SYMPOSIUM SCHOLAR*

REINVENTING DISCOVERY: PATENT LAW'S CHARACTERIZATIONS OF AND INTERVENTIONS UPON SCIENCE

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This Article concerns the sway of intellectual property law over scientists and their institutions. Patent monopolies encourage scientists and innovators to invent, but we rarely ask "as opposed to doing what?" I argue that the "what" is, at least some of the time, "basic" (nonpatentable) scientific research and discovery. This Article questions the viability of the discovery/invention distinction in patent law and considers the consequences that it has long had on the scientific enterprise.

This Article has four aims: (1) to re-engage a once-vibrant conversation about what, if any, property rights should inhere to "basic" scientific research products at the margins of existing categories of intellectual property law; (2) to contrast patent law's consequential and idiosyncratic characterizations of "basic" and "applied" science with those of other disciplines; (3) to highlight the distortions that patents foist upon the scientific enterprise by attaching monopolies to some research products but not others—affecting the distribution of scientific talent, the focus of research, the investment priorities of public and private actors, and so on; and (4) to reconsider the government's approach to basic-research funding. A view of patents as a legal construct layered upon science,

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rather than a default extracted from science, alters the political and legal status of "basic research" and "discovery." In this view, public funding of basic (nonpatentable) research becomes as much a matter of mitigating market distortions and treating likes alike as of promoting civic largesse or economic growth.

INTRODUCTION

> Science discerns the laws of nature. Industry applies them to the needs of man.
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> Rotunda, The Museum of Science and Industry, Chicago

Chicago's Museum of Science and Industry embodies America's heroic vision of science. Its space shuttle, U2 submarine, house-sized heart, and coal mine with a doomed animatronic canary are grand in scale and rich in meaning. The museum's exhibits depict triumphs of the highest virtues of our scientific history and technological present: equanimity, collaboration, and reverence for nature. Gazing into that rotunda as a child, one's choice comes down to a career of revelation or one of committed humanism; the drudgery of gel electrophoresis is only revealed years later.

The delineation between decrypting nature and fashioning it to meet needs is deeply rooted. Perhaps that is due to slogans filling museum rotundas; perhaps it is because our intellectual property regime partitions research along such lines. Either way, it is an imperfect intuition. Science and industry are tightly bound.[1] Industry massively invests in basic research.[2] Tenured researchers and government scientists spend much of their time, and generate much of their livelihood, attending to commercial interests.[3] Even the quasi mystics of

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[1] *See, e.g.*, Rebecca S. Eisenberg, *Proprietary Rights and the Norms of Science in Biotechnology Research*, 97 YALE L.J. 177, 195 (1987) ("In [biotechnology], the traditional dividing line between basic and applied research is blurred. Not only has the historical time lag between the two collapsed, but it has become difficult to characterize given research problems as belonging in one category or the other.").

[2] Industry spending has far surpassed that of the federal government in the last quarter century, becoming the primary source of research and development (R&D) investment in the United States. As of "FY 2000, private sector R&D was 67% of total U.S. R&D, federal funding a mere 30%. This compares to an even split in 1976 between these two sources of R&D funding and a higher federal R&D budget compared to that of industry in the years prior to 1975." PRESIDENT'S COUNCIL OF ADVISORS ON SCI. & TECH., EXECUTIVE OFFICE OF THE PRESIDENT, ASSESSING THE U.S. R&D INVESTMENT: FINDINGS AND PROPOSED ACTIONS 4 (2002) (footnote omitted) (citing ELISA EISEMAN ET AL., RAND SCI. & TECH. POL'Y INST., FEDERAL INVESTMENT IN R&D 15 fig.2-1 (2002)), *available at* http://www.ostp.gov/pdf/final_rd_report_with_letters.pdf.

[3] Indeed, the National Institutes of Health (NIH) recently imposed limits on its sponsored scientists' consulting engagements and private investments in order to preserve "the trust of the public." Jeffrey L. Fox, *Biotech Consulting, Investing by NIH Scientists Curbed*, 23 NATURE BIOTECHNOLOGY 274, 274 box 1 (2005) (quoting NIH director Elias Zerhouni). *See generally* Posting of Stephen Quake to The Wild Side, http://judson.blogs.nytimes.com/2009/02/17/the-absurdly-artificial-divide-between-

scientific history—the alchemists and string theorists—did science for the sake of very concrete, human goals.[4]

Science and industry, discovery and invention—these categories are not *of* science. They were not, at some critical moment, plucked from Platonic ether. They are deeply human and partial categories that reflect particular accounts of what we think we do when we do science, a legal system that relentlessly parses endeavors, and the contours of our political economy. The reality of science is far messier and far less categorical. The lines between research and application, between man's place *in* nature and study *of* nature, have ever defied glib summary. Entire disciplines study the sociology, history, and philosophy of science.[5] How we think and write about science is a flashpoint because of what it may signal about weighty topics like truth and certainty.[6] Most of these discussions take the form of academic abstraction, drawing popular attention only with high-profile Sokal Hoaxes or intermittent storms over the difference between scientific theory (say, regarding the descent of man through time) and scientific fact.[7]

Given the relative obscurity and frequent absurdity of such spats, it is easy to lose sight of the law's deeply consequential—and equally idiosyncratic—account of science. Law defines the epistemic content of evidence, as well as the legal, political, and even scientific status of entire forensic disciplines.[8] It delineates where empirics end and faith

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pure-and-applied-research/ (Feb. 17, 2009) (noting many examples of scientists moving between pure and applied research).

[4] *See generally* LYNDY ABRAHAM, MARVELL AND ALCHEMY (1990); LEE SMOLIN, THE TROUBLE WITH PHYSICS: THE RISE OF STRING THEORY, THE FALL OF A SCIENCE, AND WHAT COMES NEXT (2006).

[5] For an overview of the disciplines that study science in its many forms, see generally WALTER LIBBY, AN INTRODUCTION TO THE HISTORY OF SCIENCE (1917); STEWART RICHARDS, PHILOSOPHY AND SOCIOLOGY OF SCIENCE (1984).

[6] For a discussion of the so-called "science wars" that erupted after the Sokal Hoax, see *infra* note 83.

[7] We are all familiar with debates in public education over the status of allegedly "competing" theories of creationism (and its mildly sanitized alter-ego, intelligent design) and evolutionary biology. A classic, Pulitzer Prize–winning text on the subject is EDWARD LARSON, SUMMER FOR THE GODS: THE SCOPES TRIAL AND AMERICA'S CONTINUING DEBATE OVER SCIENCE AND RELIGION (1997). *See also* BARBARA FORREST & PAUL R. GROSS, CREATIONISM'S TROJAN HORSE: THE WEDGE OF INTELLIGENT DESIGN (2004).

