory meets the epistemic agents' actual (implicit or explicit) expectations, which render the theory accepted or unaccepted (Patton, Overgaard, & Barseghyan, 2017; Barseghyan, 2015, p. 10). Finally, the *compatibility criteria* are employed by an epistemic agent to evaluate whether two theories are compatible or incompatible with one another (Barseghyan, 2015, p. 10). Importantly, both the acceptance criteria and the compatibility criteria have corresponding *laws* – the second law (Patton, Overgaard, & Barseghyan, 2017, pp. 29-39) and the zeroth law (Barseghyan, 2015, pp. 152-64), respectively – that allow scientonomists to explain how these criteria function within a mosaic.

This list may or may not be exhaustive, since there may be "other classes of criteria which perform other functions" (Barseghyan, 2015, p. 9, footnote 14).

By contrast, there is currently no scientonomic *law* that would explain how demarcation criteria function to determine if a theory is scientific or unscientific. On the one hand, it is recognized by scientonomists that demarcation plays *some* role in the process of scientific change (if only because methods of theory evaluation can include demarcation criteria). For example, Barseghyan differentiates between the acceptance and demarcation criteria, arguing that most philosophers of science view demarcation as distinct from acceptance, at least from a logical perspective (Barseghyan, 2015, p. 10, footnote 16). On the other hand, we still lack a robust understanding of the role that demarcation plays in the process of scientific change.

We begin this paper by introducing *scientificity* as a distinct epistemic stance that epistemic agents can take towards theories. We then show that the stance of scientificity towards a theory can change through time. Finally, we use these notions alongside the demarcation criteria and introduce a new law of scientific change – *the law of theory demarcation*.

Scientificity as an Epistemic Stance

It is currently accepted in scientonomy that an epistemic agent can take three distinct stances towards a theory: acceptance, use, and pursuit (Barseghyan, 2015, pp. 30-42). A theory is said to be *accepted* by the agent if they take it as the best available description or prescription of its respective object (Sebastien, 2016, p. 7). Examples of theories that the contemporary scientific community considers as accepted include general relativity (Hartle, 2006) and the theory of evolution by natural selection (Lombrozo, Thanukos, & Weisberg, 2008). In contrast, an epistemic agent is said to be *using* a theory if they consider it a useful tool for practical applications (Barseghyan, 2015, p. 31). Use is pluralistic insofar as we simultaneously use many different, possibly conflicting theories (Chang, 2012). For instance, general relativity, quantum mechanics, and classical mechanics are used simultaneously in GPS technology for gravitational time-dilation compensation, high-precision time measurement, and satellite orbital mechanics, respectively (Kumar & Moore, 2002). Finally, an epistemic agent is said to *pursue* a theory if they consider it worthy of further elaboration. A typical example of a theory that is pursued nowadays is the string theory (Dawid, 2013).

While these three stances are essential for understanding the process of scientific change, the current framework fails to capture an important epistemic stance that epistemic agents take towards theories, *scientificity*. It is a historical fact that epistemic agents view some theories as scientific and others as unscientific. For example, general relativity is currently considered scientific by the contemporary scientific community (Hartle, 2006), while phlogiston theory is considered unscientific (Wisniak, 2004). One suggested subspecies of unscientific theories that is often considered in the literature is *pseudoscientific* theories (Hansson, 2017). This category normally includes those unscientific theories that "masquerade as genuinely scientific ones" (Baigrie, 1988, p. 438). Thus, a pseudoscientific theory is not only unscientific, but it also purports to be or is (erroneously) portrayed as scientific (Hansson, 2017; Marshall, 2012, p. 259). A classic example of a pseudoscientific theory is psychoanalysis, which is not only considered unscientific by the mainstream scientific community but is also portrayed by its champions as scientific (Derksen, 1993). Furthermore, it is also possible for an agent to not have any definitive stance concerning the scientificity of a theory. In such cases, we can say that the scientificity of that theory is *undefined* for that agent. Consider the current status of marketing. There is clearly no consensus in the scientific community about its scientific status. Some view it as an amalgamation of theories from other scientific disciplines (which some claim renders it scientific), while others contend that it does not have a scientific identity and it merely applies other theories (Brown, 1996; Anderson, 1983).

Marshall also presents a succinct literature review of the philosophy of pseudoscience (Marshall, 2012, p. 259 and p. 268, endnote 2; cf. Hansson, 2009, who proposes tripartite criteria for determining if a theory is pseudoscientific).

Now, what reason do we have to claim that scientificity is a distinct epistemic stance? More specifically, how can we show that it is distinct from the other three stances? If it can be determined that the same epistemic agent can take one stance towards a theory without taking the other, then this suffices in demonstrating that the two epistemic stances are not identical. Therefore, what needs to be shown is that an agent can take the stance of scientificity *independently* of the other three stances. Let us consider each of the three other stances in turn.

