Santa Clara High Technology Law Journal

Volume 34 | Issue 1 Article 3

9-1-2017

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Recommended Citation

Thomas M. Byron, *On Copyright and Scientific Theory*, 34 Santa Clara High Tech. L.J. 1 ().
Available at: http://digitalcommons.law.scu.edu/chtlj/vol34/iss1/3

ON COPYRIGHT AND SCIENTIFIC THEORY

***Thomas M. Byron*†**

At present, intellectual property law offers extremely limited possibilities for protecting a scientific theory in its most basic form, including fundamental hypotheses, rule-based relations, mathematical equations, models, and diagrams. Regardless of the current state of intellectual property law, this Article is willing to entertain a hypothesis of its own—that scientific theory could be a proper subject of copyright protection*. In two discussion sections, the Article defends both sides of the debate. One side of the debate argues in favor of copyright protection for scientific theories, showing that scientific theory represents an intellectual creation of the scientist, not a mere statement of uncopyrightable fact. A scientific theory offers substantial flexibility and openness in its creation due to the presence of near-infinite theories that could have been chosen instead of any given theoretical equivalent. If a scientific theory satisfies the current requirements for copyrightability, then there is no reason not to grant it protection. The other side of the debate advocates the opposite point—that copyright should not protect scientific theory—and bases this argument on science's ever-progressing nature and its community standards that favor free access to the work of other scientists. That side also opposes the presence of sufficient legal creativity to merit copyright protection of a scientific theory. To structure the arguments presented in the two primary sections, this Article relies heavily on the philosophy of the early-twentieth-century physicist and scientific historian Pierre Duhem. After an investigation of both the strengths and limitations of Duhem's theories, the Article concludes by weighing the merits of the two arguments proposed.*

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INTRODUCTION

It is close to black letter law that scientific theory[1]—at least in its sparest form of models, basic hypotheses, and equations—is not eligible for any meaningful intellectual property protection. The point can be made in a brief regime-by-regime review of intellectual property's current domains of protection. Let us begin with patents:

Patent law makes a general distinction between unapplied and applied science, wherein only the latter receives protection. It was in this vein that the Supreme Court interpreted the Patent Act in *Diamond v. Chakrabarty*, noting that:

> [t]he laws of nature, physical phenomena, and abstract ideas have been held not patentable. Thus, a new mineral discovered in the earth or a new plant found in the wild is not patentable subject matter. Likewise, Einstein could not patent his celebrated law that $E = mc^2$; nor could Newton have patented the law of gravity. Such discoveries are 'manifestations of . . . nature, free to all men and reserved exclusively to none.'[2]

If scientific laws and the equations and models simulating them are not patentable, this is because patent law's protections require more than scientific theory's observation and modeling of reality as it (purportedly) is. The Court in *Diamond* went on to hold that the microorganism at issue in the case was patentable because, unlike the

1. For purposes of this Article, scientific theory may be defined as a series of hypotheses, rule-based relations, mathematical equations, diagrams, and models that are capable of being tested and intended to serve a predictive function with respect to empirical reality. The theories discussed here may be comprised of numeric, symbolic, or linguistic components, but any non-numeric, non-symbolic aspects of the theory are assumed to be expressed as briefly and economically as possible—in other words, we are concerned here with the potential of providing intellectual property protection for the statement, "For every action, there is an equal and opposite reaction," as opposed to the question of whether Newton's *Principia* would be copyrightable as a whole (if written today). ISAAC NEWTON, PRINCIPIA, at 86 (Daniel Adee ed., Andrew Motte trans., 1846) (1687).

2. Diamond v. Chakrabarty, 447 U.S. 303, 309 (1980) (citations omitted).

natural laws just mentioned, it reflected "a non-naturally occurring manufacture or composition of matter—a product of human ingenuity."[3] Patentable subject matter is inventive, the stuff of an active human intervention to bend phenomena, both natural and man-made, to human use.[4] "Use" is the right term, because one of the requirements for the issuance of a patent is the "utility" of the potentially patentable material.[5] Where automobiles, washers, and computer systems offer certain evident forms of utility that make their subparts potentially patentable, the person attracted to Earth by the planet's gravitational pull can be much less said to be "using" the effect of that law in any meaningful, intentional way. In view of the utility requirement and the *Diamond* dicta, the scientist receiving a patent must do more than just passively observe and record nature for future theoretical predictions; she must actively tinker with nature to serve the end of non-obvious human utility.[6]

Trademark protection is even more obviously unavailing for the discoverer of a scientific law or theory. As trademark protection is

3. *Id.* at 309-10.

4. Morton v. N.Y. Eye Infirmary, 17 F. Cas. 879, 881 (C.C.S.D.N.Y. 1862) (No. 9,865) ("In its naked ordinary sense, a discovery is not patentable. A discovery of a new principle, force, or law operating, or which can be made to operate, on matter, will not entitle the discoverer to a patent. It is only where the explorer has gone beyond the mere domain of discovery, and has laid hold of the new principle, force, or law, and connected it with some particular medium or mechanical contrivance by which, or through which, it acts on the material world, that he can secure the exclusive control of it under the patent laws. He then controls his discovery through the means by which he has brought it into practical action, or their equivalent, and only through them. It is then an invention, although it embraces a discovery. Sever the force or principle discovered from the means or mechanism through which he has brought it into the domain of invention, and it immediately falls out of that domain and eludes his grasp. It is then a naked discovery, and not an invention.").

5. Arti Kaur Rai, *Regulating Scientific Research: Intellectual Property Rights and the Norms of Science*, 94 NW. L. REV. 77, 106 (1999) (discussing the utility requirement in the context of gene sequences and noting that such sequences would not be patentable until their utility was determined).

6. Isaac Asimov's short story, *The Billiard Ball*, provides a good example of the distinction between patentable applied science and unpatentable theoretical science. In that story, the scientist Priss develops a strictly theoretical basis for an electromagnetically-driven anti-gravity field that would eliminate the effects of ambient gravity to create a zero-gravity state. His rival Bloom, renowned for his applications of Priss' theories, uses this theory to invent a zero-g machine. The story does not fail to mention that Bloom was careful to patent his applications of Priss' theories (and then exploit those inventions for his own financial gain). Priss' work, meanwhile, would have been ineligible for patent protection. The story comes to a head when Priss is provided the opportunity to make the first use of Bloom's machine by sending a billiard ball into it. ISAAC ASIMOV, *The Billiard Ball*, *in* THE BEST OF ISAAC ASIMOV (Fawcett Crest 1973). In theory, Bloom as patent holder and Priss as simple scientist is how patent law would mete out its monopolistic rewards. But there remains an interesting legal fiction—what should patent law do with something that *changes* natural law? If Newton could not have patented gravity hypothetically, could someone patent a never-before-observed modification of a natural law, like "anti-gravity," distinct from a machine to implement it?

limited to goods and services in commerce,[7] its purview could not conceivably cover a newly-discovered scientific law. Extending trademark protection this far would amount to declaring that "genetics" is a good or service of Mendel, or that "gravity" was brought to the public by Newton. Obviously, this is not the case. Neither of these examples is a good or service in commerce; and even if natural laws were somehow commoditized for commercial use, they would not owe their origin to their discoverer or exploiter. The very idea of scientific discovery is that something—e.g., a mechanical relation, a magnetic attraction—*pre-dated* the discovery and continues to exist in the wake of the discovery.[8] Discovered or not, the scientific relation remains in effect to the same extent. "Relativity" might be proper as a word mark in trademark law, just not as attached to the scientific theory that Einstein proposed.

Copyright is similarly unfavorable to scientific theories, at least in their barest form. Section 102(b) of the Copyright Act clarifies that copyright protection does not "extend to any idea, procedure, process, system, method of operation, concept, principle, or discovery, regardless of the form in which it is described, explained, illustrated, or embodied in such work."[9] A scientific theory could easily be classified as an idea, a system, a concept, a principle, or a discovery, and denied protection on that basis.

At a more fundamental level of copyright law, section 102(b) derives much of its substance from the idea-expression dichotomy, which dictates that abstract ideas are not copyrightable, while the specific expression embodied in a work is. While there is no good way to distinguish an unprotected "idea" from a protected "expression,"[10] the general spirit of the idea-expression dichotomy is to prevent copyright protection from monopolizing necessary building blocks of expression like words, stock elements, and high-level concepts. We would not want to grant a monopoly on the idea of an absurdist story

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7. See 15 U.S.C. § 1127 (2012), which defines a trademark to include "any word, name, symbol, or device, or any combination thereof—

> (1) used by a person, or
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> (2) which a person has a bona fide intention to use in commerce and applies to register on the principal register established by this chapter,

to identify and distinguish his or her goods, including a unique product, from those manufactured or sold by others and to indicate the source of the goods, even if that source is unknown." *Id.*

8. This should not be misinterpreted to mean that what is discovered or posited in a scientific theory is the exact thing that pre-existed the theory. As shall be seen later, scientific discoveries may reasonably be viewed as created facts, to a certain extent.

9. 17 U.S.C. § 102(b) (2012).

10. Nichols v. Universal Pictures Corp., 45 F.2d 119, 121 (2d Cir. 1930) ("Nobody has ever been able to fix that boundary, and nobody ever can.").

about an oversized protagonist, lest Jarry's *Ubu* have blocked Ken Toole's *A Confederacy of Dunces*.[11] Similar logic would seem to dictate that the discoverer of a theory like gravity or relativity would not be able to own the discovered theory so that others may use that theory, alter it, and test it without running afoul of intellectual property protections. And indeed, this is the case, at least for expressions of a theory in its barest form of high-level statements, basic equations, models, and diagrams. Copyright would only attach to a scientific theory in an expanded explanation of the theory—Einstein, for instance, wrote a book on relativity,[12] which certainly merits copyright protection generally. Yet a copyright in a work expansively describing a theory would only apply to lengthy descriptions of the theory in words, and not the theory's underlying equations, ideas, hypotheses, or models themselves.

The only possible exception to intellectual property's lack of protection for scientific theories is trade secret protection. The typical formulation of material eligible for trade secret protection is any information that provides a competitive advantage in the marketplace by virtue of its being kept secret.[13] A business could conceivably discover a scientific theory and then keep it secret for its own personal gain. Practically speaking, however, this is probably a rare scenario. Consider, for example, Steven Goldberg's comment:

> It is rare for a scientific discovery to immediately lead to a new device. More often it takes a chain of scientific discoveries and engineering advances to bring a product to fruition. Indeed, although inventions may in theory always rely on some underlying scientific principle, many inventors have little or no knowledge of scientific theory and rely instead on their own intuitive ideas about improving previous inventions. Numerous studies, including those related to sophisticated post-World War II military inventions, show that many inventions are based primarily on earlier technology rather than on science.[14]

11. ALFRED JARRY, UBU ROI (Paul Negri & Drew Silver eds., Beverly Keith & Gershon Legman trans., Dover Publications 2003) (1896); JOHN KENNEDY TOOLE, A CONFEDERACY OF DUNCES (Louisiana St. Univ. Press 1980).

12. *See generally* ALBERT EINSTEIN, RELATIVITY: THE SPECIAL & GENERAL THEORY, (Robert W. Lawson trans., Princeton Univ. Press 2015) (1915).

13. Eric Johnson, *Trade Secret Subject Matter*, 33 HAMLINE L. REV. 545, 546 (2010). Johnson also notes other more restrictive definitions of trade secrets in Part II, but even those definitions would likely cover scientific theories discovered by a business. *See id.*

14. Steven Goldberg, *The Reluctant Embrace: Law and Science in America*, 75 GEO. L. J. 1341, 1344 (1987).

While undoubtedly there are certain commercial entities engaged in basic research, Goldberg points toward a more common division of labor between theoretical and applied science, such that those who care most about trade secrets are those least likely to have a new scientific theory to protect.[15] And even if a business did discover a theory and subsequently apply trade secret protection to it, that scenario would not prevent others from independently discovering the theory[16]—in which case, the business would have no recourse against the later discoverer.