[8] A notable example from forensic odontology is the young and amorphous discipline of "bitemark evidence." Despite repeated studies reporting alarmingly high error rates, practitioners largely support the field's empirical legitimacy and practical application. *See, e.g.*, I.A. Pretty, *A Web-Based Survey of Odontologist's Opinions Concerning Bitemark Analyses*, 48 J. FORENSIC SCI. 1117 (2003) (finding support for the continued

begins in classrooms. It also frames the incentives attached to certain forms of research.[9] In each of these contexts, as law characterizes how science is done, it also shapes how science is done. These interactions—particularly those arising from doctrines of patentable subject matter—are the subject of this Article.

Some have criticized law's approach to science for relying on archaic and even romantic conceptions of what science is and what it does. For instance, critics have assailed *Daubert*'s standard for the admissibility of scientific evidence[10] as an anachronistic hodgepodge of irreconcilable principles.[11] But *Daubert* at least possesses interdisciplinary reference points; that is more than we can confidently say about intellectual property law's vision of science, as embodied in our patent system.

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use of bitemark analyses but concluding that there exists a need for more research into error rates and proper techniques). In contrast, judicial acceptance of bitemark evidence has waned after misleading bitemark evidence led to several postconviction exonerations. *Cf.* Michael J. Saks, *The Legal and Scientific Evaluation of Forensic Science (Especially Fingerprint Expert Testimony)*, 33 SETON HALL L. REV. 1167, 1168-70 (2003) (noting that, despite assurances by forensic dentists as to bitemark analysis's accuracy and precision, one study "revealed an average of 64% false positives and an average of 22% false negatives").

[9] The impact of legal and political choices on the trajectory of research was tragically revealed during the HIV/AIDS epidemic of the 1980s. *See generally* RANDY SHILTS, AND THE BAND PLAYED ON: POLITICS, PEOPLE, AND THE AIDS EPIDEMIC (1987) (criticizing the U.S. government's failure to address, through research funding or other assistance, the AIDS epidemic of the early 1980s).

[10] Daubert v. Merrell Dow Pharm., Inc., 509 U.S. 579, 589-95 (1993).

[11] *See, e.g.*, David Crump, *The Trouble with* Daubert-Kumho*: Reconsidering the Supreme Court's Philosophy of Science*, 68 MO. L. REV. 1, 19 (2003) ("The cases do not express any recognition of the other two ingredients in the triad [of science], concept and computation. Instead, they seem to make everything depend on falsifiability, which is to say, on observation. . . . [T]he Supreme Court in *Daubert* may have reduced the meaning of science to only a part of itself."); Margaret G. Farrell, Daubert v. Merrell Dow Pharmaceuticals, Inc.*: Epistemiology and Legal Process*, 15 CARDOZO L. REV. 2183, 2183 (1994) ("Justice Blackmun's majority opinion in *Daubert* . . . acknowledges that law and science have different goals, but it fails to recognize the implications of those differences for legal process."); John H. Mansfield, *Scientific Evidence Under* Daubert, 28 ST. MARY'S L.J. 1, 12 (1996) ("[Karl H.] Popper's ideas about valid scientific knowledge [which influenced the establishment of the *Daubert* test] do not readily lend themselves to adoption in a legal rule. . . . His urging that hypotheses be developed that are prima facie easily falsified does not lead to any view as to when a hypothesis should be considered scientifically valid."). *But see* Brian Leiter, *The Epistemology of Admissibility: Why Even Good Philosophy of Science Would Not Make for Good Philosophy of Evidence*, 1997 BYU L. REV. 803, 805 ("For even if 'revised empiricist' philosophy of science *were* the dominant, or even the correct, philosophy of science, there would be no reason to think admissibility standards ought to conform to it: Feldman seems to confuse the philosopher's question . . . with the lawyer's question . . . .").

Patent law distinguishes between two products of research: discoveries and inventions. All patentable inventions are either discoveries or creations, but not all discoveries and creations are patentable inventions.[12] These categories are foreign to how scientists talk about and conduct their business, except when they discuss patent law and the commercial implications of their research. What is and is not patentable is in no way coextensive with the boundaries scientists otherwise, let alone "naturally," use to identify endeavors within their fields.

Legal literature defends its distinctions by pointing out that scientists participate in open, productive, and collaborative basic research despite the lack of attendant intellectual property protection. Legal academics describe this collaboration as a "norm" of basic research. Yet this norm did not emerge in the absence of legal, economic, and political frameworks, but *specifically in light of them.* The legal literature speaks of science as if it were an isolated ritual, as if the orienting goal of our patent system—encouraging invention—was wholly superfluous, and as if attaching monopolies to some research products but not to others has little impact on a scientist's career choices or research priorities or, more broadly, the trajectory of scientific research. Law, in short, either disregards or denies altogether the untidy consequences of its interventions upon science.

This Article reconsiders the discovery/invention distinction, borne out at the boundaries of the legal doctrines of patentable subject matter, as well as the implications of that distinction for the scientific enterprise. If there are consequences in the type of research projects that scientists pursue, in the distribution of research talent across disciplines, or in the funding priorities of our body politic, then we should want to base them on something other than tenuous constructs of legalistic metaphysics. We should aim to acknowledge, if not altogether avoid, legal mischaracterizations of science shaping the enterprise and trajectory of science itself.

I argue that the discovery/invention distinction is analytically tenuous—untethered to scientific theory or practice and imperiled by the trajectory of legal opinion. Yet it is a deeply consequential construct. Too often, lawyers portray the patent system as somehow incidental to the scientific enterprise. But what would inventors be doing

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[12] *See* 35 U.S.C. § 101 (2006) ("Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title.").

if they were not inventing? We hope to encourage invention *as opposed to what*? Basic research thrives without intellectual property protection *compared to which hypothetical alternative*? By partitioning scientific research products into two categories—only one of which we protect as intellectual property—patent law almost certainly affects the distribution of scientific talent and the focus of research. Even if these effects are marginal, they are worth discussing because they remain underacknowledged.

Even if there is no convincing reason, in principle, to distinguish unpatentable discoveries from patentable inventions, there may be practical reasons to do so. Scholars have rehashed this discussion time and again since the First World War. I re-engage the conversation not to concoct an ambitious solution—say, a novel "scientific property" right—but to reconsider the consequences of the law's bifurcated vision of science. These consequences include distortions in the scientific enterprise that encourage researchers to do some things rather than others and chronic instances of legal over- and underinclusion when we label research products "property" or "not property." The former consequence raises important questions of economic efficiency; the latter suggests a troubling discontinuity between patent and takings jurisprudence.

The Article concludes with a brief discussion of the perils presented by a legal academy that construes its interventions on science as something other than interventions—as a disciplinary default that is no default at all.