It is clear that *scientificity* and *use* are distinct, for a scientific theory may or may not be used in practical applications. Take, for instance, the theory of black holes – it is scientific but is currently lacking in practical applications (Lavelle & D'ari, 1996), whereas quantum mechanics is scientific and also used (among virtually thousands of examples, see for instance Bennett & Brassard, 1984). Hence, the distinction between scientificity and use is clear.

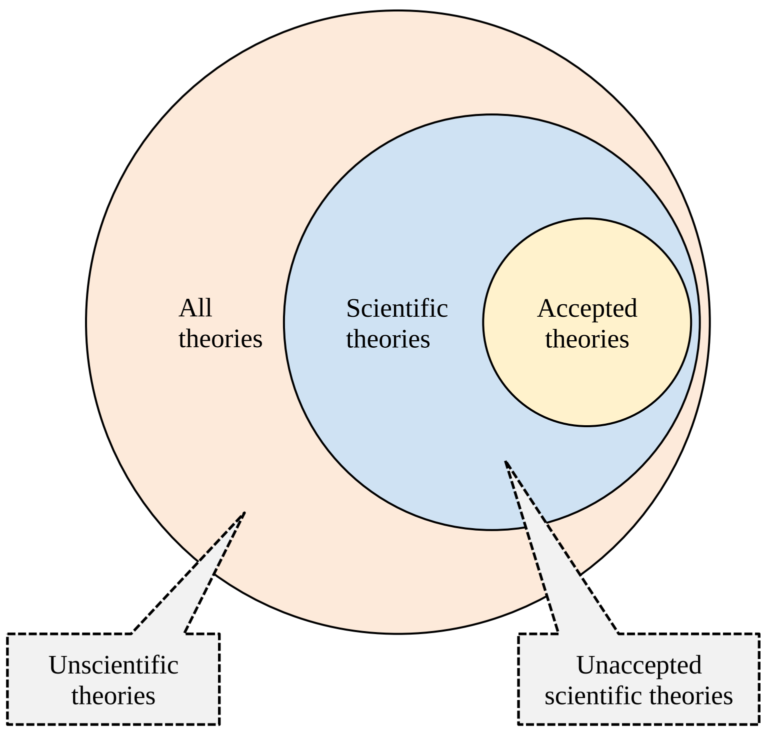
It can be shown that *scientificity* is also distinct from *pursuit*. It is true that often a theory is considered both scientific and pursuit-worthy. Any field of contemporary science provides a plethora of examples of this phenomenon. For instance, general relativity, the theory of evolution, human genetics, protein folding, and many other theories are both pursued and considered scientific at the same time; this is trivially true for any scientific theory that is still being developed. However, there are also cases when a theory is pursued despite the fact that it is considered unscientific. For example, a sizeable part of the current physics community pursues the superstring theory even though it is not considered scientific (Harnad, 2008; Jagannathan, 2006). In the literature, a variety of reasons are given for its pursuit-worthiness. In particular, it is one of the only current candidates for a theory of quantum gravity, and so many physicists are inclined to develop it further. The typical reasons range from such sociocultural factors as prestige, funding, and publications (Jagannathan, 2006) to the scientific belief that such attempts may eventually produce a unifying theory of everything (Harnad, 2008). Yet, despite 25 years of research, the superstring theories have remained unscientific, because they are "unable as yet to provide anything that may be subjected to the test of experimental verification" (Harnad, 2008, p. 67). They agree that,

Although the scientific status of all string theories is questionable, the superstring theory in particular compels us to give it the label of "unscientific" because it supposes the notion of supersymmetry which posits the existence of a class of fundamental particles that have never been observed, that are only present for theoretical purposes, and that have no novel predictions. As such, superstring theories in particular fail to satisfy the requirements of the hypothetico-deductive method employed in physics nowadays.
In any event, please note that we are using the superstring theory for illustration purposes only; it would take a focused observational scientonomic study to reveal the precise stance of the community towards the theory's scientificity.

despite the debates over the criteria of demarcation, the experimental testability of theories is a necessary condition that makes empirical theories scientific. They claim that the superstring theory is currently unscientific, as it has failed to produce hypotheses that could be subjected to empirical investigation. What is important here is that the physics community continues to actively pursue the theory despite its questionable scientificity.

Alternatively, there are theories that are considered scientific but are no longer pursued. Consider, for instance, any of the lunar theories pursued in the 18th century by the likes of Euler, d'Alembert, and Clairaut, who sought to understand the trajectory of the moon in terms of Newton's laws of motion. While these theories are no longer considered pursuit-worthy, they are regarded as scientific even nowadays (Musielak, 2014; Wilson, 2003). These and other similar examples clearly demonstrate that scientificity and pursuit are distinct epistemic stances. Thus, it is unsurprising that epistemic agents often pursue theories even if they do not deem them scientific or consider them scientific without pursuing them.