All of which would generally leave scientific theory, at least in the form of models, diagrams, and equations, squarely in the public domain. This seems like a reasonable state of affairs, at least in view of certain basic principles of the sociology of science. According to Merton's oft-cited research, science's aim of extending knowledge is served by four key values: universalism, communism, disinterestedness, and organized skepticism.[17]

The second value, which prizes communal ownership of the fruits of scientific discovery,[18] would seem anathema to the application of intellectual property rights to basic theories. Lest concerns remain that a lack of such proprietary rights erode incentives to conduct basic theoretical research, scientific culture has established its own set of alternative incentives supporting such research, including rewards, honors, career advancement, and the intrinsic satisfaction of making a meaningful discovery.[19] Further, science's accretive nature—one might think here of the line often misattributed to Newton that he saw farther because he stood on the shoulders of giants[20]—militates in favor of a broader commons whereby scientists may take advantage of the fundamental research of their predecessors without the transaction costs associated with intellectual property licensing.

Is it really inconceivable, however, to imagine a world where basic science might be protected by proprietary rights? In the first half of the twentieth century, numerous regimes for the proprietary protection of basic science were proposed in Europe.[21] The rationale

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15. *Id.*

16. *See, e.g.*, RESTATEMENT (THIRD) OF UNFAIR COMPETITION § 43 (AM. LAW INST. 1995) ("Independent discovery and analysis of publicly available products or information are not improper means of acquisition.").

17. Peter Drahos, *Intellectual Property Law and Basic Science: Extinguishing Prometheus?*, 10 LAW IN CONTEXT 56, 67 (1992). Dan Burk also includes "originality" on the list as a fifth member. Dan Burk, *Research Misconduct: Deviance, Due Process, and the Disestablishment of Science*, 3 GEO. MASON INDEP. L. REV. 305, 310 (1995).

18. Drahos, *supra* note 17.

19. *Id.* at 69.

20. The line likely owes its origin to Bernard de Chartres.

21. *See generally* Thomas R. Ilosvay, *Scientific Property*, 2 AM. J. COMP. L. 178 (1953).

behind such proposals was the failure of the then-current incentive system to promote fundamental scientific research.[22] While that incentive system may have evolved substantially in the near century since such proposals initially appeared, concerns over equitable remuneration for scientific discovery may still be well placed. If the discovery and development of a basic scientific theory were to lead directly, via a separate commercial entity's basic application of the theory, to a very popular product (a hypothetical that is not so far-fetched), then perhaps the possibility of winning an award or receiving other forms of recognition does not sufficiently protect the scientist making the original discovery. That was precisely the problem at the heart of the rivalry in Isaac Asimov's *The Billiard Ball*—the applied scientist made all the money while the theoretical scientist whose work underpinned the applied scientist's remained relegated to relative obscurity.[23]

In view of this problematic scenario, let us offer the remainder of this article as its own sort of scientific theory, or perhaps put more correctly, meta-scientific theory. We shall begin with a hypothesis, test it through a series of arguments, and try to reach a conclusion based on the results of the arguments. The hypothesis initially in question? *Scientific theories are a proper subject of intellectual property protection.*

Yet this hypothesis can be refined even further in view of the limits of current regimes of intellectual property protection. Attempting to accommodate protection of scientific theories within trademark law would be a fool's errand—non-commercial natural phenomena are conceptually too distinct from the commercial confusion and dilution protected by trademark law to suggest a meaningful bridge to that gap. Trade secret, while potentially offering a modicum of protection to the private discovery of a scientific theory, is very likely to be time-limited, particularly if the scientific theory is just waiting to be discovered by a different party.[24] And either way, if the hypothesis aims to test long-

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22. *Id.* at 179 ("But seldom does [the scientist] receive equitable remuneration for his services. The concept of scientific property contemplates legal protection of the scientist's interests by recognizing that he has a right to an appropriate award on account of the industrial application of his scientific discovery or theoretical invention.").

23. ASIMOV, *supra* note 6.

24. It is assumed here that a sufficient number of potential discoverers exists such that some combination of scientific norms promoting publication of discoveries and an eroded value in keeping a given theory secret will lead to public disclosure of the theory. At worst, the secret would become a *secret de Polichinelle*. Practically speaking, however, this may not be the case. For example, very few people have both access to, and knowledge of, something as sophisticated as the Large Hadron Collider at CERN. If CERN were a private entity, that entity could choose not to share its findings with little risk of those theories alternatively being discovered. *See*

term protection for publicly circulating theories, then trade secret is simply inapposite.

These initial refinements in the hypothesis leave patents and copyrights as potential anchoring points for the intellectual property protection of scientific theory. Yet patents also seem to be a questionable choice. As already mentioned, patent protections require utility—something hard to imagine in the case of a scientific theory in the absence of a step *applying* the theory. So, patent law would need to be rewritten for this one-off case.

Patents present additional complications when considered in connection with scientific theories. One is infringement—if Newton had been able to patent gravity, what would it mean to "practice" gravity such that one infringed Newton? It might mean using the equations underlying the theory, in which case all scientists working with Newton's theory might potentially infringe the theory. It might even mean to make use of gravity, in which case Newton would have enjoyed a twenty-year monopoly over keeping all humans planted on Earth. Somewhat related to this *reductio ad absurdum* is the woodenness of patent law in its protections. Professor Peter Lee has spoken of the importance of intellectual property in making a distinction between unprotectable "infrastructure" and protectable "application."[25] Scientific theories currently fall on the side of infrastructure—free for use by anyone who wishes to apply them in their own work (and potentially, to receive intellectual protection in such applications of the theoretical infrastructure).

While copyright and trademark laws feature certain exceptions that maintain a robust infrastructure—like fair use, the idea/expression dichotomy, and genericide—patent law is less flexible.[26] Patent holders effectively can block the practice of their patents for the twenty-year life of a patent.[27] This situation would be especially problematic in the case of patents on scientific theories because such theories are more likely to be *upstream* of further inventions applying them. So, any patent holder in a scientific theory would have potentially much greater

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Drahos, *supra* note 17, at 64 ("At the same time, the cost of industry r&d [sic] has continued to rise. The cost of major science facilities, like particle accelerators, which most countries see as essential to maintaining a high technology capability, amount to billions of dollars. Obtaining scientific truth is now a multi-billion dollar enterprise." (citations omitted)).

25. *See generally* Peter Lee, *The Evolution of Intellectual Infrastructure*, 83 WASH. L. REV. 39 (2008).

26. *Id.* at 45.

27. *Id.* at 41. Technically, patent law does have an exception to infringement liability for "experimental use," but that exception is limited to "strictly philosophical purposes that have no commercial application." Rai, *supra* note 5, at 139. It is not clear that even that exception would overcome patent blocking in the hypothetical space of non-applied science.

influence when enforcing that patent than an inventor simply protecting a patented invention. Instead of the one-to-one comparison between patented invention and potentially infringing device, the scientific theory patent might preempt a broad range of unrelated fields and applications using the theory (and thereby stifling innovation). Accordingly, patent law seems ill-suited as a protective regime for scientific theory.

That leaves copyright.[28] With due respect to commentators who believe that copyright deals "with the arts and [has] no obvious relevance to science at all,"[29] that view misconceives the fluidity that exists between the aesthetic and artistic, on one hand, and the utilitarian and scientific, on the other. Marcel Duchamp's ready-mades were little more than utilitarian objects transplanted directly into the world of art. Emile Zola's *Roman Expérimental* project described how the novelist—more particularly, the naturalist novelist—could reduce the act of writing a novel to the experimental method of the physician Claude Bernard.[30] The latter, it should be recalled, viewed experimental science as leading to a form of absolute certainty, where certain initial conditions in the human body could be shown to lead to corresponding, and correspondingly certain, pathological outcomes.[31]

Literature for Zola and science for Bernard were, at least in Zola's view, one in the same. Meanwhile, as we shall see in more detail later,[32] the arrow directing science into the space of art is bidirectional—artistic and aesthetic tendencies are also capable of informing the process of scientific discovery, which cannot reasonably be reduced to so many dry, un-copyrightable facts. Once there are forms of mechanical literature and aesthetic science, then the simple binary categorization between science and art loses its probative force.

Perhaps in recognition of this fluidity, copyright has developed to protect more than just traditionally artistic and aesthetic works.

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28. Technically, theories might also be granted *sui generis* protection, the likes of which have already been granted for vessel hulls and semiconductor designs. *See* 17 U.S.C. §§ 1301-32 (2012); 17 U.S.C. §§ 901-14. However, in the interest of working with an established body of law featuring certain helpful doctrines like fair use, copyright will be the subject of the hypothesis here. *Sui generis* protection for scientific theories could serve as the basis for a different article under a different hypothesis. Appropriately so, for as we shall see a little later, science is a space where hypotheses abound.

29. Drahos, *supra* note 17, at 58.

30. *See generally* EMILE ZOLA, LE ROMAN EXPÉRIMENTAL (G. Charpentier ed., 2d ed. 1880), http://bit.do/Zola_Le-Roman-Experimental.

31. *See generally* CLAUDE BERNARD, INTRODUCTION À L'ÉTUDE DE LA MÉDECINE EXPÉRIMENTALE, (Paris, Bailliére et Fils 1865), http://bit.do/Bernard_LEtude-Medecine-Experimentale.

32. *See infra* notes 90-108 and accompanying text.

Copyright has been found sufficiently broad to protect dryer content like used car prices,[33] forms compiling baseball statistics,[34] and computer software.[35] Because of a variety of limits built into copyright law (of which are not present in patent law), granting protection to these classes of more functional works is not particularly problematic as a matter of the scope of monopoly. Thanks to the idea-expression dichotomy, a specific set of used car prices might be copyrightable if they reflect the price author's judgment; but the act of setting used car prices, with or without judgment, is not copyrightable. Others may then seek their own copyright prices through their own separate acts of judgment. Similarly, the application of copyright theory to a selected set of statistics in a specific form does not foreclose use of any of the individual statistics within that form, or the compilation of another form using a different set of statistics. Due to the restrictions in section 102(b), software copyright protection does not extend to the functionality of the program, just the expression of that functionality.[36] And in each case, the mere user of the copyrighted work will not infringe the original without exercising any of the rights protected by the Copyright Act.[37] In other words, if the consumer of the used car prices, stats sheet, or software, merely uses the copyrighted artifact without copying, distributing, modifying, or displaying that artifact, then the use is not within the ambit of the Copyright Act.

All of these limits commend copyright as a candidate for the potential intellectual property protection of scientific theories. Much as copyright protects computer code that contains dry content intended to support functionality by protecting only the *expression* of that functionality, so too might a scientific theory be properly viewed as a form of *expression* worthy of protection in the observation and prediction of a particular phenomenon. That expression might be viewed as protectable without reaching the underlying idea of the theory. Further, unlike patent law whose protections would hypothetically impact the use of natural laws if such laws were patentable, copyright's limited set of rights would not impact a mere user of the scientific theory protected by copyright (presuming no other protected rights were implicated in the user's activity). Copyright offers the further attribute of fair use, which would allow many applications of protected scientific theory without requiring the license

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33. CCC Info. Serv. v. Maclean Hunter Mkt. Reports, Inc., 44 F.3d 61, 67 (2d Cir. 1994).
34. Kregos v. Associated Press, Inc., 937 F.2d 700, 704-05 (2d Cir. 1991).
35. Apple Comput., Inc. v. Franklin Comput. Corp., 714 F.2d 1240, 1249 (3d Cir. 1983).
36. 17 U.S.C. § 102(b).
37. *See* 17 U.S.C. § 106.

necessary in a patent-blocking situation. So, let us update the hypothesis proposed for the scientific experiment (or meta-experiment) proposed here: *Scientific theory is the proper subject of copyright protection.*

To test this theory, this Article will rely in no small part on the epistemology and philosophy of science of Pierre Duhem. Who was Duhem? He was something of a modern Renaissance man in the world of science.[38] During Duhem's lifetime (1861-1916),[39] theoretical science witnessed massive upheaval, upheaval in which he participated, if on the "losing" team.

With the late-nineteenth and early-twentieth centuries came the growth of Darwin's evolutionary biology, James Clerk Maxwell's electro-magnetism, Clausius and thermodynamics, Boltzmann's statistical mechanics, the adoption of atomic theory, and, of course, the arrival of relativity via Einstein. Lost in the shuffle of these now-textbook fields of scientific study is the domain of energetics. Often associated with the work of Wilhelm Ostwald,[40] energetics proposed the study of the flow and transformation of energy. Duhem's work supplemented Ostwald's; to this day, the Gibbs-Duhem equation—measuring the amount of free energy in a system based on its volume and temperature—still bears his name.