I. THE LEGAL CANON: MAN AND NATURE

A. *Economic Principle, Ontological Categories*

The origins of, incentives for, and rationales behind our patent system have been recited many times over.[13] The general aim of patent protection is explicit in the constitutional text from which the patent system derives: "To promote the Progress of Science and useful Arts."[14] The tradeoffs of this formulation have been apparent since

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[13] *See, e.g.*, ROBERT PATRICK MERGES & JOHN FITZGERALD DUFFY, PATENT LAW AND POLICY 1-16, 67-68 (4th ed. 2007) (describing the development of patent law in the United States); Mark A. Lemley, *Property, Intellectual Property, and Free Riding*, 83 TEX. L. REV. 1031, 1031 (2005) (explaining the conventional view that patent protection in the United States is "about generating incentives to create").

[14] U.S. CONST. art. I, § 8, cl. 8.

the Venetian patent statute of 1474, which cultivated "ingenious" works and "devices" by extending ten-year monopolies to inventors.[15] Today we frame those tradeoffs using the parlance and conceptual topography of modern economics, focusing discussions around the so-called "public-goods problem." But the core concern—balancing deadweight losses of monopoly power with innovation deficits when investors cannot recoup the costs of research—has been well rehearsed for centuries.[16]

If our patent system aims to solve a public-goods problem, then we should extend patent monopolies only to those innovations that would otherwise be underincentivized.[17] Yet patent review famously lacks

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[15] The Venetian statute states that

> every person who shall build any new and ingenious device in this City, not previously made in our Commonwealth, shall give notice of it to the office of our General Welfare Board when it has been reduced to perfection so that it can be used and operated. It being forbidden to every other person in any of our territories and towns to make any further device conforming with and similar to said one, without the consent and license of the author, for the term of 10 years.

Giulio Mandich, *Venetian Patents (1450–1550)*, 30 J. PAT. OFFICE SOC'Y 166, 177 (1948) (quoting the Venetian Patent Statute of 1474).

[16] Patents have also been justified by natural rights theory, but the theory's heyday has long passed. A natural right to property should be a right in perpetuity, as a matter of desert: an inventor owns her invention, and should *monopolistically* own her invention, since her innovation was hers and hers alone. Yet we grant no such right. Patents are limited to twenty-year monopoly rents. Moreover, the natural rights view sits uneasily with coinvention: if several inventors have independently derived an idea and reduced it to practice, the order of invention should not matter. But how many coextensive monopolies can exist before we are no longer talking about monopolies? The polymath Robert Nozick argued that a natural rights theory may be unsatisfying because we will in time reinvent almost everything. Teleology is at play: inventions are solutions to practical needs and, given eight billion industrious, inventive folks, lightning will often (if not always) strike twice. *See* ROBERT NOZICK, ANARCHY, STATE, AND UTOPIA 181-82 (1974) (suggesting that patent time limits serve "as a rough rule of thumb" for approximating the amount of time that independent invention would have taken). Natural rights theory cannot accommodate teleology, and so an irony of our intellectual property framework is that the dominant theory—social good—is in thrall with an old-fashioned teleological dogma: that nature is out there, awaiting discovery as Truth and revelation. Part III addresses the influence of this anachronistic, storybook view of science upon our intellectual property law.

[17] The paradigmatic economic vision of patent law comes from Judge Richard Posner's concurring opinion in *Roberts v. Sears, Roebuck & Co.*, 723 F.2d 1324, 1345 (7th Cir. 1983) (Posner, J., concurring), in which he argues that "[t]he purpose of allowing people to obtain patents is strictly utilitarian—to create incentives to invent useful things." *See also* David S. Olson, *Taking the Utilitarian Basis for Patent Law Seriously: The Case for Restricting Patentable Subject Matter* 6 (Boston Coll. Law Sch. Legal Studies Research Paper Series, Research Paper No. 163, 2008), *available at* http://ssrn.com/

such precision, rendering that ambition elusive.[18] Moreover, such a thoroughly modern economic formulation is largely incidental to the established ontological requirements of patentable subject matter.[19]

In the constitutional text defining Congress's copyright and patent power, "useful Arts" is the imperative phrase.[20] Congress and the courts have interpreted "useful" to limit patent protection to applied technology, as distinguished from basic scientific research. Hence, the Patent Act formally defines patentable subject matter as "any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof."[21]

Yet statutory and constitutional text can only tell us so much about patentable subject matter, for the case law has "acquired a distinctly common law feel" over the centuries.[22] The interaction of statutory and common law has, at various times, placed "works of nature,"[23] "law[s] of nature,"[24] "theoretical discoveries,"[25] "abstract intellectual concepts,"[26] "fundamental truth[s],"[27] and simply "[a]n idea . . . itself"[28] all beyond the pale. In *Diamond v. Chakrabarty*, the Supreme Court famously asserted that "laws of nature, physical phenomena, and abstract ideas" cannot be patented.[29] Thus the Court seemingly qualified its own interpretation of legislative history, stated just a

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abstract=933167 ("[F]or much of U.S. history the federal courts took it upon themselves to analyze classes of subject matter and exclude from patentability those types of innovation for which the patent grant likely would increase beneficial invention by less than the patent monopoly would cost society.").

[18] A banality of contemporary patent scholarship is that we extend patents to many research products that neither merit nor require monopoly protection. *See, e.g.*, Mark Lemley et al., *What to Do About Bad Patents*, REGULATION, Winter 2006, at 10, 10-12; Lawrence Lessig, *The Problem with Patents*, INDUSTRY STANDARD, Apr. 23, 1999, http://www.thestandard.com/article/0,1902,4296,00.html.

[19] In other words, the doctrinal requirements of patentable subject matter—novelty, nonobviousness, enablement, and so forth—are at best incidentally related to those research products that do, or do not, receive an optimal level of social, political, and economic incentives. As the case law has shown, these are fundamentally ontological categories, not economic ones.

[20] U.S. CONST. art. I, § 8, cl. 8.

[21] 35 U.S.C. § 101 (2006).

[22] MERGES & DUFFY, *supra* note 13, at 68.

[23] Funk Bros. Seed Co. v. Kalo Inoculant Co., 333 U.S. 127, 130 (1948).

[24] O'Reilly v. Morse, 56 U.S. (15 How.) 62, 132 (1854) (Grier, J., dissenting).

[25] Mackay Radio & Tel. Co. v. Radio Corp. of Am., 306 U.S. 86, 94 (1939).

[26] Gottschalk v. Benson, 409 U.S. 63, 67 (1972).

[27] Parker v. Flook, 437 U.S. 584, 589 (1978) (quoting *Gottschalk*, 409 U.S. at 67).

[28] Rubber-Tip Pencil Co. v. Howard, 87 U.S. (20 Wall.) 498, 507 (1874).