Finally, it can be shown that *scientificity* is also distinct from *acceptance*. It is clear that all accepted theories are also necessarily considered scientific. This is trivially true: it is implicit in the notion of acceptance that any theory that is part of the scientific mosaic is also scientific. This fact has been tacitly assumed by scientonomists (Barseghyan, 2015, p. xi), but it must be made explicit: only scientific theories can be part of the mosaic of accepted theories. This relationship can be represented as follows:



For the sake of simplicity in the diagram, we assume that every theory is either scientific or unscientific, ignoring the case of indeterminate scientificity, as our main purpose here is to show that not all scientific theories are also accepted, i.e. that there are *unaccepted* scientific theories. One such example these days is the evolutionary theory of punctuated equilibrium, which claims that evolutionary changes, such as speciation, often occur during sudden, substantial events rather than through slow and gradual changes (Eldredge & Gould, 1972). This theory has been criticized by many notable evolutionary theorists and is currently not accepted by the biological community at large (Dennett, 1995; Dawkins, 1986; Scott, 2007). However, it is still considered scientific, as even critics admit that it is an "interesting but minor wrinkle on the surface of neo-Darwinian theory" (Dawkins, 1986, p. 251). The existence of unaccepted scientific theories is also evident in the practice of science funding agencies, which often grant money for the pursuit of scientific theories that are often not accepted. What this demonstrates is that scientificity and acceptance are distinct epistemic stances: a theory that is considered scientific may or may not be accepted by the agent.

In short, we see that scientificity is a distinct epistemic stance that can be taken towards theories. With this in mind we now proceed to formulate a new scientonomic law – the *law of theory demarcation*.

The Law of Theory Demarcation

It is evident that the scientificity of a theory may change through time. We have historical cases when a theory that was once considered scientific lost its status and became unscientific. Theology, for example, constituted an integral part of the Aristotelian-Medieval mosaic, wherein discussions about natural philosophy and theology were intimately connected. The theological arguments about divine creation had important implications for the causal mechanisms of the Aristotelian-Medieval universe (Barseghyan, 2015, pp. 64-66; Osler, 1998). It played an equally important role in the Cartesian and Newtonian mosaics (Osler, 1998). Indeed, in the Cartesian mosaic the existence of God was a necessary precondition for the theories of fundamental physics, while Newtonians thought that the purpose of natural philosophy was to elucidate the work of God (Osler, 1998). However, theology is no longer a part of the scientific mosaic (Barseghyan, 2015, pp. 171, 210). Importantly, theological propositions are not even considered scientific (Barseghyan, 2015, pp. 65, 192).

Or consider the case of the theory of phlogiston, which was once considered scientific but is nowadays classified as unscientific. Formulated in the late 17th century by Becher and developed by Stahl in the early 1700s, the theory posited that all combustible substances contain *phlogiston*, which is released into the air when a substance is burned (Wisniak, 2004, p. 732). The theory was an integral part of the mosaic of the time, because it provided a "broad conceptual scheme into which could be fitted most of the chemical phenomena known in the eighteenth century" (Wisniak, 2004, pp. 732-733, 740), such as such as fluidity, volatility, colour, and odour. Since phlogiston was thought to be released into the air during combustion, the weight of the object being burnt should have correspondingly decreased. However, experiments showed that the objects' weight increased (Wisniak, 2004, pp. 733-734). Lavoisier's theory of combustion, developed in 1778, was as an attempt to explain this anomaly. According to Lavoisier, "the supporters of the phlogiston theory… fall in a vicious circle and are forced to reply that combustible bodies contain the matter of fire because they burn, and they burn because they contain the matter of fire" (Wisniak, 2004, p. 735). Lavoisier instead postulated that combustion depended on the combination of combustible matter and air (oxygen), thereby explaining the anomaly as well as the constituent elements of water. The results from the experiments conducted by the Académie des Sciences had them conclude that "if we doubt of a truth established by experiments so simple and palpable, there would be nothing certain in natural philosophy" (Wisniak, 2004, p. 742). Eventually, this led to the acceptance of Lavoisier's theory and the rejection of the theory of phlogiston. Importantly, the theory of phlogiston is not only rejected these days but is also considered unscientific. Thus, we can safely say that the scientificity of the theory has changed.

Among many similar examples is the case of natural astrology which underwent a transition from scientific to unscientific during the 18th century (Curry, 1986; Fara, 2003).

There is historical evidence suggesting that scientificity of a theory can change in both directions. Consider, for instance, the proposition that dissection can reveal something important about human anatomy. This basic idea is considered scientific nowadays but was once deemed unscientific. In their pursuit to understand the workings of the human body, ancient Greek scholars focused on animal anatomy, as dissection of human bodies was forbidden. The ban on dissection was "largely out of respect for the dead and the then popular belief that dead human bodies still have some awareness of things that happen to it [*sic*] and therefore still had an absolute right to be buried intact and undisturbed" (Malomo, Idowu, & Osuagwu, 2006, p. 99). While dissections were banned mostly due to religious reasons, from the scientonomic perspective the important point is that the relevant epistemic agents did *not* take the stance of scientificity towards anatomical dissection. In modern medicine, by comparison, dissection plays a crucial role, as autopsies are quite common, and cadavers are regularly used for study. As a result, the theory "dissection reveals anatomical truths about the human body" went from

Atomism underwent a similar transition from being scientific (around the time of Democritus) to unscientific and then back to scientific with the acceptance of atomic theory in the 19th and 20th centuries.

being unscientific to becoming scientific, hence signifying a transition in the epistemic stance of scientificity.