Despite his contributions to theoretical science, Duhem picked the wrong theory to support. Because of energetics' focus on what moves between objects, it came to serve as an antithesis to atomic theory's object-oriented approach.[41] With proof of the existence of atoms in the

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38. Pierre Humbert estimates Duhem's talent worthy of a professorial chair at the Sorbonne (a chair that he never achieved, instead remaining in Bordeaux for much of his career). PIERRE HUMBERT, LES MAÎTRES D'UNE GÉNÉRATION, PIERRE DUHEM 16 (Paris, Librairie Bloud et Gay 1932), http://bit.do/Les-Maitres-dune-Generation. To demonstrate the scope of Duhem's talents, one need look no further than the titles of Humbert's chapters in his biography of Duhem—"[t]he man," "[t]he physicist," "[t]he philosopher," "[t]he historian," and "[t]he master." Stanley Jaki refers to Duhem as "a giant of the intellect." STANLEY L. JAKI, SCIENTIST AND CATHOLIC: PIERRE DUHEM 17 (Christendom Press 1991).

39. HUMBERT, *supra* note 38, at 9-10.

40. A good description of the debate between Ostwald's energetics and Boltzmann's mechanics is available, see, for example, ÉTIENNE KLEIN, LE FACTEUR TEMPS NE SONNE JAMAIS DEUX FOIS (Éditions Flammarion 2007).

41. HUMBERT, *supra* note 38, at 56; *see, e.g.*, PIERRE DUHEM, L'ÉVOLUTION DE LA MÉCANIQUE (J. Vrin 2000) (1903) *translated in* PIERRE DUHEM, THE EVOLUTION OF MECHANICS (G. Æ. Oravas ed., Michael Cole trans., Sijthoff & Noordhoff International Publishers 1980). Duhem's 1903 book details, among other things, his view of the conflict between atomically-focused theory and his preferred non-atomic view. *Id.* at 87-88. Where theory based on the presumption of the existence of atoms (then not proven to exist, it should be noted) required somewhat strained calculations that sacrificed precision in Duhem's view, Lagrangian mechanics, based only on the relation between artificial parts of a system (though not necessarily atoms), offered a better means of understanding that system. *Id.*

early-twentieth century, energetics was largely discarded, relegated to a footnote in the annals of science along with constructs like phlogiston[42] and ether.[43] Despite the gradual rejection of energetics, which had already begun during Duhem's life, he always considered himself a scientist first and foremost—he even went so far as to reject an academic promotion that would move him from Bordeaux to Paris because the position was not for a physicist, but for a historian of science.[44]

Yet it was in this latter field that Duhem made some of his most notable contributions. Much of his work concerned the period between ancient Greek science and Galileo—a period comprised, in large part, of the Middle Ages. Duhem's arduous research into this supposedly fallow period for science tended to show that rather than present a lacuna between the Romans and the Renaissance, the science of the Middle Ages contributed directly to the developments of the Renaissance.[45] Specifically, Galileo's discoveries followed from an unbroken chain of scientific thought dating at least back to 1200 AD.[46] At the time of his passing, Duhem was in the process of expanding his historical work into what was intended to become a twelve-volume encyclopedia of the history of science from Plato to Copernicus.[47] As if that weren't enough, beyond the practice of theoretical science and its history, Duhem's work even reached the domains of epistemology and the philosophy of science. This Article will rely on many notions familiar to Duhemian philosophy of science in constructing its arguments for and against copyright protection in scientific theory.

It bears note here why the philosophy of science generally, and Duhem's philosophy of science, more specifically, serve to structure the polemic presented here. To answer the first question, inflecting the philosophy of science to address questions of how law should treat

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42. Phlogiston was the substance proposed to explain combustibility. THOMAS S. KUHN, THE STRUCTURE OF SCIENTIFIC REVOLUTIONS (Otto Neurath, Rudolf Carnap, & Charles Morris eds., Univ. of Chicago Press, 2d ed. 2012) (discussing at length its ultimate failure as a scientific construct).

43. Ether, like phlogiston, was a fictitious scientific creation inserted in pre-Relativity models to explain certain deviations from Newton's theory in the behavior of light. *See, e.g.*, PIERRE DUHEM, LA THÉORIE PHYSIQUE: SON OBJET, SA STRUCTURE 29-30 (J. Vrin 2007) (1906) *translated in* PIERRE DUHEM, THE AIM AND STRUCTURE OF PHYSICAL THEORY (Philip P. Wiener trans., Princeton Univ. Press 1954) [hereinafter DUHEM, LA THÉORIE PHYSIQUE].

44. HUMBERT, *supra* note 38, at 17-18.

45. *Id.* at 89.

46. *Id.*

47. See 1 PIERRE DUHEM, LE SYSTÈME DU MONDE: HISTOIRE DES DOCTRINES COSMOLOGIQUES DE PLATON À COPERNIC (A. Hermann 1913) and subsequent volumes, of which seven volumes had appeared in print at the time of Humbert's biography. HUMBERT, *supra* note 38, at 106.

science adds an additional, authentic dimension beyond basic policy concerns more internal to the law itself. Recalling Timothy Terrell's *Flatlaw* article, law as a "Flatlaw" system may be viewed as a two-dimensional, self-contained space of internal rules.[48] Yet that space might also be transcended, where law's two dimensions serve as a sub-component of a three-dimensional space—a reflection of "larger social phenomena" guiding the law from the exterior.[49] Terrell lists "community standards of morality and justice, economic efficiency, group behavior," and "social and political forces"[50] as examples of phenomena that might add a transcendent dimension to the study of law. Here, it is proposed that the philosophy of science furnish a further transcendent dimension by which to consider the legal protections of science from outside the law itself. And a particularly authentic dimension at that, as the philosophy of science normally does for science, what the larger social phenomena mentioned by Terrell can do for the law—they place a domain in contact with itself through a form of external circuitry or added dimensionality. What the philosophy of science can do for science itself, it might just as well do for the law of science—at least we will work from that assumption.

But why Duhem's philosophy of science, in particular? Duhem, of course, is not the only philosopher of science, and any number of other such philosophies could serve equally well, if in very different ways,[51] when held up to the possibility of protecting a scientific theory through copyright law. Some of these possibilities will be presented in any event, but Duhem's theory represents a reasonable spine both due to its generality and due to a few critical ways in which his view of science reflects a way of thinking currently applicable to copyright law. Additionally, where Duhem's theories run into conceptual trouble—as we shall see—is precisely where the application of copyright to scientific theory runs into trouble. So even though Duhem was not a copyright scholar, or even a legal theorist or a lawyer, his theories are particularly well-suited to address questions of copyright law in the space of science.

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48. Timothy P. Terrell, *Flatlaw: An Essay on the Dimensions of Legal Reasoning and the Development of Fundamental Normative Principles*, 72 CAL. L. REV. 288 (1984).

49. *Id.* at 303-04.

50. *Id.* at 304.

51. To name a few possibilities, one could also rely on the mechanistic philosophy of science of a La Mettrie or a Jacques Monod, a theologically-inspired, deductive method à la Descartes, the theory of "personal knowledge" of Polanyi, the doctrine of falsifiability of Karl Popper, the more anarchistic scientific theory of Feyerabend, or the vitalism of Lamarck, Bergson, or Bichat.

This Article was undertaken with no preconceived conclusion, in the spirit of the scientific value of "disinterestedness" proposed by Merton.[52] It will test the hypothesis that copyright law might protect scientific theory openly, by marshalling evidence for both sides of the debate. This certainly could be organized as a dialogue in the nature of Galileo's *Dialogo sopra i due massimi sistemi*, with an updated form of Salviati, in favor of changing copyright law to protect scientific theory, conversing with a more conservative Simplicio in favor of keeping the laws as they are. Yet that might be a bit hard to follow, with a certain layering of circularity preventing meaningful conclusion. Instead, Part II of the Article will present the case for protecting scientific theory under copyright law. Part III will present the case against such protection. In both cases, the arguments will remain mostly restricted to the philosophy of science, with limited forays into the sociology of science. Rather than rely on empirically unsupported assertions the likes of "scientific research *is* currently adequately incentivized" or "scientific research *is not* properly incentivized"—the philosophy of science will provide a more concrete structure whereby such direct, unsupported contradictions may be at least partially avoided. Part IV will offer a conclusion based on the merits of the arguments in Parts II and III. In that way, the hypothesis offered here will be subject to rigorous testing and experimentation to see if it should be accepted as a theoretical possibility, or on the other hand, if it should be set aside like another energetics or phlogiston.

I. An Argument to Protect Scientific Theory under Copyright Law

When attempting to determine the utility of a scientific theory, the traditional distinction between realism and rationalism is of central importance.[53] According to realism, a scientific theory—or any other fact, for that matter—represents an objective truth, a truth that preexists specific human perception and remains exterior to human perception even having been perceived.[54] The scientific fact, model, or theory is not merely a subjective construction; it is reality. The scientist operating in a realist framework does not create the models that she proposes; she merely *reveals* a relation that was there prior to the

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52. Drahos, *supra* note 17.

53. GASTON BACHELARD, LE NOUVEL ESPRIT SCIENTIFIQUE 5-6 (Les Presses Universitaires de France 2013) (1934).

54. BRUNO LATOUR & STEVE WOOLGAR, LABORATORY LIFE: THE CONSTRUCTION OF SCIENTIFIC FACTS 180 (Princeton Univ. Press 1986) (1979).

discovery.[55] According to rationalism, by contrast, scientific theory is a creation of the human mind—an artificial and subjective intermediary used by humans to subject the ever-distinct outside world to more rigorous organization or classification. The fact or scientific model is not merely revealed in rationalism; it is *created* by a series of social actors and forces.[56] Where realism is the province of an empirical worldview that presumes potential contact with the foundations of the reality observed, rationalism favors a more theoretically-motivated approach that applies a gloss of human creation to what is observed.[57] Of course, when the two doctrines are considered in close interplay, each can be viewed as wrapping around the other. For realism to envelop rationalism, one need only view the supposedly rational creation of the human mind as immediately integrated into an ever-growing reality. For rationalism to envelop realism, one need only treat the supposedly real laws discovered by direct contact with reality as a creation of the mind.[58]

Despite the apparent insolubility in the dichotomy separating—or perhaps incomprehensibly muddling—rationalism and realism, the former seems the better-supported approach by which to view modern scientific research and theory. The sociologist Bruno Latour explains the rationalism built into just such research, but then subtly evacuated in the ultimate scientific theory. Such is the outcome of a process of *division* and *inversion*.[59] At the outset of a new scientific project—one seeking a new molecule, for example—a number of hypotheses may be proposed regarding the structure and composition of the undiscovered molecule. As the molecule's structure is discovered with a greater degree of certainty, the hypothesis that ends up successfully reflecting that structure assumes a sort of double meaning—on the one hand, as a mere description in words signifying the newly discovered molecule, and on the other, as the actual molecule itself.[60] With the molecule's newfound reality, the first of these two meanings increasingly splits off and is discarded in favor of the second.[61] Meanwhile, the temporal orientation of the process of scientific discovery undergoes an artificial inversion. Where that process originally posited the molecule as an artificial pre-condition of

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55. *Id.* at 178.

56. *Id.*

57. BACHELARD, *supra* note 53, at 13 (discussing how neither one nor the other is an appropriate theoretical perspective for the entirety of physical theory).

58. *Id.* at 6 (suggesting these doubled constructions).

59. LATOUR & WOOLGAR, *supra* note 54, at 181.

60. *Id.* at 180.

61. *Id.*

research, the ultimately discovered molecule seems to provide a *post hoc* justification for the original hypothesis, such that the discovered molecule can be treated as having always existed. This leads to the realist's tautology whereby the nature of external objects can only be described by the words chosen to constitute them.[62] A rationalist view that conceives of such words as a construction or layer artificially added to reality better describes the products of theoretical science. As a final point in favor of rationalism, a realist viewpoint is hard to square with the nature of science, which François Jacob qualified as "partial" and "temporary."[63] If scientific theory ever reflected reality in its fullness, the theory achieving such perfection would never be replaced. Yet as scientific discovery from ancient Greece until the present has repeatedly shown, no scientific construct intended to reflect reality has achieved anything more than a temporary hegemony over other theories and a close approximation in its predictive calculations.