[29] 447 U.S. 303, 309 (1980).

paragraph prior, that "anything under the sun that is made by man" is fair game.[30]

These restrictions—including the so-called "law of nature" exception—limit the set of innovations deemed patentable. It is worth at least asking whether this combination of criteria represents a reasonable proxy for identifying the research products and innovations susceptible to a public-goods problem. The dominant rationale for patent protection is not necessarily or intuitively coextensive with the ancient ontological categories that define subject-matter patentability in American law.[31]

A tangle of distinctions at this scale and frequency suggests that the race between legal line drawing and scientific ingenuity is no contest at all. Jurists have frequently engaged in intellectual contortions to partition science into two distinct boxes—often dodging their own jurisprudential formulations in doing so—but the normative rationales for their acrobatics have rarely survived scrutiny.

Early American cases often ignored or wholly disavowed metaphysical constructs distinguishing between "natural" principles and "man-made" products. They focused instead on concrete statutory demands of patent law, insisting, for instance, that inventions demonstrate a connection to the useful arts. One prominent commentator thus interpreted *O'Reilly v. Morse*[32] to "turn[] entirely upon a view taken of [the patent holder's] general claim, which gave it an extent

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[30] *Id.* (quoting S. REP. NO. 82-1979, at 5 (1952), *as reprinted in* 1952 U.S.C.C.A.N. 2394, 2399; H.R. REP. NO. 82-1923, at 6 (1952)). Robert Merges and John Duffy have suggested that there is some inconsistency between this broad statement and the restrictions that the Court has placed on patentable subject matter:

> To see the tension between these two statements, carefully consider the invention as described in footnote 1 of the Court's opinion. Chakrabarty discovered that naturally occurring plasmids capable of breaking down the components of oil could be combined into a naturally occurring host bacterium. Isn't it merely a physical phenomenon that the oil-degrading plasmids can be maintained within the bacterium?

MERGES & DUFFY, *supra* note 13, at 77. Or one might simply ask, in what sense are abstract ideas *not* developed by men and women?

[31] Indeed, I argue that it is precisely because of a public-goods problem that we publicly fund scientific research that is explicitly cut off from patent protection by the metaphysical quirks and shifting exceptions in our common law framework. *See infra* Section III.B.

[32] 56 U.S. (15 How.) 62 (1854). The *O'Reilly* Court held Samuel Morse's claim on any use of an electric current to print characters at a distance invalid as an overly broad claim on an "idea." The Court upheld the other seven claims from Morse's telegraph patent that applied the principle to particular machinery.

that divested it of all conditions and made it an abstraction."[33] Justice Felix Frankfurter similarly railed against quasi metaphysics in *Funk Bros. Seed Co. v. Kalo Inoculant Co.* nearly a century later, arguing that "[i]t only confuses the issue . . . to introduce such terms as 'the work of nature' and the 'laws of nature.' For these are vague and malleable terms infected with too much ambiguity and equivocation."[34] Contemporary scholars have shared Justice Frankfurter's skepticism. One recent article suggested that the doctrine of inherency can help distinguish patentable from unpatentable research products, rendering much of the law of nature exception analytically superfluous.[35]

Even if doctrines like nonobviousness, utility, and novelty can tell us what inventions are not patentable, they cannot tell us which innovations should be considered intellectual property. The law of nature exception is not solely concerned with what is statutorily patentable; it often arises in conversations about what ought to be considered "property" in the first place. To the extent that patents, copyrights, and trademarks exhaust our forms of intellectual property, what *is* patentable and what products *should be* considered intellectual property may descriptively align. However, there is no reason that they necessarily should be one and the same. References to, and reliance upon, the law of nature exception is not evidence of anxiety about the insufficiency of other patent doctrines, their actual insufficiency, or even ignorance of those doctrines. They are, rather, expressions of anxiety about the appropriate bounds of intellectual property protection for the whole range of scientific insights and innovations.

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[33] GEORGE TICKNOR CURTIS, A TREATISE ON THE LAW OF PATENTS FOR USEFUL INVENTIONS, AS ENACTED AND ADMINISTERED IN THE UNITED STATES OF AMERICA § 159, at 184-85 (4th ed. 1873), *quoted in* MERGES & DUFFY, *supra* note 13, at 98.

[34] 333 U.S. 127, 134-35 (1948) (Frankfurter, J., concurring).

[35] As Burk and Lemley argue,

> Inherency also seems well-suited to explaining the prohibition against patenting laws of nature. The objection . . . seems to be that such principles are "inherent" in the universe, waiting to be discovered, and so not the product of human ingenuity. Yet this characterization flies in the face of the current understanding that scientific "laws" are human constructs, clearly the products of human ingenuity, as is the language of mathematics in which such laws are expressed. The distinction between "invention" and "discovery" cannot credibly account for declining to patent such human formulations. However, these principles may well be said to be in public use, benefiting the public, even if their formulation is unarticulated or unexpressed.

Dan L. Burk & Mark A. Lemley, *Inherency*, 47 WM. & MARY L. REV. 371, 408 (2006) (footnotes omitted).

Whether a scientific product is patentable is a matter of patent law's internal (and fundamentally "legal"—meaning quasi-sociological, quasi-economic, and quasi-philosophical) logic.[36] But whether patent law draws reasonable distinctions in defining what scientific products should or should not be deemed property is a matter outside of patent law's formal doctrinal logic. It is at that periphery—the partition between property and nonproperty—that the law of nature exception rightly or wrongly holds singular valence.

To summarize, a discovery may be unpatentable for two broad reasons: First, it may fail to meet the basic statutory criteria. Second, its subject matter may somehow be beyond the patentable pale (i.e., it seemingly meets statutory requirements but is made an exception because of some elemental characteristic). Even if a discovery accords with every statutory requirement on the books, it cannot be patented if it falls within a common law exception to the statutory guidelines. And so the law of nature exception perseveres. It holds currency precisely because of its quasi metaphysics, rather than in spite of them.

B. *Law's Astrology*

1. A Proliferation of Tests

Tests for patentable subject matter are famously short lived. American courts have formulated and rejected an array of exceptions to the class of innovations that would otherwise be patentable. The natural-phenomenon test, the physical-transformation test,[37] the mental-steps doctrine,[38] the mathematic-algorithm exception,[39] and the business-method exception[40] are all examples of constructs conjured, then qualified or abandoned altogether through the evolution of pat-

[36] That logic is infused with metaphysical speculations like the law of nature exception. Patent doctrines were not developed in some presocial abstract, but rather were created precisely with a vision of what we are comfortable with patenting.

[37] *See, e.g.*, Cochrane v. Deener, 94 U.S. 780, 788 (1877) (stating that a patentable process is "an act, or a series of acts, performed upon the subject-matter to be transformed and reduced to a different state or thing").