Regardless of whether our historical hypotheses about scientificity of different theories are correct, one thing seems clear: the scientificity of a theory can change through time. It is also clear that these changes should somehow be related to the respective agent's demarcation criteria. But how exactly do the agent's demarcation criteria determine a theory's scientificity? Specifically, what happens when a community considers a previously unscientific theory as scientific and *vice versa*? For instance, why is theology no longer a scientific theory even though it formed an important part of many scientific mosaics? Conversely, why is it that theories such as anatomical dissection have gone from being unscientific to scientific? It is clear that the current scientonomic laws and theorems cannot shed light on these questions. Thus, a new law is needed. What can such a law sound like?

Let us begin by proposing a cursory formulation: "a theory is scientific if it satisfies the demarcation criteria of the time". It becomes immediately clear that, like the original form of *the second law*, this formulation is tautologous as it follows directly from the definition of *demarcation criteria* (Barseghyan, 2015, p. 129; Patton, Overgaard, & Barseghyan, 2017). The latter is defined as "criteria for determining whether a theory is scientific or unscientific" (Barseghyan, 2015, p. 10). Since within the scientonomic framework "a law is supposed to have some empirical content, i.e. its opposite should be conceivable, at least in principle" (Barseghyan, 2015, p. 129, footnote 18), we cannot accept this as a suitable formulation.

Consider another formulation: "a theory is scientific if and only if it satisfies the demarcation criteria of the time". This proposal appears plausible at first, because it provides both the necessary and sufficient conditions that make a theory scientific. However, it relies on an untenable tacit assumption: namely, it is not feasible for cases that have *inconclusive* assessment outcomes. Theories whose scientificity has not been conclusively determined would be excluded from any consideration by this formulation.

In short, we need a demarcation law that would not be tautological and would accommodate inconclusive assessments. Our proposal is as follows:

The Law of Theory Demarcation
If a theory satisfies the demarcation criteria of the method employed at the time, it becomes scientific; if it does not, it remains unscientific; if assessment is inconclusive, the theory's status can become scientific, unscientific, or uncertain.

Before the relationship between assessment outcomes and their effects is explored, it must be realized that the demarcation criteria yielding conclusive assessment outcomes is uncontroversial. The history of science provides many examples of theories that conclusively satisfied or failed to satisfy the demarcation criteria of the time. General relativity has clearly satisfied the contemporary demarcation criteria and is seen as scientific by the community. Conversely, the theory of phlogiston fails to satisfy our contemporary demarcation criteria and is undoubtedly viewed as unscientific nowadays.

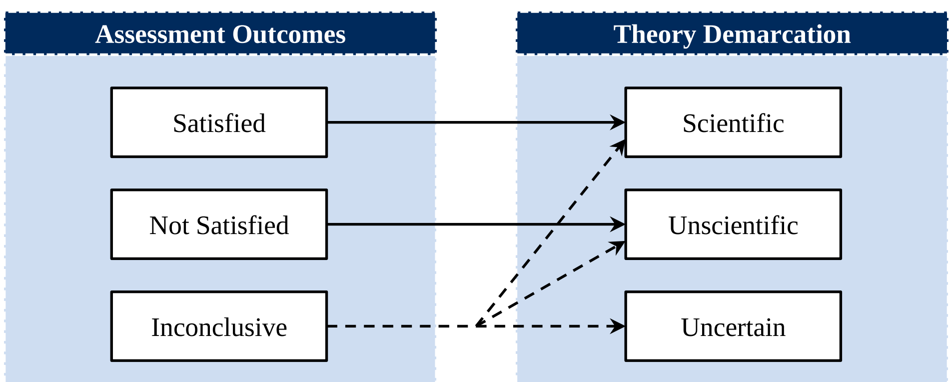
More controversial, however, is the notion that assessment by demarcation criteria can lead to *inconclusive* outcomes. It may at first appear counterintuitive to suppose that there could exist inconclusiveness in the process of scientific demarcation. After all, is there not a clear distinction between what scientists do and what pseudoscientists do? What we mean by *inconclusive* is that at times there can be an ambiguity or uncertainty in the agent's stance towards a theory's scientificity. For instance, urban design is a field of study that attempts to design physical features of cities and towns. Unlike architecture, which focuses on individual buildings, urban design is occupied with large-scale city-wide or town-wide projects. Although urban design relies on scientific theories from many disciplines, there is no unifying "urban design theory" that could give the discipline its scientific grounding (Marshall, 2012). Marshall argues that, according to the scientific community, "urban

> A lack of clear historical evidence about the scientific status of a theory may itself be regarded as an indicator of an inconclusive assessment outcome.

design is at least to some extent pseudoscientific, in that it appears to be based on scientific foundations, and yet those foundations are not always constructed with scientific validity" (Marshall, 2012, p. 264). Therefore, it is not entirely clear what the scientific status of urban design is, especially in light of the fact that some of its elements are scientific, whereas other elements are unscientific. We must therefore note that urban design presents a case where the assessment outcome of scientificity is *inconclusive*, as it is a discipline that is based in scientific discourse but one that may or may not use this basis in a scientific manner.