Pierre Duhem reaches a similar outcome via a slightly different approach. One of his earliest points in *La Théorie Physique, Son Objet, Sa Structure* is to question what a physical theory really is. A theory might be defined in one of two ways—either as an *explanation* of the reality that it models or as a *summary* of that same reality.[64] The explanation/summary dichotomy in many ways maps isomorphically to the rationalist/realist dichotomy. Theory as explanation would be akin to realism, in that the physical theory aspires to explain reality as it is, right down to the final causes that account for attractive or repulsive forces. Theory as mere summary is more rationalist in its reserve, as a summary theory only aspires to predict the mathematical parameters of the relations between objects. Newton's theory of gravity provides a good example of this conflict, and its creator's ostensible belief that his theory was merely a summary.[65] Newton's equations provided a highly-effective model to predict the mechanical motion of various objects in space, such that the freefall of an initially still cannonball from a tower to the ground could be predicted with a high degree of accuracy. Yet that set of mathematical relations does not justify more far-reaching hypotheses as to *why* the cannonball falls as it does.[66] To take this additional step, Duhem argues, is to render a physical theory subordinate to a metaphysical system,[67] which, in turn,

62. *Id.* at 183.

63. FRANÇOIS JACOB, LE JEU DES POSSIBLES : ESSAI SUR LA DIVERSITÉ DU VIVANT 11 (1981) (« partiel » and « provisoire » are his words).

64. DUHEM, LA THÉORIE PHYSIQUE, *supra* note 43, at 27.

65. *Id.* at 80-81.

66. *Id.* at 81.

67. *Id.* at 31.

renders that explanatory physical theory inconsistent with other explanatory physical theories subordinate to different metaphysical systems inconsistent with the original's.[68] Asking *why* of a physical theory via hypothesis introduces the further risk of injecting occult qualities into science.[69] For example, when the seventeenth-century Cartesian philosopher Malebranche considered the phenomenon of billiard balls striking each other, he did not limit his theory to a simple model of the direction and magnitude of the balls' movement on the table, he saw the striking of the ball's as a means of carrying out the will of the divine agent governing the balls.[70] A step like Malebranche's might lead to a clearer notion of reality under his metaphysical system, but it exceeds the rationalist charge of physics as conceived by Duhem. As he notes, "A physical theory is not an explanation. It is a system of mathematical propositions, deduced from a small number of principles, which have the goal of representing as simply, as completely, and as exactly as possible, a group of experimental laws."[71]

This rupture between scientific theory as explanatory hypothesis and scientific theory as mere mathematical summary tracks a dichotomy that Duhem explored in depth in his book *Sauver les apparences*.[72] The dichotomy in question divides the scientific role of the "astronomer" from the role of the "physicist." The task of the astronomer is merely to construct a model that simulates the external world as completely and accurately as possible based on the external appearances of what is being modeled.[73] The astronomer does not pose deeper metaphysical questions of a scientific theory, and will accept it as sufficient if it accurately predicts, for example, the location of a star or the behavior of weights on a lever. The physicist, by contrast, *is* concerned with deeper metaphysical questions.[74] This concern translates to a requirement to select among a series of equally supportable hypotheses to determine which best suits a given

68. *Id.* at 36.

69. *Id.* at 38-39.

70. NICOLAS MALEBRANCHE, DE LA RECHERCHE DE LA VÉRITÉ, at 447 (J. Vrin 2006) *translated in* NICOLAS MALEBRANCHE, THE SEARCH AFTER TRUTH, at 448 (Thomas M. Lennon & Paul J. Olscamp eds., Cambridge Univ. Press 1997) (1674-75).

71. DUHEM, LA THÉORIE PHYSIQUE, *supra* note 43, at 44.

72. PIERRE DUHEM, SAUVER LES APPARENCES : SUR LA NOTION DE THÉORIE PHYSIQUE DE PLATON À GALILÉE (J. Vrin 2d ed. 2005) (1908) *translated in* PIERRE DUHEM, TO SAVE THE PHENOMENA: AN ESSAY ON THE IDEA OF PHYSICAL THEORY FROM PLATO TO GALILEO (Univ. of Chicago Press 1985) (1969) [hereinafter DUHEM, TO SAVE THE PHENOMENA].

73. *Id.* at 15-20.

74. *Id.*

metaphysical system.[75] So for the astronomer, the distinction between equally likely hypotheses is no great matter; for the physicist, it is all that matters.[76] In his historical trace of the astronomer/physicist dichotomy from the time of Aristotle until the sixteenth century, Duhem concludes with a reproach of Kepler and Galilee,[77] who abandoned the astronomer's reserve in favor of a physician's metaphysics. For Duhem, scientific theory is merely the model and the associated set of mathematical equations, not the hypothesis or set of hypotheses that inform it.

Indeed, scientific theory viewed as mere mathematical summary creates a divergence between the theory's content and the hypotheses informing it. On each side of the balance, a certain degree of freedom necessarily remains. Along the lines of what we have seen, Duhem notes that

> more often, physical theory cannot attain [a high] degree of perfection; it cannot offer itself as a *certain explanation* of perceptible appearances; the reality that it proclaims to reside beneath these appearances it cannot make accessible to our senses; it must make do with proving that all of our perceptions are produced *as if* reality was what the law affirms; such a theory is a *hypothetical explanation*.[78]

Yet no hypothetical explanation exists to the certain exclusion of all others.[79] Hypotheses may form the basis for a theory, but they need only be logically consistent when taken together.[80] So if one wishes to hypothesize, as Malebranche did, that a divine force propagates movement among billiard balls, that hypothesis is acceptable as one way of imagining that mechanical interaction. Others, however, might view other hypothetical causes at work which are equally valid, because equally unprovable. This fluidity, and potentially infinite growth, in hypothetical systems flows from Duhem's proposition that there is no such thing as an *experimentum crucis*.[81] The latter, it may be recalled, is a logical construction by which hypotheses may be tested experimentally and winnowed serially by a sort of process of elimination. If, for example, there were but two possible hypotheses for

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75. *Id.*

76. *Id.* at 36.

77. *Id.* at 146-48.

78. DUHEM, LA THÉORIE PHYSIQUE, *supra* note 43, at 29.

79. DUHEM, *supra* note 41, at 77-78, 81. Duhem speaks of the rupture in the mechanics of his time between those who posited the existence of atoms and those that did not. Each was an acceptable view in terms of the consequences drawn from each theory.

80. DUHEM, LA THÉORIE PHYSIQUE, *supra* note 43, at 44.

81. *Id.* at 265-66.

a given phenomenon—Duhem provides light as either a particle or a wave as an example of two such hypotheses[82]—then one experiment designed to distinguish between the two hypotheses would lead to the certain rejection of one and the acceptance of the other. What the proponent of the *experimentum crucis* forgets, however, is that hypotheses three, four, five, and so on are also equally possible and have not been tested. The near-infinite overgrowth of hypotheses possible for a given phenomenon is not amenable to much metaphorical trimming either, as any experiment produces its own internal, insurmountable complexities. Such complexities flow from the number of conditions needed to control a phenomenon experimentally, the remarkable edifice of theory implied by a given experiment, the tooling relied upon for experimentation, and other sources of error that remain inevitable. Hypotheses grow with alacrity, in Duhem's view, and shrink with hesitation.

The same may be said of mathematical models. There remains an irresolvable difference between empirically-observed facts and the mathematical equations used to model them.[83] In that difference resides a good bit of mobility in translation between a practical fact and its theoretical representation. A single observed fact may thereby fan out into an "infinity" of theoretical representations.[84] The mathematical equations and associated theoretical constructions are not a mere one-to-one proposition with respect to reality; they are open to infinite variation and permutation. So, both hypotheses and mathematical models typically offer a freedom in construction that goes well beyond the often-singular set of equations presented for a given theory. If Newton had been inclined to hypothesize,[85] an infinite number of hypotheses might have explained gravity. And if he had wanted to alter his mathematical model, an infinite number of additional equations might have effectively served the same mathematical end.

The notable exception in Duhem's theory to science's realm of endless possibilities is what he calls *la classification naturelle*,[86] the natural classification. The natural classification is a point of passage by which a theory becomes more than a mere arbitrary layer of

82. *Id.* at 264.

83. *Id.* at 191.

84. *Id.* at 192. *See also* DUHEM, *supra* note 41, at 50 (highlighting that when one attempts to describe the forces at play in a mechanical system, there remains at all times the possibility of substituting an infinity of alternative forces to describe that movement).

85. There remains some debate as to whether Newton actually intended to hypothesize as to the underlying cause or meaning of gravity. But Newton himself claimed to avoid that temptation. *See* DUHEM, *supra* note 41, at 34.

86. DUHEM, LA THÉORIE PHYSIQUE, *supra* note 43, at 50.

mathematical laws and hypotheses placed between reality and the scientific observer. Without going so far as to explain the fundamental reality of the phenomena modeled, a theory touching on the natural classification achieves a reflection of the "real affinities" at play in those very phenomena.[87] Again, science does not satisfy the realist's ambitions via a natural classification—Duhem is still careful to use the word "image"[88] to describe even the most perfected theories. Yet it does asymptotically seem to reach an evanescent point of contact joining the logical and the ontological.[89] In view of this ethereal perfection, it is not surprising that natural classifications do not come around particularly often. Duhem reserves the designation for only those theories that have achieved a high degree of perfection in their predictive function and often, a high degree of aesthetic beauty in their articulation.[90]

With a sufficient background in Duhem's philosophy of science in tow, we can now return to the hypothesis proposed here—that the models, equations, and hypotheses of a scientific theory might be worthy of copyright protection. To merit copyright protection, a work must qualify as "original" within the meaning of the Copyright Act. "Originality" is comprised of two elements: (1) original creation by the author or creator of the work, and (2) evidence of a modicum of creativity in the work.[91] Each of these requirements merits attention when considering the potential copyrightability of scientific theory.

As to the originality of creation of a scientific theory, the discussion of the distinction between rationalism and realism has tended to demonstrate that a scientific theory is not merely the product of nature or a set of dry facts. Were it simply the scientist's job to reveal the inner workings of nature in its theoretical form, then the resulting theory would scarcely qualify as original to the scientist; it would be original to the external universe being studied. As the Supreme Court has noted,

> It is this bedrock principle of copyright that mandates the law's seemingly disparate treatment of facts and factual compilations. No one may claim originality as to facts. This is because facts do not owe their origin to an act of authorship. The distinction is one between creation and discovery: the first person to find and report a particular fact has not created the fact; he or she has merely discovered its existence. To

87. *Id.* at 52.
88. *Id.* at 53.
89. *Id.*
90. *Id.* at 50.
91. Feist Publ'ns, Inc. v. Rural Tel. Serv. Co., 499 U.S. 340, 346 (1991).

> borrow from *Burrow-Giles*, one who discovers a fact is not its "maker" or "originator."[92]

Scientific discoveries, however, are not simple facts. As Latour explained, the development and experimentation that lead to a new scientific fact or theory are not simply a process of revelation or discovery, but of *creation*.[93] The scientist, by a trick of inversion, may ultimately lead colleagues and the consuming public to believe that a given theory *is* reality; yet this is an incorrect way of couching the theory. Minus this artificial inversion, scientific theory is revealed for what it really is—something that did not exist prior to the scientist's creation of it. Duhem's philosophy would reach a similar conclusion via the distinction between scientific theory as summary and scientific theory as explanation. As the proper ambit of theory is a summary in Duhem's view, theory can never achieve the pure reflection of reality that would reduce it to mere fact. Indeed, scientific theory is *neither true nor false* in the manner of a common-sense fact;[94] it is merely an approximation,[95] one of many possible summaries of a given natural phenomenon. So, in view of either a Latourian or Duhemian perspective, the first of the two requirements of originality under the Copyright Act seems satisfied here.