[38] This doctrine attempted to remove mathematical formulas, methods of computation, or other mental operations from the realm of patentable subject matter. *See, e.g.*, *In re* Heritage, 150 F.2d 554, 556 (C.C.P.A. 1945) ("[P]urely mental acts are not proper subject matter for protection under the patent statutes . . . .").

[39] *See, e.g.*, Parker v. Flook, 437 U.S. 584, 594 (1978).

[40] *See* Hotel Sec. Checking Co. v. Lorraine Co., 160 F. 467, 469 (2d Cir. 1908) ("A system of transacting business disconnected from the means for carrying out the system is not . . . an art. Advice is not patentable.").

entable-subject-matter jurisprudence. A familiar lament of patent scholars is that courts abandoned their gatekeeping responsibilities as they abandoned these tests, allowing the set of inventions deemed patentable to balloon.[41] The rise and fall of tests may, indeed, constitute an abdication of sorts. But logical coherence—rather than judicial irresponsibility—has spurred the abandonment.[42] These tests have proven ever malleable and provisional, incapable of successfully grappling with borderline cases and emerging technologies.[43]

Thus, the most enduring exception to patentable material is among the oldest and most analytically slippery: laws of nature, natural phenomena, and abstract ideas—none of these may be awarded monopoly rents. Arguably, it is from this foundational observation that later (and late) tests of patentable subject matter were derived. After all, it is not immediately apparent what makes a phenomenon natural or an idea abstract, nor is it clear what differentiates them from unnatural (man-made?) phenomena or concrete ideas. Jurists have crafted a bevy of tests at least in part to make sense of these lines, to render them coherent and applicable. By and large, their efforts have failed.

Legal habit compels us to cordon off certain innovations as unpatentable if we hope to have a working patent system. (For what is a legal category without a line?) By implication, jurists have simply gotten their formulations consistently wrong.[44] At some stage, however,

[41] *See, e.g.*, Olson, *supra* note 17, at 63 ("[T]he federal courts' abandonment of the subject matter patentability gatekeeper role has decreased total social utility and [Patent and Trademark Office] efficiency.").

[42] *See* Robert P. Merges, *Property Rights Theory and the Commons: The Case of Scientific Research*, *in* SCIENTIFIC INNOVATION, PHILOSOPHY, AND PUBLIC POLICY 145, 155-56 (Ellen Frankel Paul et al. eds., 1996) ("[I]t is perhaps surprising that basic research is now considered an entirely proper source of patentable subject matter. . . . To some extent, this is a result of growing sophistication by patent lawyers, who have learned to state a scientific finding in terms of an at least nominally useful application.").

[43] In particular, these tests did not survive the rise of computer hardware and software, and they similarly could not grapple with the blurred line between basic and applied science in the field of biotechnology. The death knell of many of these tests, and arguably the gatekeeping role of courts, came in *Diamond v. Diehr*, 450 U.S. 175 (1981), which ostensibly overturned *Flook* by permitting nonphysical computer programs to be patented.

[44] The theory that jurists have made incessant mistakes of this sort is popular in the patent-reform literature. *See, e.g.*, Jay P. Kesan & Andres A. Gallo, *Why "Bad" Patents Survive in the Market and How Should We Change?—The Private and Social Costs of Patents*, 55 EMORY L.J. 61, 90-92 (2006) (noting that the problem of courts' lack of information or experience to evaluate patent applications has been exacerbated by "the increase of patents on Internet business methods and software technology").

we should ask whether a jurisprudence marked by incessant failures suggests an underlying deficiency in its premise. In the case of patent jurisprudence, that would mean a closer scrutiny of the law of nature exception itself and of the division that it projects between man and nature, irrespective of scientific history, principle, or practice. Let us thus turn to the origins of the exception and its epistemic roots.

2. Laws of Nature, Laws of Men

One of the Supreme Court's earliest invocations of the law of nature exception—and arguably the first of its regular tautologies on the topic—was in *Le Roy v. Tatham*.[45] There, the Court sweepingly concluded that "a principle is not patentable. A principle, in the abstract, is a fundamental truth; an original cause; a motive; these cannot be patented, as no one can claim in either of them an exclusive right."[46] In other words, courts cannot give monopoly rents to a "fundamental truth," "original cause," or "motive," because such insights cannot be patented. *O'Reilly v. Morse* later reiterated that principle, if not its reasoning, in holding that "the discovery of a principle in natural philosophy or physical science, is not patentable."[47] The question of *why* one may not hold such a right—due to law, logic, or nature—remained ambiguous.

In the century since, scholars and jurists have generally relied on two answers to this question. One relates to pragmatic concerns (e.g., would such a right be economically desirable or efficient, and even if so, how could we ever practically exclude others from using a basic principle?); the other relates to metaphysical considerations. I bracket at present questions of law and policy, such as whether discoveries can be or are patentable, or whether we should pragmatically want them to be patentable. The focus of this subsection is nature itself: whether removing scientific principles or discoveries from patentable subject matter is analytically sound.

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[45] 55 U.S. (14 How.) 156, 174-75 (1853).

[46] *Id.* at 175.

[47] 56 U.S. (15 How.) 62, 116 (1854). To be fair, while *O'Reilly* does not explain why a discovery should be unpatentable, it at least draws a workable line, unlike most other subject-matter cases. Justice Grier's view—a common interpretation of the case—is that this rule arose from the utility requirement: that patents should only apply to an inventor "who takes this new element or power [of nature], as yet useless, from the laboratory of the philosopher, and makes it the servant of man." *Id.* at 132 (Grier, J., concurring in part and dissenting in part).

Later cases articulated the metaphysical core of the law of nature exception. The Supreme Court's paradigmatic statement of this metaphysics, against which Justice Frankfurter railed, came in *Funk Bros.*:

> [P]atents cannot issue for the discovery of the phenomena of nature. . . . The qualities of these bacteria, like the heat of the sun, electricity, or the qualities of metals, are part of the storehouse of knowledge of all men. They are manifestations of laws of nature, free to all men and reserved exclusively to none. He who discovers a hitherto unknown phenomenon of nature has no claim to a monopoly of it which the law recognizes.[48]

The notion of a shared "storehouse" in nature—a sort of public library in the cosmos packed with "manifestations" of natural laws, marked by open access, universal check-out rights, and, presumably, a baffling card catalogue—is a central motif in the logic of the discovery/invention distinction and the law of nature exception.