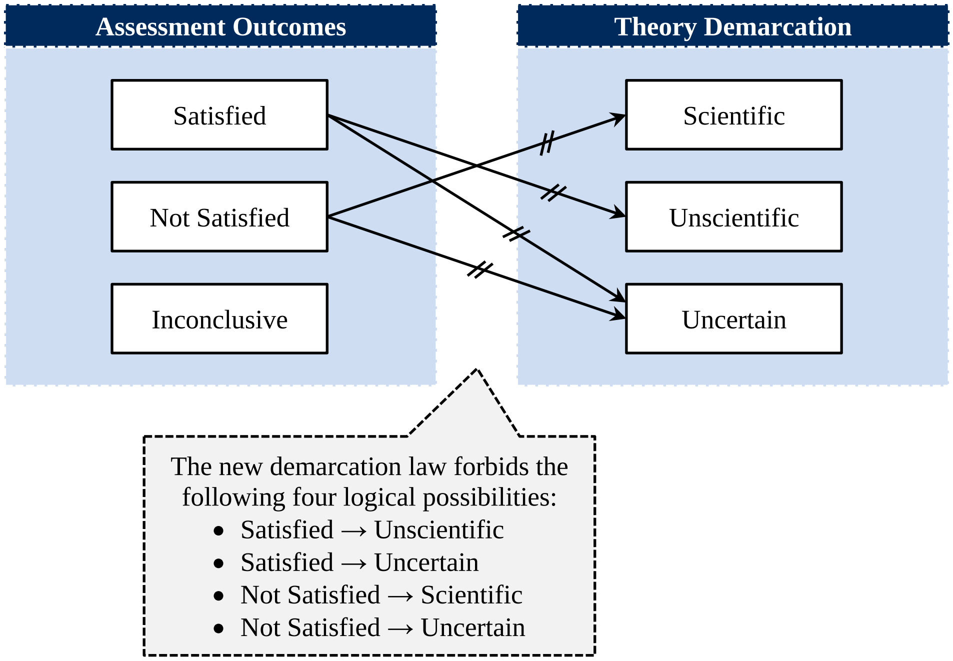
Another point to be borne in mind is that, unlike theory acceptance, lack of consensus-formation about the scientificity of a theory does not seem to have detrimental consequences. The acceptance (or lack thereof) of a theory has important practical and pedagogical implications such as whether or not the theory should be included into the textbooks and university curricula. As we know, when it is unclear whether a theory satisfies the respective *acceptance criteria*, it often leads to the simultaneous acceptance of two incompatible theories and, thus, to a mosaic split (Barseghyan, 2015, pp. 203-216). It can be argued that in many contemporary scientific communities this potential risk of schisms helps foster communal consensus on theory acceptance. Physicist, chemists, and biologists seem to know all too well the potential risks of inconclusive theory assessment. In the case of demarcation, however, the community may stay divided about the scientificity of a theory without much risk of splitting. This supposition (though it needs empirical support) seems to favor the notion that inconclusive theory assessments of demarcation obtain, because there is little practical incentive to reach consensus.

We will now focus on how the demarcation law connects assessment outcomes with their consequences by following the template laid out by Patton, Overgaard, and Barseghyan (2017). If the demarcation criteria of the method employed at the time are conclusively satisfied, then the epistemic agent necessarily deems the theory as scientific (i.e. it takes the stance of scientificity towards it). If the demarcation criteria employed at the time conclusively adjudicate the theory to be unscientific, then the agent regards the theory as unscientific. Lastly, if the assessment outcome is inconclusive – i.e. the theory neither conclusively satisfies the demarcation criteria nor decidedly fails to satisfy it – then the theory's scientificity remains uncertain:



In theoretical scientonomy, we *logically* separate the assessment outcomes from their effects in order to understand the actual relation between the two. Whether or not there is a *temporal* dimension between an assessment outcome and the change in the theory's status is to be tackled by observational scientonomy. Some examples suggest that assessment outcomes and their effects take place over long periods of time, while others indicate that the two processes happen almost simultaneously. For instance, it seems as though the assessment of astrology took place over a few centuries, with each generation of scholars taking issue with a particular part of the theory (Rutkin, 2008). This suggests that evaluation by the demarcation criteria does not necessarily lead to its corresponding effect in an instant fashion. By contrast, the Human Genome Project (HGP) was welcomed as one of the greatest scientific endeavors of the late 1900s. The project was approved within a short period of time and a funding of $200 million per year for the next fifteen years was promised (Collins, Morgan, & Patrinos, 2003). This indicates that the HGP was unanimously taken to be scientific from the outset, without any substantial delay. These examples make clear that although the assessment outcomes and their consequences are in principle logically separable, there may also be a time lag between an assessment outcome becoming satisfied and its corresponding impact taking place.