That leaves the question of creativity, and once again, the view of scientific theory as proposed by Duhem would seem capable of evidencing just such creativity. By almost any measure that a court might use when determining the presence of creativity in a work, a scientific theory might potentially merit copyright protection as creative. One might first consider the case originating the creativity standard in copyright, *Feist Publications, Inc. v. Rural Telephone Service Co.* In that case, the Supreme Court considered the copyrightability of the traditional white pages of a phone directory,[96] and ultimately denied copyright protection to the phone directory because it was not sufficiently creative.[97] Although the Court was not particularly clear in what actually did qualify as sufficiently "creative," it did leave a few clues here and there in its opinion. On the one hand, the Court set a very low bar for the creativity necessary to merit copyright protection—a "modicum"[98] of creativity would suffice. It

92. *Id.* at 347 (citations omitted).

93. *See* BRUNO LATOUR & STEVE WOOLGAR, *The Creation of Order Out of Disorder*, *in* LATOUR & WOOLGAR, *supra* note 54, at 235-38, 244-46.

94. DUHEM, LA THÉORIE PHYSIQUE, *supra* note 43, at 242.

95. *Id.*

96. *Feist*, 499 U.S. at 342-44.

97. *Id.* at 342-44, 363.

98. *Id.* at 346.

further clarified, "the requisite level of creativity is extremely low; even a slight amount will suffice. The vast majority of works make the grade quite easily, as they possess some creative spark, no matter how crude, humble or obvious it might be."[99] Yet the Court found the white pages at issue to be entirely "garden-variety"[100] and "devoid of even the slightest trace of creativity."[101] What qualifies as "creative" may not be very clear, yet it is clear that very little creativity is necessary to satisfy this standard, and that only the most rote and obvious works—like a strictly alphabetical listing of names and their phone numbers—will fail to evidence sufficient creativity.

If the Court's language in *Feist* is generally vague and tautological, lower courts have attempted to provide precision as to what creativity might mean in the context of copyright law. The Federal Circuit's recent decision in *Oracle America, Inc. v. Google Inc.*,[102] represents one common approach to creativity, by looking to the presence of sufficient alternative forms of expression for a given idea. As the court noted when considering the copyrightability of Oracle's Java language, "copyrightability is focused on the choices available to the plaintiff at the time the computer program was created."[103] Similarly, Google's Android operating system could be found infringing of the copyrightable Java language because, among other reasons, "Google could have structured Android differently and could have chosen different ways to express and implement the functionality that it copied."[104] The Second Circuit in *Matthew Bender & Co. v. West Publishing Co.*,[105] offered a similar view as to copyrightable creativity, "when it comes to the selection or arrangement of information, creativity inheres in making non-obvious choices from among more than a few options."[106] Still other courts have relied on similar reasoning when determining a work's copyrightability.[107] So thus far,

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99. *Id.* at 345.

100. *Id.* at 362.

101. *Id.*

102. Oracle Am. Inc. v. Google Inc., 750 F.3d 1339 (Fed. Cir. 2014).

103. *Id.* at 1370.

104. *Id.* at 1368.

105. Matthew Bender & Co. v. West Publ'g Co., 158 F.3d 674 (2d Cir. 1998).

106. *Id.* at 682.

107. See, for example, Am. Dental Ass'n v. Delta Dental Plans Ass'n, 126 F.3d 977 (7th Cir. 1997), where the Court reasoned that classifications or taxonomies might merit copyright protection because

> [c]lassification is a creative endeavor. Butterflies may be grouped by their color, or the shape of their wings, or their feeding or breeding habits, or their habitats, or the attributes of their caterpillars, or the sequence of their DNA; each scheme of classification could be expressed in multiple ways. Dental procedures could be classified by complexity, or by the tools necessary to perform them, or by the parts

creativity appears to require both an element of authorial selection or judgment by a work's creator, and the presence of sufficient alternative expressive alternatives available to the creator making such a selection in view of the work's unprotectable idea.

The creation of a scientific theory is capable of satisfying each of these elements under Duhem's philosophy. This much may be shown both for scientific theory as a set of hypotheses and for scientific theory as a set of mathematical symbols, equations, or models. To model the movement of the Sun, traditional astronomy could propose either an eccentric circle or an epicycle, and each could be modeled mathematically.[108] Modern astronomy, of course, has come to model the Sun as a point around which the Earth rotates along an elliptical orbit. Other variations on these hypotheses are undoubtedly possible—Duhem noted the possibility of infinite hypotheses to explain a phenomenon, where the choice among hypotheses was a mere question of metaphysics and not pure science. If one wishes to hew to a mostly disfavored view of geocentrism, one has the eccentric and epicycle theories as choices. If one wishes to adopt the philosophical stance of Galileo, one may adopt the elliptical model. If one wishes to be more creative, any number of other choices are available. In the space of hypotheses, there is evidently the possibility of adequate choice for at least some scientific theories —Duhem's use of the word "infinite" is telling in this respect. Further, the scientist is free to choose among the universe of possible hypotheses using the sort of personal (or metaphysical) judgment that characterizes a finding of creativity in previous court decisions.

Exactly the same may be said of the specific models and equations that make up a scientific theory. Newton was free to propose an equation that based gravity on the reciprocal of the square of the distance between two objects (among other things), and that did not preclude Einstein from developing a theory of relativity that very differently models gravity via his field equations. Any number of mathematical representations for a given theory are possible, not just as between different theories in the Newtonian and Einsteinian cases,

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> of the mouth involved, or by the anesthesia employed, or in any of a dozen different ways.

Id. at 979. See also, *Lexmark Int'l, Inc. v. Static Control Components*, where the Court concluded that certain copier codes were not copyrightable. 387 F.3d 522 (6th Cir. 2004). In this respect, it faulted the district court's previous finding of alternatives in the codes by noting that the possible use of other constants in the codes "do not appear to represent alternative means of expressing the ideas or methods of operations embodied in the Toner Loading Program; they appear to be different ideas or methods of operation altogether." *Id.* at 540.

108. DUHEM, TO SAVE THE PHENOMENA, *supra* note 72, at 16.

but within a single theoretical framework. Mathematics is generally a pliable enough field that many different equations can be relied upon to achieve effectively the same set of results. Although they were ultimately rejected, eccentrics and epicycles did a reasonable job of predicting the movement of various celestial bodies, and those two could be used in some respects as a near one-to-one replacement for a set of calculations based on the elliptical orbits of the planets of the Solar System. This sort of mathematical openness and interchangeability, which pervades any number of domains beyond simple mechanics, speaks to the possible presence of sufficient alternatives for a finding of copyrightable creativity in the selection of one particular set of mathematical equations or models for a given theory. Further, as the scientist selecting such mathematical symbolism for a theory will often have exercised more than a "garden-variety" amount of judgment,[109] the second prong of the creativity test regularly applied by courts will equally be satisfied. Mathematical models in support of scientific theory should, in principle, be susceptible of the sort of creativity that merits copyright protection.

Even where scientific theory most approaches reality—via the *classification naturelle*—it still is capable of evidencing creativity. Again, despite the purported perfection and elegance of a theory that achieves the rare reflection of the *classification naturelle*, that theory is still only an approximation of reality—it has not passed into the space of the real by virtue of its highly-predictive modeling. Yet might it be *too close* to reality to merit copyright protection? One might argue this point by noting that there are very few alternatives that embody the proposed scientific theory with such clarity, economy, or accuracy. For want of alternatives, copyright should be hesitant to grant an overbroad monopoly on a theory that is both necessary to other researchers and hard to replace. This argument may be answered by noting that this leads to the somewhat perverse outcome that the scientists generating the most elegant theories would fail to receive copyright protection while lesser scientific theories are rewarded for their inaccuracies and lack of economy. The argument is doubly persuasive in view of Duhem's belief that theories that reflect the *classification naturelle* are

109. *See* Burk, *supra* note 17, at 334 ("The scientist chooses carefully and deliberately what aspects of his research deserve to be reported. In doing so, he exercises the creativity that lies at the heart of science. The universe is far too complex to be completely and accurately described by humans; science presents not a comprehensive description of nature, but rather a simplified model that the human mind can grasp. The essence of scientific genius is the ability to choose what ought to be included in the model, and what ought to be left out."). It should be noted that this citation supports not only the premise that scientists exercise a form of creative authorial choice, but also that their models and theories are not realist, but rationalist, in nature.

sources of the highest form of aesthetic beauty in science. Aesthetic beauty and artistry are precisely what copyright has always sought to protect—there is no reason the most aesthetically-pleasing books and paintings should be eligible for copyright protection while the embodiment of the most beautiful scientific theories is not (and certainly not if we are willing to accord copyrightability to other theories).

Affording copyrightability to scientific theory would not necessarily run afoul of copyright's bedrock principle—the utilitarian theory of copyright. The utilitarian theory operates on a premise of exchange—by granting artists, musicians, authors, and other creators certain economic incentives in their work, those creators will be more likely to create and circulate their work.[110] This exchange requires a certain balance to be struck in the incentives and goods to be exchanged, lest one side unduly profit at the other's expense. If, for example, a copyright protected no more than the exact words in a book or the exact notes in an entire song, then would-be infringers could get off with strictly *de minimis* changes to an original work, and the economic incentives to create would suffer. If, on the other hand, a copyright protected a work so thoroughly as to cover the very general idea of the work, fundamental ideas necessary for future works would be monopolized by the first person to embody them in any work at all, and society would suffer for lack of both non-infringing protected works and an ample public domain. Fortunately, copyright law mostly avoids these obvious pitfalls (and others less obvious) by maintaining a dichotomy, mentioned above, between unprotectable "infrastructure" and protectable "application." Professor Peter Lee defines unprotectable infrastructure according to three criteria:

> (1) the resource is at least partially nonrival;
>
> (2) it derives its primary social value from facilitating downstream productive activity; and
>
> (3) it serves as an input into a wide range of goods and services, including private, public, and nonmarket goods. Extended to intellectual property, intangible resources satisfying these criteria qualify as intellectual infrastructure.[111]

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110. *See* Lee, *supra* note 25, at 52-53 ("Although the 'immediate effect' of copyright law 'is to secure a fair return for an 'author's' creative labor,' the 'ultimate aim is, *by* this incentive, to stimulate artistic creativity for the general public good.'" (emphasis added)) (citing Twentieth Century Music Corp. v. Aiken, 422 U.S. 151, 156 (1975)).

111. *Id.* at 55.

By way of clarification, the first factor turns on the resource not being diminished by additional use;[112] the second views the resource as more of a means of communication than an end in itself; and the third, of course, speaks to the need for subsequent reuse of the resource.[113] It makes perfect sense that words or general ideas would be considered infrastructure according to this definition, as each serves as a means to support endlessly growing downstream production.

Although natural laws end up lumped in with words and ideas,[114] it is less clear why such laws, at least embodied in the form of scientific theory, should necessarily qualify as infrastructure. While scientific theory may lead to a variety of downstream creation—both educational and applied, that does not mean that scientific theory does not serve as an end in and of itself. Scientific theory is a human construction to improve understanding of natural phenomena and perhaps even to bend reality to the theoretical construction, if Gaston Bachelard's view of relativity is to be believed.[115] Such a construction can both be created and stand on its own, without any further application. That is science in its purest form—that someone might come along to profit from it by applying it downstream seems all the more reason to *protect* scientific theory against such exploitation. In some respects, the infrastructure construction may be an ill fit in this particular case.

In others, though, infrastructure's division may be a good fit in support of the protection of scientific theory. Copyright law's preservation of necessary infrastructure relies on two key limits in copyright's scope—fair use and merger—that makes it a good candidate to protect scientific theory without *overprotecting* scientific theory.

Fair use, defined generally if wordily, is an exception to infringement where a party that has no rights to a copyrighted work may under certain circumstances exercise protected rights in that work without a license from the work's owner.[116] The exception is based on the understanding the intellectual progress often means that current work must be based in part on prior work and must be able to access, retransmit, and transform such work. Parodists need to be able to use the original work that they parody to a certain extent.[117] Academic commentators need to be able to quote the original works on which

112. *Id.*

113. *Id.* at 56.

114. *Id.* at 54.

115. *See generally* GASTON BACHELARD, LA VALEUR INDUCTIVE DE LA RELATIVITÉ (J. Vrin 2014).

116. 17 U.S.C. § 107 (2012).

117. *See, e.g.,* Campbell v. Acuff-Rose Music, Inc., 510 U.S. 569 (1994).

they comment. Teachers need to be able to instruct their students in reliance on original works, not paraphrases contrived to attempt to avoid infringement. Fair use exists to allow such practices and others like it.