The Court famously reiterated this language and reasoning in *Diamond v. Chakrabarty*, distinguishing between man-made constructs and manifestations of nature.[49] The *Chakrabarty* Court declared that "Einstein could not patent his celebrated law that $E=mc^2$; nor could Newton have patented the law of gravity."[50] The inventor in *Chakrabarty* merited a patent, the Court explained, because his claim was "not to a hitherto unknown natural phenomenon, but to a non-naturally occurring manufacture or composition of matter—a product of human ingenuity."[51] The innovation, then, was "not nature's handiwork, but his own."[52] "[T]he relevant distinction," for the *Chakrabarty* majority, "was not between living and inanimate things, but between products of nature, whether living or not, and human-made inventions."[53]

Chakrabarty's dichotomies—between nature's ingenuity and man's insights, between natural elements and man-made products—are emblematic. They have been repeated in various iterations for centuries. The underlying principle at play is this: Equations and abstract ideas are not human creations. They can be categorically distinguished from confabulations like radiators, medications, or—as in *Chakra-*

[48] Funk Bros. Seed Co. v. Kalo Inoculant Co., 333 U.S. 127, 130 (1948).
[49] 447 U.S. 303, 309 (1980).
[50] *Id.*
[51] *Id.*
[52] *Id.* at 310.
[53] *Id.* at 313.

barty—artificially created life forms.[54] This motif has emerged frequently in American courts, constituting a shared judicial mythology of science.

Scientific progress, as imagined in American law schools and bar associations, slowly reveals a static, underlying reality—discovered and as of yet undiscovered rules, perpetually there, waiting to be plucked from the heavens. "The underlying notion," argued the Court in *Parker v. Flook*, "is that a scientific principle, such as that expressed in respondent's algorithm, reveals a relationship that has always existed."[55] These rules, once revealed, are manifestations of nature. They are not properly classified as "inventions" because they are not confabulations thought up and constructed by particular individuals, but rather the shared store of mankind, common property that we have all always owned (blind to that ownership though we collectively have been). "Discover differs from invent," asserted the holding of *In re Kemper*.[56] "We discover what before existed. We invent what did not before exist . . . . Invention differs from discovery. Invention is applied to the contrivance and production of something that did not before exist. Discovery brings to light that which existed before, but which was not known."[57] Both discoveries and inventions, in this view, are accomplishments of man, but only inventions are created by man. It is unclear what we discover when we discover—heavenly clockwork or ambivalent Darwinian materialities. But whatever it is, it is already out there: discoverers find it, while inventors create anew.

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[54] Arguably, creating a hard-and-fast distinction between discoveries and inventions may make more sense if we are talking about tangible elements of nature—for instance, stumbling upon previously undocumented plants, animals, and chemicals. *See* Letter from Mark Lemley to author (Apr. 4, 2007) (on file with author). That we describe finding and identifying these elements of nature as "discoveries" reflects the broad spectrum of things we class as "discoveries." The dangers of such an expansive use of the term are discussed *infra* note 82.

Of course, "discovering" a previously unknown plant or animal is quite different from "discovering" practical uses for them—manipulations (actual or conceptual) that answer our questions and meet our needs. Even if we believe that species are simply species, identifying uses for them is clearly tied to human endeavors and interests—that is, utility. Such "discoveries" are significant primarily because they introduce new tools to meet human needs. Unsurprisingly, such "discoveries" are often patentable subject matter. The same arguably cannot be said of merely identifying new plants, animals, or chemicals.

[55] 437 U.S. 584, 593 n.15 (1978).

[56] 14 F. Cas. 286, 287 (C.C.D.C. 1841) (No. 7687) (quoting the then-current edition of *Webster's Dictionary*).

[57] *Id.*

This vision of science holds that Truths are afloat, awaiting discovery by luck, perseverance, or both. It is only a matter of time before someone discovers that it is not phlogiston, but oxygen, that explains the burning of wood.[58] Because these insights are Truths, they are a shared legacy, free to all. To strip them from the commons and place them into the hands of individuals would be akin to exercising inverse eminent domain upon the laws of nature, God's handiwork, the elegant universe: taking from the commons and giving to the few. From this perspective, allowing patents on discoveries would be savagely monopolistic and perhaps borderline heretical.

What a dramatic vision of science, and what a rich lineage it bears! Its ancient tropes appear throughout the writings of the great scientists and theologians of history.[59] That laws of nature are Truths to be uncovered and mastered by reason is a notion that continues to hold deep intuitive sway. There is no way to disprove this conjecture. But that is a far cry from saying that it is a reasonable cornerstone of modern patent law.

C. *Accounting for Science*

The law of nature exception perseveres, but the vision of science upon which it rests has fared poorly over the centuries. Pragmatists of the last 150 years, inspired by Darwinian principles of change over time, have reformulated how we think and talk about Truth (in part, by bracketing the conversation altogether). Historians and philosophers of science—not only Kuhn, but also Holton, Latour, Feyerabend, Popper, Shapin and Schaffer, and so on—have altered the basic narrative of science's history from an unbending teleological march to one of rich contingency, informed by cultural, political, aesthetic, religious, and ideological reference points.[60] Their histories and approaches suggest that scientific "truths" tend to change.

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[58] For a broad overview of phlogiston theory in the history of chemistry, see RICHARD MORRIS, THE LAST SORCERERS: THE PATH FROM ALCHEMY TO THE PERIODIC TABLE (2003).

[59] *See, e.g.*, THOMAS AQUINAS, SUMMA THEOLOGICAE (Timothy McDermott ed., 1989); ARISTOTLE, NICOMACHEAN ETHICS (Terence Irwin trans., 2d ed. 1999); JOHN W. CARROLL, LAWS OF NATURE (1994).

[60] *See, e.g.*, PAUL FEYERABEND, AGAINST METHOD (1975); MICHEL FOUCAULT, THE BIRTH OF THE CLINIC: AN ARCHAEOLOGY OF MEDICAL PERCEPTION (A.M. Sheridan Smith trans., 1973); GERALD HOLTON, THEMATIC ORIGINS OF SCIENTIFIC THOUGHT: KEPLER TO EINSTEIN (1973).

We cannot expect, and probably do not want, law to reflect all of these developments—many of which are so arcane, controversial, and abstract that unloading them in our courtrooms and legislative chambers would be deeply delegitimizing.[61] But when law wades into other disciplines—when it makes statements of deep structural consequence about, say, the nature of science—we should want it to be responsive to those fields that it deigns to characterize and mold. And yet, patentable-subject-matter jurisprudence is filled with metaphysical curiosities that bear little resemblance to how historians of science, philosophers, or even scientists think about science. Let us, then, briefly turn outwards.