It is also important to appreciate that the demarcation law is *not* tautological as it forbids a number of logically conceivable scenarios:



If the assessment results in the outcome *satisfied*, then the theory's scientific status cannot be unscientific or uncertain. If the assessment outcome is *not satisfied*, then the theory cannot be deemed as scientific or uncertain by the demarcation criteria. Since *inconclusive* assessment outcome can lead to any possibility, it does not preclude any theory's status from being scientific, unscientific, or uncertain. The demarcation law explicitly prohibits the possibility of particular empirical phenomena from obtaining. In this way, the law makes substantive claims which are empirically risky, and it is thus falsifiable. Hence, the demarcation law has empirical content.

Some suggestions on the direction that observational scientonomists may take with respect to this investigation are in order. Ordinarily, indicators like textbooks, encyclopedias, conference proceedings, and journals can be used to ascertain if a theory was or was not *accepted* by a given epistemic agent at a given point in the past. However, it is unclear whether similar indicators can also be found to determine if evaluation by the demarcation criteria took place. This is mostly due to the fact that scientists may presumably keep track of only those theories that are accepted, not those that are unaccepted (and are scientific). Thus, there is a legitimate question concerning the indicators of scientificity. Once this question is reasonably answered, one may try to locate historical indicators that could tell us whether an assessment of scientificity was *conclusive* or *inconclusive*. It is conceivable that we may find solid indicators of conclusive assessments, while having trouble locating indicators of inconclusive assessments. In any event, we think that observational scientonomists should consider these questions in their investigations of actual assessments by the demarcation criteria.

Where is the Definition of Scientificity?

In this final section of our paper, we would like to address one major concern that we see with our proposal: the lack of the *definition* of *scientificity*. Our reluctance to provide, at this stage, a working definition for the term stems from the difficulty of narrowing down the concept in concrete terms, as well as from our repeated unsuccessful attempts at formulating such a definition. Here, we will discuss one of these attempts and highlight the problems inherent in it.

Consider the following definition (suggested to us by Paul Patton in a private correspondence): “a theory is said to be scientific if it is taken to deal with a legitimate topic of scientific inquiry”. At first, this definition seems to be a plausible starting point. After all, *questions* have been recently accepted into the scientonomic ontology of epistemic elements, and it strikes us as intuitive that any theory that claims to be scientific must, at the very least, try to answer a question that is itself considered scientific. However, this definition will not do as it has at least four drawbacks.

To begin with, it uses the concept of “a legitimate topic of scientific inquiry”, which itself is circularly dependent on the concept of scientificity. In order to understand what makes an inquiry scientifically legitimate, one must understand what scientificity is, and in order to understand what scientificity is, one must know what scientifically legitimate inquiry is. Clearly, this definition does little to clarify the notion of scientificity.

Second, the phrase “legitimate topic of scientific inquiry” is itself undefined in the scientonomic context. The only time something similar to this phrase occurs in scientonomic literature is in Rawleigh’s definition of *question acceptance*: “a question is said to be accepted if it is taken as a legitimate topic of inquiry” (Rawleigh, 2018, p. 10). However, Rawleigh is cautious enough to not include “scientific” in his definition. Consequently, although we do have an accepted definition of *question acceptance*, we currently lack any notion of *question scientificity*. Thus, if we were to define the notion of *theory scientificity* by means of *question scientificity*, we would be relying on a yet undefined concept and would be pushing the task further back without introducing much clarity to the definiendum.

This inquiry, of course, raises an important question whether or not epistemic agents take the stance of scientificity towards *questions*. Since questions are elements of the scientific mosaic alongside theories and methods, one can similarly inquire whether epistemic agents take the stance of scientificity towards *methods*. We believe that both of these questions are legitimate topics of scientonomic inquiry.

Furthermore, dealing with a “legitimate topic of scientific inquiry” may be a *necessary* condition for the scientificity of a theory, but it cannot be a *sufficient* condition. It is possible that a theory may attempt to answer scientific questions, but the answers it provides may not be considered scientific. Take, for example, the question “what determines the variation in human temperament?” which is currently considered scientific in mainstream personality psychology. Naturally, the very fact that a certain theory attempts to answer this question is not sufficient to render the theory scientific. After all, one could give astrological or phrenological explanations for the differences in human temperaments. This would be a case of a theory providing unscientific answers to a scientific question. Thus, attempting to answer a legitimate topic of scientific inquiry is not sufficient for a theory to be considered scientific.