The doctrine, which draws its origin in the common law,[118] but has since been codified in statutory form,[119] defines the circumstances where a use will be deemed "fair" based on a four-factor balancing test. The four factors to be considered are: (1) the purpose and character of the use, including whether it transforms the original, or is for educational, academic, or non-commercial purposes, (2) the nature of the original copyrighted work—that is, whether it is more or less creative, (3) the amount of the original work used, both qualitatively and quantitatively, and (4) the effect that the use will have on the market for the original work.[120] Either the great attribute or the great fault of fair use—depending on one's view—is that it allows for no bright-line rules; but the statutory factors and case law do provide certain high-level data points. Uses are likely to be found fair if they tend to: (1) be more transformative of the original,[121] (2) borrow from a more functional or dry source,[122] (3) use less than all of the original work, including avoiding using the heart of the work,[123] and (4) have little or no impact on the market of the original.[124] As the test is based on a weighing of factors, however, a use does not need to "win" on all four factors to be found fair.

Even in view of this high-level background, it is easy to imagine how fair use would accommodate the use of a protected set of scientific models, equations, or hypotheses in certain key cases. The most typical examples would involve the use of the theory in an academic or scholarly setting—as fodder for a conference talk, a journal article, or a textbook. In each of these cases, the argument for fair use will often

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118. The case offered as a historical origin for the doctrine is *Folsom v. Marsh*, 9 F. Cas. 342 (C.C.D. Mass. 1841) (No. 4,901).

119. 17 U.S.C. § 107.

120. *See id.*

121. *See, e.g.,* Blanch v. Koons, 467 F.3d 244, 250 (2d Cir. 2006) (finding use of a photograph transformative when used as generic raw material for a larger artistic work); Seltzer v. Green Day, Inc., 725 F.3d 1170 (9th Cir. 2013) (finding the use of a modified piece of artwork during Green Day's concerts sufficiently transformative).

122. Peter Letterese & Assocs. v. World Inst. of Scientology Enters. Int'l, 533 F.3d 1287, 1312 (11th Cir. 2008) ("Works that are 'closer to the core of intended copyright protection,' and thus merit greater protection, include original as opposed to derivative works; creative as opposed to factual works; and unpublished as opposed to published works.").

123. Campbell v. Acuff-Rose Music, Inc., 510 U.S. 569, 587 (1994) (This factor "calls for thought not only about the quantity of the materials used, but about their quality and importance, too.").

124. *Id.* at 590.

be compelling. Most critically, under the first factor, the use would be non-commercial in many cases, as the conference talk or article may not involve direct compensation. The uses would be academic, a type of use explicitly mentioned in the statute as favoring a finding of fair use. Finally, the uses would be very likely to be transformative, for even if the entire equation or model was reproduced, it would be within a larger work that altered the theory's context by critiquing it, classifying, or explaining it along with other scientific theories. In other words, later scientific users would be likely to be producing new and valuable material based on the original equation rather than simply exploiting it as a source of misappropriated gain.[125] Meanwhile, commercial users relying on an entire theory for commercial gain would be less likely to be deemed non-infringing due to fair use. Those users would by definition be commercial in nature; they would be taking the entirety of a work; and they would be operating in a derivative market that the theorist might have leveraged for commercial gain. If fair use were to work this way for scientific theory—by excusing the academic user while demanding license fees of the commercial user—it would seem to be serving its core aim, the promotion of a wholly equitable result.

The merger doctrine would serve a similar end by eliminating copyright protection entirely for certain scientific theories. As the word "merger" suggests, merger doctrine applies when a work's idea and its expression are deemed to merge—in other words, when an idea admits of so few different alternative forms of expression that the idea and the expression are effectively one and the same. In such cases, a work is not eligible for copyright protection. Examples of merger have occurred in cases involving a map of a pipeline route,[126] a set of box-top instructions,[127] and a building code subsequently adopted as law in a Texas town.[128] These cases share a very limited space in which the idea may operate. Once a pipeline route has been selected, its map follows as a matter of course. Box-top instructions to make a purchaser aware of a contest or a rebate tend to be fairly sparse and strictly informational. A building code, once adopted into law, has transformed into an inflexible, uncopyrighted artifact. One can imagine a scientific theory that would offer a similar lack of openness, due to the simplicity

125. Maxtone-Graham v. Burtchaell, 803 F.2d 1253, 1259 (2d Cir. 1986) ("From the earliest days of the [fair use] doctrine, courts have recognized that when a second author uses another's protected expression in a creative and inventive way, the result may be the advancement of learning rather than the exploitation of the first writer.").

126. Kern River Gas Transmission Co. v. Coastal Corp., 899 F.2d 1458 (5th Cir. 1990).

127. Morrisey v. Procter & Gamble Co., 379 F.2d 675 (1st Cir. 1967).

128. Veeck v. S. Bldg. Code Cong. Int'l, 293 F.3d 791 (5th Cir. 2002).

of both the theory's idea and the phenomenon modeled, and the lack of alternative means of constructing an equivalent theory. Where Duhem's proposed openness finds a real-life counterexample, copyright will not honor that theory with its protection—perhaps all the more reason to trust Duhem's theory in the first place. Either way, between fair use and the merger doctrine, copyright offers two key means for protecting a robust public domain, even if scientific theory were to become copyrightable.

We might close this argument with an evocation of an image offered by the French academician Michel Serres. His book *Le Parasite* is—consistent with most of his work—a meditation on information theory and on information's susceptibility to error in transit, its decay in time, amid the overarching chaos of pure noise.[129] Information is not just the message traveling on an electrical wire or other network, however; information is any arrangement that breaks from the chaotic equilibrium, be it a machine, a living organism, or an unusual concentration of gas particles. It is the Lucretian *clinamen* rippling turbulently amid a field of unidirectional, laminar flow. In all things, both order and chaos, information and noise are capable of co-existing and interacting in an ever-evolving cycle. So, when Serres speaks of treating a certain arrangement of atoms (like a human body) as a "system," he highlights the side of the system often neglected. Where most see the system as a site of overarching order, Serres is quick to recall that this externally-constructed (and externally-projecting) information retains an internal double of noise and chaos that continue to exist within the system despite its apparent containment. For example, in the system tracking the interaction between oxygen and the human body, one is quick to recall that oxygen is a beneficial source of heat yet quick to forget that oxygen is also a part of the oxidation process that is aging.[130] The system is a black box that simultaneously reveals a certain amount of information about the relations selected all while interposing an opaque barrier between the observer and the chaotic or deviant behavior that remains within the system.[131]

In its latter ignorance, the system is not knowledge, but "non-knowledge."[132] Serres views knowledge as a bridge between pure chaos and system.[133] If this be the case, then knowledge is a form of transit, of transformation, that can only meaningfully generate

129. *See generally* MICHEL SERRES, LE PARASITE (Pluriel 2014) (1980) *translated in* MICHEL SERRES, THE PARASITE (Lawrence R. Schehr, trans., Johns Hopkins Univ. Press 1982).

130. *Id.* at 72.

131. *Id.* at 73.

132. *Id.*

133. *Id.*

understanding through the creation of systems. Science and scientific theory clearly merit this treatment. What this suggests is still another dimension of indeterminacy in the creation of scientific theory.

Where to this point in the Article Duhem's philosophy has highlighted the fundamental openness in *translation* between observed phenomenon and the resulting scientific model or theory, Serres would add that indeterminacy also exists *within* the model or theory finally proposed. By selecting a certain set of conditions and mathematical symbols, certain behaviors in a system may be modeled well, but there ever remains a fringe within the system which does not align with a model's predictions, that remains unpredictable and unknown. This additional space of indeterminacy, of Brownian motion, of chaos serves as a reminder that scientific theory is never complete and never completed. It is instead an ever-open and ever-evolving set of constructs that require as much creativity fed into the choice of a system and its parameters as it requires pure factual observation and tabulation. Irreducible movement and creativity is the hallmark of what copyright law protects. Accordingly, copyright law should be open to protecting scientific theories.

II. AN ARGUMENT NOT TO PROTECT SCIENTIFIC THEORY UNDER COPYRIGHT LAW

The distinction between rationalism and realism is an equally good starting point for an argument *against* the copyrightability of scientific theories. To justify potential protection for scientific theory, recourse to a rationalist point of view is necessary, as realism could not possibly accommodate protection. If the equations and models of scientific theory *are* in fact reality, then granting copyright in such works would be tantamount to granting legal control over reality. That would quite obviously run afoul of the section 102(b) prohibitions on copyright protection—that copyright does not protect any "idea, procedure, process, system, method of operation, concept, principle, or discovery."[134] Scientific theory as reality would be relegated to simple principle tethered to natural phenomena, mere discovery of pre-existing reality, stripped of any Latourian inversion.[135]

Beyond the language of section 102(b), the policy motivating it—the utilitarian theory of copyright protection—would suffice to show that a realist construction of scientific theory would not provide the basis for any copyright protection in scientific theories. It may be

134. 17 U.S.C. § 102(b) (2012).

135. *See supra* notes 59-62 and accompanying text.

recalled that the utilitarian theory aims to strike a balance in protection such that creators retain sufficient economic incentives to create without giving such creators *too much* protection in the interest of preserving a rich public domain for subsequent creators. Granting copyright in *reality* is a form of clear overprotection, where copyright's comfort zone shielding specific words on a page or bits on a drive morphs into an uncomfortable protection of the very phenomena that happen in the perceived universe. We would effectively be back in the *reductio ad absurdum* case where intellectual property in Newton's gravitational equations would allow a modern Newton to exact royalties for activities like sitting in a chair or jumping up and down. That would represent an unacceptable level of economic control for a creator at the expense of the public domain.

Yet arguments against the copyrightability of scientific theories do not require espousing a realist perspective—the protection of theories need not be any more palatable under a rationalist view. Because the rationalist argument in favor of copyright protection for scientific theory is already well-established, the rationalist argument against protection of scientific theory will require a bit more development. First, it will be necessary to flesh out certain important details of Duhem's philosophy of science that were critically left underarticulated in the first part. For all of the seeming equivalence that Duhem viewed as built into scientific theory in both hypotheses and mathematical models, he was also aware of—if occasionally somewhat refractory to—science's tendency to advance better and better models. Thereafter, it will be necessary to move beyond Duhem's thought by demonstrating certain ways in which his philosophy of science is arguably inadequate to capture the movement of science, even as a rationalist endeavor. This will require a certain degree of reliance on Kuhn's *The Structure of Scientific Revolutions*.[136] Lest this move seem to violate an unspoken rule of argument here, it should be noted that critics have seen Duhem's work as thoroughly anticipating Kuhn's by fifty or so years.[137]

To present Duhem's philosophy as it was in the first part of this Article is to depict the great edifice of scientific theory as a completely relative, interchangeable, and open construction. Any scientific theory is potentially open to being expressed—either as a hypothesis or as a mathematical model—in the form of infinite unexpressed alternatives. If each potential theory were a node in a great network, scientists could

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136. KUHN, *supra* note 42.

137. Paul Brouzeng's introduction to Duhem's *La Théorie Physique* claims as much. *See* DUHEM, LA THÉORIE PHYSIQUE, *supra* note 43.

pass from one equivalent node to the next without loss in predictive precision. Any scientist unhappy with the node that current science favored could simply shift to an adjacent equivalent and continue to produce good results. To add a temporal dimension to this, science would also be able to jump without substantial loss of precision between theories propounded at very different times. Take, for example, the difference between Ptolemaic epicycles, post-Galilean ellipses, and the more complicated motion of Einsteinian relativity when modeling the movement of the planets around the Sun. In its most open form, Duhem's theory would seem to view these, and an infinite number of mathematical alternatives, as effectively equivalent ways of modeling the same thing.[138] Science is in this respect wholly *reversible*, able to pass seamlessly between different theories, both forwards and backwards in time. Science couched in these terms is *Newtonian*, for Newton's equations yield the same results without regard to the direction of the time vector. Anything that has been done under Newton's laws can be undone and redone infinitely.[139] To support copyright in scientific theory, one must favor this open temporality which, in turn, leads to infinite generativity in the realm of possible scientific theories. And if infinite equivalent models are possible, then no scientific creator risks accruing a problematic monopoly over intellectual property infrastructure. On the contrary, all scientific theory could safely be viewed as a form of protectable intellectual property *application*.