1. Laws in Nature

In the view of the law of nature exception, unpatentable discoveries are "manifestations of laws of nature,"[62] ever present if heretofore hidden. It is science's duty and destiny to gradually, teleologically accrue such fundamental Truths. This narrative would be considered endearingly antiquated in other disciplines. It would, for instance, be deeply ungenerous to characterize even those who embrace the correspondence theory of truth as arguing that unpatentable scientific discoveries accurately represent an underlying Truth in nature.[63] But it may be worth briefly highlighting sources that have critically undercut the sustainability of such a view in other fields, despite its continued relevance in law.

a. *The Pragmatists*

One source was American pragmatism, which emerged at the end of the nineteenth century. Pragmatists and their intellectual progeny—a group that includes a vast swath of philosophers, historians of

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[61] *See, e.g.*, Leiter, *supra* note 11 (discussing the difficulty of applying current conceptions of scientific truth to the rules of evidence).

[62] Funk Bros. Seed Co. v. Kalo Inoculant Co., 333 U.S. 127, 130 (1948).

[63] The most common form of this argument, instead, is that certain scientific insights have a special relationship to the world. *See, e.g.*, PETER GODFREY-SMITH, THEORY AND REALITY: AN INTRODUCTION TO THE PHILOSOPHY OF SCIENCE 188-89 (2003) (discussing the application of the correspondence theory, which holds that "there is some kind of special and valuable relationship between true theories and the world"). Modern debates tend to focus on the "responsiveness" of scientific theories to the actual world around us, rather than the far more radical epistemic claim that particular scientific discoveries somehow accurately represent some static truth in the world around us, or that we can ever know such a thing for certain. *See id.* at 154.

science, and legal scholars—complicated the notion of a Truth in the ether, discernible by science. They argued that we could never know if discoveries constituted the "true" nature of things and so considered such debates irresolvable.[64] William James famously wrote that pragmatism is "primarily a method of settling metaphysical disputes that otherwise might be interminable."[65] It is not that pragmatists found discussions about the correspondence of a truth to an underlying reality somehow incorrect; they simply found these discussions inconclusive and fundamentally unhelpful and quixotic.[66] Debates over the reality of Truth, or the correspondence of scientific theories to that Truth, were, in James's famous example, akin to arguments about chasing a squirrel around a tree: they were all bound to be interminable.[67]

The pragmatists' approach to truth and science elevated experimentalism over stasis, construing universalism as a descriptive element of science's applicability rather than as a facet of its origins. In James's famous formulation, "[t]he truth of an idea is not a stagnant property inherent in it. Truth *happens* to an idea. It *becomes* true, is

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[64] As William James wrote, pragmatism

> converts the absolutely empty notion of a static relation of "correspondence" (what that may mean we must ask later) between our minds and reality, into that of a rich and active commerce (that anyone may follow in detail and understand) between particular thoughts of ours, and the great universe of other experiences in which they play their parts and have their uses.

WILLIAM JAMES, *What Pragmatism Means*, *in* PRAGMATISM: A NEW NAME FOR SOME OLD WAYS OF THINKING 19, 30-31 (Barnes & Noble 2003) (1907).

[65] *Id.* at 20.

[66] Richard Rorty explained that "truth is not a goal of inquiry. . . . A goal is something you can know that you are getting closer to, or farther away from. But there is no way to know our distance from truth, nor even whether we are closer to it than our ancestors were." RICHARD RORTY, TRUTH AND PROGRESS 3-4 (1998). Rorty argued that the heart of pragmatism is its nonrepresentationalism. *See id.* at 2 ("[P]hilosophy will get along better without the notions of 'the intrinsic nature of reality' and 'correspondence to reality' than with them. For those who find these notions indispensable, but only for them, this will look like an argument that there is no truth.").

[67] James explained that

> [t]he pragmatic method in such cases is to try to interpret each notion by tracing its respective practical consequences. What difference would it practically make to anyone if this notion rather than that notion were true? If no practical difference whatever can be traced, then the alternatives mean practically the same thing, and all dispute is idle.

JAMES, *supra* note 64, at 20.

made true by events."[68] James's contemporary, John Dewey, applied this pragmatic vision of truth to the scientific enterprise:

> [T]heory began to count in the sciences . . . when . . . dogmatism was replaced by the use of hypotheses in conducting experimental observations to bind concrete facts together in systems of increasing temporal-spatial extent. The *universality* that belongs to scientific theories is not that of inherent content fixed by God or Nature, but of range of applicability—of capacity to take events out of their apparent isolation so as to order them into systems which (as is the case with all living things) prove they are alive by the kind of change which is *growth*. From the standpoint of scientific inquiry nothing is more fatal to its right to obtain acceptance than a claim that its conclusions are final and hence incapable of a development that is other than mere quantitative extension.[69]

Dewey suggested that we look at ideas and discoveries not as Truths, but as provisional tools for understanding and grappling with our world.[70] Louis Menand further explained that

> Dewey thought that ideas and beliefs are the same as hands: instruments for coping. An idea has no greater metaphysical stature than, say, a fork. When your fork proves inadequate to the task of eating soup, it makes little sense to argue about whether there is something inherent in the nature of forks . . . that accounts for that failure. You just reach for a spoon. . . . Knowledge is not a copy of something that exists independently of its being known, "*it is an instrument or organ of successful action*."[71]

This is too limited a space to do justice to the rich heterogeneity of the pragmatists' accounts of truth.[72] Yet as nearly every pragmatist

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[68] WILLIAM JAMES, *Pragmatism's Conception of Truth*, *in* PRAGMATISM, *supra* note 64, at 86, 88.

[69] JOHN DEWEY, RECONSTRUCTION IN PHILOSOPHY 14 (Beacon Press 1950) (1920). This passage reflects the influence of Darwinian principles on many pragmatists. They observed that facts of science transformed over time into other truths. This transformation is embodied by Dewey's recurring metaphor of "growth." *Id.* at 48.

[70] Dewey's and James's pragmatisms were not one and the same—indeed, they emerged out of vastly different intellectual backgrounds. (Dewey's was grounded in Hegelian thought; James disdained Hegel.) But their views, however different, are considered core articulations of an identifiable "pragmatic" philosophy. *See* LOUIS MENAND, THE METAPHYSICAL CLUB 358-60 (2001).

[71] *Id.* at 361 (quoting JOHN DEWEY, *The Bearings of Pragmatism upon Education*, *in* 4 THE MIDDLE WORKS, 1899–1924, at 178, 180 (Jo Ann Boydston ed., 1977)).