Finally, it is reasonable to suspect that any attempt to define *theory scientificity* in terms of its relation to questions will inevitably be problematic for the same reasons listed above. It is always possible to construct *ad hoc*, non-scientific theories that answer a given question. We could, for instance, answer the question of the shape of the Earth by something as nonsensical as “the Earth is donut-shaped”. If the scientificity of a theory were to be determined by the qualities of the questions being answered, then any nonsense could potentially qualify as scientific. Therefore, it is clear that the content of questions cannot determine scientific theories from unscientific theories.

Although this was only a single attempt to formulate a definition of scientificity, it highlights many of the complexities that arise when one tackles this problem. It is for these reasons that we do not herein define *scientificity*. The explication of the meaning of the term beyond its intuitive understanding would be a substantial undertaking that is best left for another study.

Conclusion

This paper can now be concluded by restating that scientificity is a unique epistemic stance that epistemic agents take towards theories. We have demonstrated that accepted theories are a subset of scientific theories, making the former necessarily scientific. It has also been shown that a theory’s scientificity can change overtime; the process of these changes is fully within the scope of scientonomy. As theoretical scientonomy currently lacks any account of how scientificity changes through time, a new scientonomic law is in order. The demarcation law that we have proposed in this paper is meant to fill this gap by explaining the underlying mechanism of transitions from scientific to unscientific and *vice versa*. We have shown that the new law is not tautological by logically separating the theory assessment outcomes from the ensuing stances regarding the theory's scientificity and demonstrating that the law clearly forbids a number of logical possibilities. This discussion, we hope, will stimulate future research on the role of demarcation in the process of scientific change.

Acknowledgments

We are indebted to Paul Patton and Hakob Barseghyan for their helpful suggestions that led to the maturation of our views. We would also like to thank our colleagues Maxim Mirkin and Chris Kaumeyer for their recommendations to the first draft, as well as other participants of the seminar of 2018 for their helpful insights.

Suggested Modifications

Thus, we suggest the following modifications:

[Sciento-2018-0013]

Accept *scientificity* as a distinct epistemic stance that epistemic agents can take towards theories.

Also accept the following questions as legitimate topics of scientonomic inquiry:

- *Scientificity*: How should *scientificity* be defined?
- *Scientificity of Methods*: Can the epistemic stance of scientificity be taken towards *methods*? Can there be unscientific or pseudoscientific methods?
- *Scientificity of Questions*: Can the epistemic stance of scientificity be taken towards *questions*? Can there be unscientific or pseudoscientific questions?

[Sciento-2018-0014]

Accept the following law as a new scientonomic axiom:

- *The Law of Theory Demarcation*: if a theory satisfies the demarcation criteria of the method employed at the time, it becomes scientific; if it does not, it remains unscientific; if assessment is inconclusive, the theory's status can become scientific, unscientific, or uncertain.

The Law of Theory Demarcation
If a theory satisfies the demarcation criteria of the method employed at the time, it becomes scientific; if it does not, it remains unscientific; if assessment is inconclusive, the theory's status can become scientific, unscientific, or uncertain.

Accept that the *law of theory demarcation* is not a tautology.

Also accept the following questions as legitimate topics of scientonomic inquiry:

- *Indicators of Theory Scientificity*: What are the historical indicators of a theory's scientificity? Can traditional indicators like textbooks, encyclopedias, conference proceedings, and journals be used to determine if evaluation by the demarcation criteria took place?
- *Indicators of Conclusiveness for Scientificity Assessment*: What are the historical indicators that an assessment by the demarcation criteria was conclusive or inconclusive? Does the lack of agreement or evidence count in favor of inconclusive assessment outcome?

References

Anderson, P. F. (1983). Marketing, Scientific Progress, and Scientific Method. *Journal of Marketing* 47(4), pp. 18-31.

Baigrie, B.S. (1988). Siegel on the Rationality of Science. *Philosophy of Science* 55(3), pp. 435-441.

Barseghyan, H. (2015). *The Laws of Scientific Change*. Springer.

Bennett, C. H. & Brassard, G. (1985). An Update on Quantum Cryptography. In Blakley & Chaum (Eds.) (1985), pp. 475-480.

Blakley, G. R. & Chaum, D. (Eds.) (1985). *Advances in Cryptology*. Springer.

Brown, S. (1996). Art or Science? Fifty Years of Marketing Debate. *Journal of Marketing Management* 12(4), pp. 243-267.

Chang, H. (2012). Scientific Pluralism and the Mission of History and Philosophy of Science. *Inaugural Lecture. Department of History and Philosophy of Science, Cambridge University.* Retrieved from https://www.youtube.com/watch?v=zGUsIf9qYw8.

Collins, F. S.; Morgan, M. & Patrinos, A. (2003). The Human Genome Project: Lessons from Large-Scale Biology. *Science* 300(5617), pp. 286-290.

Curry, P. (1986). *The Decline of Astrology in Early Modern England, 1642–1800.* A Ph.D. thesis submitted to the Department of History and Philosophy of Science, University College London.

Dawid, R. (2013). *String Theory and the Scientific Method*. Cambridge University Press.

Dawkins, R. (1986). *The Blind Watchmaker*. Penguin.