This is not even how scientific theory works within Duhem's philosophy, however. The freedom to express alternatives in any number of ways is automatically trimmed according to two critical criteria—economy of thought and the temporally-bound, accretive movement of science via the *classification naturelle*. Economy of thought as key in the creation and perpetuation of scientific theories—an idea often associated with the scientists Ernst Mach[140] and Henri Poincaré—speaks to a successful theory's lapidary way of distilling incredible complexity to a manageable and memorable snapshot.[141] One can easily be overwhelmed imagining the disparate number, type,

138. DUHEM, *supra* note 41, at 188-89.

139. This is Ilya Prigogine's complaint about Newtonian physics and any scientific theory that relies on such a construction of time. *See generally* ILYA PRIGOGINE & ISABELLE STENGERS, LA NOUVELLE ALLIANCE (Folio, 2d ed. 1986) (1978); *see also* ILYA PRIGOGINE, LA FIN DES CERTITUDES (Editions Odile Jacob 1996).

140. Duhem offered a very favorable review of the first French translation of one of Mach's works. He also noted Mach's claim to have been the first to highlight economy of thought as a driving factor in the creation of scientific theory. DUHEM, *supra* note 41, at 444.

141. DUHEM, LA THÉORIE PHYSIQUE, *supra* note 43, at 46-48.

size, and shape of mechanical bodies governed at least generally by Newton's gravitational and force equations. Newton's equations allow much of this variety to be treated as mere noise, while focusing on critical variables like the mass of the objects in question and their distance apart. With these critical data points in tow, meaningful calculations are possible via a few easily-recalled equations. If a variety of other mathematical equations might approximately achieve the same numerical results as Newton's equations, basically every such equation would be more difficult to remember and use than its Newtonian analogues. The same could be said of other similarly economical formulae, like Snell's Law to measure the refraction of light, Einstein's relation between mass, energy and the speed of light ($E = mc^2$), and the ideal gas law.

The *classification naturelle* exerts a dual limitation on the possible existence of alternative means of expressing a scientific theory. One such limitation is temporally based; the other is linked to predictive precision. The two limitations generally evolve in tandem, however, where change in theory over time is closely linked to improvement in theory's predictive results.[142] Because of the improved precision of theories that merit the designation of a *classification naturelle*, science is ever undergoing an accretive, unidirectional process of improvement where theories provide closer and closer predictions of the behavior of natural phenomena.[143]

Duhem provides an analogy for precisely the tension at issue here—the observer of the ocean's waves from the shore.[144] Such an observer will very clearly see the seemingly haphazard struggle of one wave crashing into another, or a set of waves pulling back into the ocean as another pushes its crest shoreward. Yet beneath the stochastic noise and seeming lack of progress of these movements, there is a guided movement, that of the tide coming in or going out. The proponent of copyright protection in scientific theory would ask to see

142. A notable exception to this tandem growth is string theory in astrophysics. Unlike Newtonian mechanics and Einsteinian relativity before it, string theory has not made particularly meaningful predictions to explain anomalous observations not yet understood. This is in part due to the lack of a single monolithic string theory (there are infinite possible string theories, so perhaps copyright law would not be ill-applied here), and in part because of the lack of testability of much of what any such string theory posits. All of this has led one notable physicist to refer to string theory as a fallow field granted institutional importance only through a sort of groupthink. *See generally* LEE SMOLIN, THE TROUBLE WITH PHYSICS (Mariner Books 2007) (2006).

143. There is a reason that one of Duhem's books contains the word *evolution* in its title. In that case, Duhem speaks of the evolution of mechanics. Mechanics in Duhem's time, he proclaims in the final paragraph of his book, was a corollary to mechanics reaching back to ancient Greece and would undoubtedly serve as a corollary for future development in the field. DUHEM, *supra* note 41, at 188-89.

144. DUHEM, LA THÉORIE PHYSIQUE, *supra* note 43, at 38-39.

only the frothy turbulence of scientific movements crashing into each other chaotically, without guided movement. All waves are more or less equal, that proponent suggests, and can be swapped in and out of human conception with little or no loss. That proponent misses the ocean's movement for the waves (and the forest for the trees, of course), as science pursues a process that is often as much *irreversible* as it is *reversible*.

To take the three examples provided above, one cannot seamlessly slip between Ptolemaic, Galilean, and Einsteinian theoretical systems. Ptolemy's epicycles may have developed mathematically accurate predictions as to the locations of planets and stars, but it relies on a geocentric construction belied by later models. Galilean ellipses may remedy the geocentric flaw, but even they do not adequately predict the progression of Mercury's perihelion—only Einstein's theory does that.[145] As scientific theory gets more and more accurate in time, new phenomena fall within its purview, all while long-studied phenomena become better and better understood. Scientific theorists cannot simply move from theory at one point in time to another and expect equally good results.[146]

This series of constraints on the interchangeability of scientific theory within the philosophy of Duhem has an analogue in current copyright jurisprudence—the treatment of computer software as copyrightable. The analogue is not completely surprising—just as one court has noted that software combines elements of creative and technical expression in one work,[147] so too does scientific theory capture the creativity and inventiveness of the scientist alongside the technical requirements of empirical and mathematical precision.

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145. *See* EINSTEIN, *supra* note 12, at 117-18.

146. *See* Burk, *supra* note 17, at 308 ("Much of the social mechanism of science is devoted to regulating the acquisition, dissemination, and interpretation of empirical data. Empirical truth forms the foundation of the scientific edifice, and each participant in the scientific enterprise builds upon the work done by previous participants. In order to participate, the scientist must be aware of previous work and in turn, make his work known to others. Consequently, in order to advance the state of science, and to avoid unnecessary duplication of effort, the system must encourage scientists to share their results with one another. As a result, the scientific community consists of a cooperative structure within which empirical data may be freely shared." (footnotes omitted)). *See also* Goldberg, *supra* note 14, at 1342 ("[S]cience appears unambiguously to make progress. It may be a truism to say that scientists today know more than scientists in the past, but it is a truism with important implications. An assistant professor of biology today may know more about evolution than Darwin. That does not mean the professor is brighter than Darwin, but only that she stands on Darwin's shoulders and on the shoulders of many other scientists. Because science is in this sense cumulative, it is possible to say that a particular scientist has made an important contribution.").

147. Comput. Assoc. Int'l, Inc. v. Altai, Inc., 982 F.2d 693, 704 (2d Cir. 1992).

In the space of software copyright cases involving a claim of infringement, courts often rely on the three-step abstraction-filtration-comparison test originally proposed by the Second Circuit in *Computer Associates International, Inc. v. Altai, Inc*.[148] The first two steps of the test involve the identification of aspects of an original piece of software code that is not copyrightable due to a variety of factors, and the subsequent removal of such unprotectable aspects from the ultimate infringement comparison. Items that the Second Circuit deemed appropriate for such filtration included software elements dictated by efficiency considerations,[149] software elements dictated by external factors (like programming language- or interoperability-related constraints),[150] and elements already in the public domain.[151] In the realm of scientific theory under Duhem's philosophy, similar abstraction and filtration steps would yield the removal of elements of a theory dictated by: (1) a desire to achieve an economy of thought in formulation, (2) a better capacity to model and predict actual phenomena compared to previous scientific models and theories, (3) high-level, unprotectable ideas (i.e., that "objects are attracted to one another"), and (4) elements of the theory dictated by the advance of science, including elements of prior science that have fallen into (or have always been in) the public domain. In view of these constraints, what once looked like a field ripe for copyright protection in Part II now would seem to offer almost no possibility for copyright protection at all.

The creator of a traditional aesthetic work and the modern-day scientist face very different decision trees when undertaking their work, and thus the creator and scientist should face very different legal protection systems in the result of that work. For an author, sculptor, painter, or other aesthetically-motivated creator, there remains tremendous freedom to generate work based on any source of inspiration. An author can jump back in time to Homer for poetic structure, take a cue from Nabokov or Dickens when writing a novel, or write a play based on the ideas of Ibsen, Shakespeare, or Tennessee Williams. Artists can similarly draw guidance from a Turner, Monet, or Seurat in visual art. Or perhaps the author or artist wants to follow a new direction and found a school that would be the new Dadaism or Cubism or any other -ism. Even the *Roman Expérimental* project

148. *Id.* at 706.
149. *Id.* at 707-09.
150. *Id.* at 709-10.
151. *Id.* at 710.

proposed by Zola,[152] where a novel's events were allegedly the result of a scientifically-determined sequence of events, is not to be taken particularly seriously. The idea of that project was much more an answer to Zola's critics (who did not like what they perceived as vulgar content in his books) than it was an actual description of how any novel comes together. There remains a substantial margin of freedom in the creation of any aesthetically-motivated work, where time and space can bend, and the rules of a school of thought or a view of the universe can be bent, broken, repurposed, or reinvented.

In comparison with the artist or author, much less is possible for the typical scientist, who must work within an established framework that applies constraints in a variety of dimensions. One is what Gaston Bachelard calls the *phénomènotechnique*,[153] the set of technological preconditions assumed by a science at a given time. The theory governing many modern phenomena does not only *depend* on modern tools like a mass spectrometer; it is entirely *constituted* by such tools.[154] With each complicated tool which modern science requires, a host of assumptions must be made about the reliability of such tools and the theories that went into their construction. Scientists also are generally required to remain up-to-date in the current state of their field (to avoid duplicative results, to promote new work, etc.).[155] By doing that, however, scientists are buying into a great theoretical construct that may draw on numerous mathematical and scientific disciplines, and centuries of slow development, much of which is taken as assumed. An astronomer may have a lot of freedoms, but among them are not the ability to re-invent calculus or re-adopt Ptolemy. The overarching takeaway may be a bit over-generalized and over-simplified, but it is safe to say that traditional aesthetic artists are free to work in their own specific *clinamen*-informed ripples while scientists must pay much more attention to their domain's overarching tide.

Before re-emphasizing this point in a final argument that owes much to Kuhn's *The Structure of Scientific Revolutions*, a few points of copyright policy bear mention here in their lack of support for the protectability of scientific theory. While it is true that copyright

152. *See supra* note 30 and accompanying text.

153. *See generally* BACHELARD, *supra* note 53 (discussing the concept of *phénomènotechnique*); *see also* LATOUR & WOOLGAR, *supra* note 54, at 63-64, 238 (revisiting the concept).

154. LATOUR & WOOLGAR, *supra* note 54, at 59.

155. *See* sources cited *supra* note 140 and accompanying text; *see also* Rai, *supra* note 5, at 124 ("As Rebecca Eisenberg has emphasized, these accounts hold that progress in basic science occurs most quickly not when it is coordinated by a single entity (such as a patent holder) but, rather, when different teams of scientists, working independently but with an awareness of each other's efforts, use divergent approaches to the same problem.").

protects dryer content—the examples of used car prices, statistical forms, and computer software have been given[156]—these are areas where copyright struggles mightily to find its bearings. Take, for example, the area of parts numbers or other basic numerical sequences, which some litigants have proposed to be worthy of copyright protection.[157] Courts have consistently struggled in such cases to determine a workable definition of both the idea and the expression involved in the assignment or creation of such numbers.

Southco, Inc. v. Kanebridge Corp. is a good example of this, where the majority found that a parts numbering system did not merit copyright protection. The system itself was a set of short codes that indexed different characteristics of rivets, latches, and similar pieces of hardware, where the codes could be combined serially to describe a given part.[158] The majority dismissed the possibility that such codes could be protected, as the creation of the initial codes reflected a mere unprotectable "idea" or "system," and that the subsequent application of the system to specific parts was a wholly uncreative exercise.[159] The dissent in *Southco* disagreed with the majority's characterization of the specific code numbering system at issue as an uncopyrightable idea.[160] The dissent instead viewed the concept of code numbering systems in general as the idea and the specific system selected by the plaintiff as an expression of that idea.[161]

The reality is, neither the majority nor the dissent is overwhelmingly persuasive in *Southco*, but that is not their fault. They are deciding a case in a space where the unprotectable "idea" has only two possible forms—"the idea of creating a parts numbering system" or "the idea of creating the specific parts numbering system at issue here." The protectable expression, meanwhile, is even harder to discern, as the application of numbers to parts does not involve any meaningful, articulable aesthetic choice. On one hand, a court could find such parts numbers protectable in their very specific articulation and not worry too much as other such systems would be available to others (as did the dissent), or it could determine that there is no expressive content at any level in the system (as did the majority).

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156. *See* cases cited *supra* notes 33-35.

157. *See, e.g.,* Toro Co. v. R & R Prods. Co., 787 F.2d 1208 (8th Cir. 1986); Mitel, Inc. v. Iqtel, Inc., 124 F.3d 1366 (10th Cir. 1997); Southco, Inc. v. Kanebridge Corp., 390 F.3d 276 (3d Cir. 2004).

158. *See Southco*, 390 F.3d at 278.

159. *Id.* at 282.

160. *Id.* at 291 (Roth, J., dissenting).

161. *Id.* at 291-92.

It is easy to imagine similarly difficult questions arising in a space where scientific theory in its purest form of equations and models is believed to be potentially eligible for copyright. The equations and models would be as dry and functional as any set of parts numbers, and they would be motivated by a clear, functional idea underlying the specific equation chosen. Courts would be left wondering what about that specific equation or model is expressive in a way that is not thoroughly dictated by the underlying idea and other constraints already discussed here.

Courts would face an additional issue presented by the *Southco* case and other functional works eligible for copyright—the paradoxical incentive to provide the greatest protection for that which should be *least* copyrightable due to its functionality. Likely the most valuable element of the *Southco* numbering system was its ability to communicate characteristics about a part based on a number. Yet this communicative ability followed foremost from a dry or rote application of pre-established codes to existing parts. In other words, the system's point of value is precisely its least creative, most functional feature. The same could be said of copyright in software, where software's real value is its ability to do something successfully in a computer system and not its reliance on fanciful code that does not perform well or efficiently. One would correctly assume that it is the latter that should be most eligible for copyright protection, while the former functionality should remain unprotected under section 102(b). The same logic would apply to scientific theory, where copyright would seem most adequate to protect parts of a model or theory that do not represent reality well, while the most accurate portions would work a merger between the equation, on one hand, and the observed phenomena or underlying scientific idea, on the other. The *classification naturelle* may have been beautiful to Duhem, but its beauty derives from the perfection of its functionality, its predictive precision—the very aspect of the theory that should not merit copyright protection.

The question of infringement by later theorists in the same scientific space would present its own unusual challenges. What sort of equation or theory that leads to the same results could be found infringing? It could be *just* the original equation or theory, such that all alternative articulation of the original's terms avoids a finding of infringement. Such would be a presumption of a very thin copyright in a theory. Or perhaps courts might figure out a way to determine infringing alternatives from non-infringing ones. Yet how could that distinction be made plausibly? In the space of copyrightable works relying on written language like articles and books, there is some ability to distinguish between a non-infringing second work and a second work that merely illicitly paraphrases the original (even if that work does not go so far as exact copying). In mathematical symbolism, it is much less clear what *paraphrasing* might mean. It could mean anything from—(1) two equations that lead to effectively the same results, to (2) two equations that use a certain percentage of the same functions, to (3) two equations that rely on similar mathematical theories, to (4) two equations that are the same but for *de minimis* changes. Any of these choices would seem defensible, but would lead to very different, and potentially very hard-to-administer, legal rules.

It is not at all clear that wading into these murky waters offers all that much benefit. As already mentioned, the community of theoretical scientists currently enjoys its own system of rewards, privileges, and incentives largely outside of the domain of copyright protections. Further, commentators have often observed institutional science's aversion to the insertion of legal rigors in their practices.[162] There seems little necessity to alter incentives in a system that is currently functioning, particularly where the creation of additional incentives would bring along a host of new legal complexities that would be very costly to figure out and manage. Only re-enforcing this point is the intellectual property infrastructure argument—because scientific theory is often needed for use in a range of downstream goods and services, it fits more appropriately in the space of unprotected *infrastructure* than in that of protectable *application*. When a system functions reasonably well, as here, perhaps the best approach is to let it continue and keep the more drastic changes for a different situation.

As a final point, Thomas Kuhn's *The Structure of Scientific Revolutions* provides a reminder that some of the relativizing views of Duhem or Latour do not have as much currency in a domain of legal analysis. Latour, it may be recalled, focuses his sociological studies broadly, on both the *vainqueurs* and the *vaincus*,[163] the winners and the losers in a given scientific domain investigated. Duhem, for his part, was unfortunate enough to be on the losing team, as his commitment to energetics would ultimately prove misguided due to the rise of atomic theory. When approaching the study of science from a

162. *See* Burk, *supra* note 17, at 320 (Legal procedures "do not necessarily reflect the values and norms of science, and the intrusion of such procedures into the scientific community poses something of a challenge to the culture of science."); *see also* Goldberg, *supra* note 14, at 1345 (noting the tension between the lawyer's focus on process and the scientist's focus on progress).

163. *See* LATOUR & WOOLGAR, *supra* note 54, at 15-17; *see also* BRUNO LATOUR, PASTEUR : GUERRE ET PAIX DES MICROBES 55 (La Découverte 2011) (1984) *translated in* BRUNO LATOUR, THE PASTEURIZATION OF FRANCE 111 (Alan Sheridan & John Law eds., Harvard Univ. Press 1988).

perspective of the *vaincus*, one is more inclined to see the relative merits of competing theories and avoid completely rejecting plausible theories due to the sole influence of social forces. Science has not, however, developed solely due to social factors, and not all theories that were once held in esteem should be viewed as more or less equivalent to currently influential theories (though by no means should rejected theories be slighted entirely in a glorification of those who ultimately won).

The theory of relativity—ironically enough—stands as an exemplary obstacle to an ideal that relativizes a range of scientific theories. To understand this, awareness of the rise of non-Euclidean geometry is of some importance, as that framework broke with centuries of belief that Euclid's straight line- and plane-based geometry was the only way to do such mathematics. With non-Euclidean geometry, another system seemed to perform just as well, even if based on parabolas or hyperbolas instead of lines. What seems like a justification for a more relativized view of mathematics—a world with multiple equivalent systems of geometry—breaks down with relativity because the general theory of relativity *does not work* in Euclidean geometry.[164] Not all systems are equally good for all calculations; not all theories should be given equal weight. Relativity pushed out Newtonian mechanics to a certain extent; and someday another theory will come along to supplement or replace relativity.

This leaves science in a state of Kuhnian evolution. As Kuhn noted, the institution of science operating within an established framework (or paradigm) mostly relies on that paradigm to generate problems of normal science—puzzles that practitioners will attempt to solve to explore the bounds of the current paradigm.[165] Other paradigms are generally excluded at this phase of normal, gradual scientific development as the scientific community ossifies its practices (if only temporarily) around the current paradigm by developing specialized equipment and vocabulary to incorporate the paradigm.[166] During these periods, science cannot be treated as purely relative, a sea of alternatives where each scientist may choose one without risking copying another. Far from it – scientists *must* be able to use the exact methods and theories of the current paradigm to participate in their community.

In time, however, each paradigm runs its course. As new results or anomalous findings contradict its teachings and expectations, the

164. EINSTEIN, *supra* note 12, at 109.

165. KUHN, *supra* note 42, at 38.

166. *Id.* at 64-65.

theory will cease to be able to respond adequately to the demands placed on it, and the science of the field will pass through a period of crisis.[167] A new paradigm will be sought to rectify the current paradigm's shortcomings. This is the famous Kuhnian *paradigm shift*,[168] where a whole new way of seeing the world scientifically effectively inverts a previously accepted set of interpretations.[169] Even in this phase, there remains a crisis of difference that presupposes the prior paradigm as a baseline, before a new period can begin, in which the incoming paradigm drives normal science. At all times, what is accepted as a matter of current scientific theory needs to be available for use—either in the generation of work of normal, scientific puzzle-solving or in the push to improve, and possibly overturn, the current paradigm in favor of a new one. Protecting such science by copyright law could impose substantial hurdles to the fundamental accomplishment of non-applied science's task.

CONCLUSION

Under Kuhn's theory governing the advancement of science, science can be said to evolve according to an almost *Darwinian* notion of time, where theories play the role of species in the theory of natural selection.[170] Established theories are capable of occupying new spaces as their proponents solve new puzzles in normal practice, much in the way that a species favored by the environment might spread. Yet as environmental conditions change, established theories may become disfavored, first in limited areas where the theory's principles lead to anomalous or inaccurate results and later when a more general crisis calls for a better theory entirely. According to this process, new theories arise in competition with established theories and can overcome such theories where they are unable to compete for lack of a flexible response to the scientific environment. When replaced, as in the case of ether or phlogiston, a scientific theory may even pass from hegemony to eventual extinction, as better adapted theories continue to propel science's slow forward movement. Science evolving according to Kuhn's theory follows a movement that is *directed* and *historically dependent*. This view stands in stark contrast to the concept of science, proposed earlier here, as a truly relative, atemporal, *Newtonian* construction in time.

167. *Id.* at 82.

168. *See, e.g.*, *id.* at 89.

169. *Id.* at 112-13.

170. *See* CHARLES DARWIN, ON THE ORIGIN OF SPECIES (The Collier Press 1909), for many of the concepts discussed in this paragraph.

Science's movement retains elements of each of these types of *time*, of course. The measures of laminar movement pushing the tide to shore, and the current theories to perfection or replacement are matched by ripples and turbulence that are far more relative and free in their movements. For the guided Darwinian movement of science, copyright protection is a decidedly poor fit.[171] Current scientists need free access to prevailing theories to improve that theory or propose paradigm-shifting alternatives, just as future scientists will need to access new paradigms in their work.[172] In this highly-contingent environment, it is not entirely clear that copyright law would even know what to protect within the models and equations of a theory, in terms of separating expression from underlying idea, process, or principle. Yet science's turbulent movements may come with greater freedom for the scientist in a specific moment in time, a set of equally-palatable alternatives rich enough in variation to merit copyright protection. And one should not forget that no matter how accurate a theory becomes, it remains reasonably conceived of as a rationalist construction reflecting scientific creativity, as opposed to a dry set of uncopyrightable facts.

For now, the system denying most forms of intellectual property protection seems to work well enough. Science continues to advance through its own funding channels[173] and with its own set of non-legal incentives.[174] Yet, if Duhem's theories taught us nothing, it is that science could—under some circumstances—be an appropriate target for protection by copyright law.[175] For the moment, the hypothesis

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171. Drahos, *supra* note 17, at 71 ("When advanced into the area of basic science, property rights have the potential to disrupt those normative practices (centred around open communication), which are to operate to coordinate individual activity within science in a way that ensures that the problem solving capacity of science as a whole is improved. Once formal property rights enter basic science, the selections that individuals have to make become more complicated."); Rai, *supra* note 5, at 119 ("To the extent that norms of invention and communalism are eroded by pressures to secure property rights, we lose a relatively cost-free mechanism for enriching the store of knowledge.").

172. *See* Burk, *supra* note 17, at 310 ("The linchpin of [the scientific] reward system is the publication of scientific papers, or research reports. Such reports detail the investigation performed, the methods used, the results obtained, and the researcher's conclusions. By publishing such a report, the researcher offers his work to the community and adds it to the fund of scientific knowledge by describing his methods and by making his results accessible to other scientists who may wish to incorporate them into their own research efforts.").

173. *Id.* at 340 (referring to public funding as the "lifeblood" of science).

174. *See* Drahos, *supra* note 17, at 69 ("Basic science operates with a reward structure which involves no formal property claims by individuals in relation to discoveries. Instead, individuals are given recognition and honour. The scientific discoveries themselves become part of a scientific commons which everyone is free to draw on for their own purposes. A reward system based on recognition dictates that individuals publish, thereby serving the goal of open communication.").

175. *See, e.g.*, *id.* ("If science is sufficiently socially demeaned or loses its status to other disciplines, then it will no longer appear to be so intrinsically satisfying, and property rights may

proposed here should at least remain open to future consideration, even if it would best remain rejected for the time being. Perhaps it need merely await a future paradigm shift in the culture of science.

have to be asked to play a greater role in soliciting creativity.").