Dennett, D. C. (1995). Darwin's Dangerous Idea. *The Sciences* 35(3), pp. 34-40.

Derksen, A. A. (1993). The Seven Sins of Pseudo-Science. *Journal for General Philosophy of Science* 24(1), pp. 17-42.

Eldredge, N. & Gould, S.J. (1972). Punctuated Equilibria: An Alternative to Phyletic Gradualism. In Schopf (Ed.) (1972), pp. 82-115.

Fara, P. (2003). Marginalized Practices. In Porter (Ed.) (2003), pp. 485-507.

Hansson, S. O. (2009). Cutting the Gordian Knot of Demarcation. *International Studies in the Philosophy of Science* 23(3), pp. 237-243.

Hansson, S. O. (2017). Science and Pseudo-Science. In Zalta, E. (Ed.) (2017). *The Stanford Encyclopedia of Philosophy (Summer 2017 Edition)*. Retrieved from https://plato.stanford.edu/archives/sum2017/entries/pseudo-science/.

Harnad, J. (2008). Review of: The Trouble with Physics: The Rise of String Theory, the Fall of a Science, and What Comes Next. *The Mathematical Intelligencer* 30(3), pp. 66-69.

Hartle, J. B. (2006). General Relativity in the Undergraduate Physics Curriculum. *American Journal of Physics* 74(1), pp. 14-21.

Jagannathan, K. (2006). Not Even Wrong: The Failure of String Theory and the Search for Unity in Physical Law; The Trouble with Physics: The Rise of String Theory, the Fall of a Science, and What Comes Next. *Physics Today* 59(12), pp. 57-58.

Kumar, S. & Moore, K. B. (2002). The Evolution of Global Positioning System (GPS) Technology. *Journal of Science Education and Technology* 11(1), pp. 59-80.

Lakatos, I. (1970). Falsification and the Methodology of Scientific Research Programmes. In Lakatos (1978), pp. 8-101.

Lakatos, I. (1978). *Philosophical Papers. Volume I.* Cambridge University Press.

Lavelle, S. & D'ari, R. (1996). The New Scientific Spirit. *BioEssays* 18(7), pp. 603-606.

Lombrozo, T.; Thanukos, A. & Weisberg, M. (2008). The Importance of Understanding the Nature of Science for Accepting Evolution. *Evolution: Education and Outreach* 1(3), pp. 290-298.

Malomo, O. A.; Idowu, O. E. & Osuagwu, F. C. (2006). Lessons from History: Human Anatomy, from the Origin to the Renaissance. *International Journal of Morphology* 24, pp. 99-104.

Marshall, S. (2012). Science, Pseudo-Science and Urban Design. *Urban Design International* 17(4), pp. 257-271.

Musielak, D. (2014). Euler: Genius Blind Astronomer Mathematician. *ArXiv:1406.7397 [Math]*. Retrieved from http://arxiv.org/abs/1406.7397.

Osler, M. J. (1998). Mixing Metaphors: Science and Religion or Natural Philosophy and Theology in Early Modern Europe. *History of Science* 36(1), pp. 91-113.

Park, K. & Daston, L. (Eds.) (2008). *The Cambridge History of Science. Volume 3: Early Modern Science.* Cambridge University Press.

Patton, P.; Overgaard, N. & Barseghyan, H. (2017). Reformulating the Second Law. *Scientonomy* 1, pp. 29-39. Retrieved from https://www.scientojournal.com/index.php/scientonomy/article/view/27158.

Popper, K. (1963). *Conjectures and Refutations: The Growth of Scientific Knowledge*. Routledge.

Porter, R. (Ed.). (2003). *The Cambridge History of Science. Volume 4: Eighteenth-Century Science.* Cambridge University Press.

Rawleigh, W. (2018). The Status of Questions in the Ontology of Scientific Change. *Scientonomy* 2, pp. 1-12. Retrieved from https://www.scientojournal.com/index.php/scientonomy/article/view/29651.

Rutkin, H. D. (2008). Astrology. In Park & Daston (Eds.) (2008), pp. 541-561.

Schopf, T.J.M. (Ed.) (1972). *Models in Paleobiology.* Freeman, Cooper & Co.

Scott, H. (2007). Stephen Jay Gould and the Rhetoric of Evolutionary Theory. *Rhetoric Review* 26(2), pp. 120-141.

Sebastien, Z. (2016). The Status of Normative Propositions in the Theory of Scientific Change. *Scientonomy* 1, pp. 1-9. Retrieved from https://www.scientojournal.com/index.php/scientonomy/article/view/26947.

Thagard, P. R. (1978). Why Astrology is a Pseudoscience. *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association*, Vol. 1978, pp. 223-234.

Wilson, C. (2003). Astronomy and Cosmology. In Porter (Ed.) (2003), pp. 328-353.

Wisniak, J. (2004). Phlogiston: The Rise and Fall of a Theory. *Indian Journal of Chemical Technology* 11(5), pp. 732-743. Retrieved from http://nopr.niscair.res.in/handle/123456789/9538.