[72] *Compare, e.g.*, HILARY PUTNAM, REASON, TRUTH AND HISTORY 216 (1981), *with* RICHARD RORTY, *supra* note 66, ch. 2 (responding to Putnam's criticism of Rorty). Some have even argued that the "pragmatic tradition" actually represents two distinct and divergent philosophies that reflect a fundamental misunderstanding between the two "fathers" of American pragmatism, Charles Peirce and William James. *See* H.O. MOUNCE, THE TWO PRAGMATISMS: FROM PEIRCE TO RORTY 231 (1997).

predicted, debates continue over the correspondence theory of truth. Whether scientific theories embody something real in nature remains as unresolved as the pragmatists predicted it would be a century ago. The pragmatists' vision of science and its relationship to truth is neither the most unorthodox nor the most conservative approach developed in the last century. Their view is an emblematic one, though, pointing to an underlying deficiency of "law of nature" metaphysics.

b. *Beyond Verification*

The writings of Karl Popper offer another reference point,[73] illustrating how many scientists think about their trade.[74] Philosophers of science tend not to view Popper with the reverence that he enjoys from many scientists and public figures like Justice Blackmun[75] and Nassim Nicholas Taleb.[76] Some philosophers have even branded Pop-

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[73] I limit the examples to Popper and the pragmatists, not because their arguments represent an academic mainstream or have fared especially well over the years, but because they are deeply influential. The full story of the breakdown of archaic naturalism—perhaps the best way to describe the metaphysics of the law of nature exception—would include a sweeping array of figures and movements, from Hume to Goodman, from the logical positivists to Quine. My goal is not to account for a century of scholarship in the philosophy of science, but to highlight trends that have catalyzed the breakdown of archaic quasi-Platonic notions of what science is and what it can do.

[74] Peter Godfrey-Smith writes that

> Karl Popper is the only philosopher discussed in this book who is regarded as a hero by many scientists. Attitudes toward philosophy among scientists vary, but hardly ever does a philosopher succeed in *inspiring* scientists in the way Popper has. It is also rare for a philosopher's view of science to be used within a scientific debate to justify one position over another. That has happened with Popper too.

GODFREY-SMITH, *supra* note 63, at 57.

[75] *See* Daubert v. Merrell Dow Pharm., Inc., 509 U.S. 579, 593 (1993) ("[T]he criterion of the scientific status of a theory is its falsifiability, or refutability, or testability." (alteration in original) (quoting KARL R. POPPER, CONJECTURES AND REFUTATIONS: THE GROWTH OF SCIENTIFIC KNOWLEDGE 37 (5th ed. 1989))).

[76] *See* NASSIM NICHOLAS TALEB, FOOLED BY RANDOMNESS: THE HIDDEN ROLE OF CHANCE IN THE MARKETS AND IN LIFE 106 (2001) ("Popper came up with a major answer to the problem of induction (to me he came up with *the* answer). No man has influenced the way scientists do science more than Sir Karl—in spite of the fact that many of his fellow professional philosophers find him quite naïve . . . .").

per a naïve falsificationist,[77] but that is precisely what makes his writings particularly useful for our purposes.[78]

Popper is, of course, best known for the idea that falsificationism can be used as a litmus test for science—a solution to the demarcation problem of distinguishing scientific from nonscientific insights. Popper's demarcation has been used by some to elevate science, to accord it a status transcending other fields. Among the ironies of such a move is that Popper himself did not believe that science needed to be so mythologized. Instead, he embraced falsificationism with a broader goal in mind: to solve Hume's famous problem of induction.[79]

Falsificationism is a rejoinder to ambitions of verifiability: the notion that a scientific theory can ever be considered "confirmed." Popper's critique of verifiability is integral to his vision of science, but the critique rarely comes up in legal discussions of his writings. For Popper, one can never truly verify a theory. This does not perplex scientists because verification is not, in Popper's account, what science shoots for. Science is ultimately characterized by repeated attempts to use observations to refute theories, rather than to confirm them.[80] We can never be certain, argued Popper, that a theory is true.[81] In a famous example often credited to Hume, even after a life spent as an ornithologist, one cannot say that all swans are white. The most one

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[77] *See, e.g.*, Imre Lakatos, *Falsification and the Methodology of Scientific Research Programmes*, *in* CRITICISM AND THE GROWTH OF KNOWLEDGE 91, 93 (Imre Lakatos & Alan Musgrave eds., 1970).

[78] A troubling feature of legal scholarship is that wildly inconsistent views of science dominate different camps of the academy. Justice Blackmun's *Daubert* opinion famously borrowed Popperian notions of falsifiability as a standard for the admissibility of scientific evidence. *See Daubert*, 509 U.S. at 593. Yet Popper's core insights are nowhere to be found in the contemporary intellectual property jurisprudence. Such rifts do of course exist in other fields, but they generally emerge from genuine, informed disagreements (for instance, about whether string theory is any less valid because elements of the theory may or may not be falsifiable). It is hard to imagine why different legal fields (evidence versus patent law, in this case) should disagree about the epistemic content of science.

[79] *See generally* DAVID HUME, AN ENQUIRY CONCERNING HUMAN UNDERSTANDING (Eric Steinberg ed., 1977).

[80] *See* GODFREY-SMITH, *supra* note 63, at 235 (defining Popper's falsificationism as the idea "that a theory is scientific if it has the potential to be refuted by some possible observation"); *see also* KARL R. POPPER, CONJECTURES AND REFUTATIONS: THE GROWTH OF SCIENTIFIC KNOWLEDGE (1963); KARL R. POPPER, THE LOGIC OF SCIENTIFIC DISCOVERY ch. 4 (1959) (discussing and defining the condition of falsifiability).

[81] *See* GODFREY-SMITH, *supra* note 63, at 59 ("The harder question is whether or not we can be reasonable in *increasing* our confidence in the truth of a theory when it passes observational tests. Popper said no. The logical empiricists and most other philosophers of science say yes.").

can conclude is that not all swans are black. This was Popper's solution to the so-called problem of induction. The best we can say about a theory is that it has not yet been shown to be wrong—that it has not been falsified *but can be falsified*.

Contrast this view with the law of nature metaphysics. Where falsificationism views successful theories as falsifiable but not yet falsified, legal metaphysics construes them as mirrors of nature. Where the former sees the work of scientists as incessantly challenging accepted theories, the latter sees this work as confirming a static reality. In this way, both the rhetoric and gist of Popperian falsificationism runs counter to the core vocabulary and content of the law of nature exception.

I have briefly introduced Popperian falsificationism and American pragmatism as exemplars. These views do not come close to exhausting the visions of truth in and of science propounded in the past century. Perhaps we, the practitioners of a more grounded guild, do not even care what philosophers or historians of science have to say about science. What use do patent attorneys have with such abstract and arcane disputes? Perhaps it is better to simply assume the truth of theories in order to draw the boundaries around patentable subject matter that are so essential to sustaining a viable patent regime. And yet, even if some scientific discoveries do rise to the level of Truth—assuming we could ever know when they did so and could correctly identify which ones—that is a far cry from saying that all basic discoveries, scientific theories, and abstract ideas are somehow laws of nature.[82] A point so theoretical seemingly has little relevance for patent law. Yet the obscure disputes of the philosophy of science have been made relevant by the metaphysics of patent law, a metaphysics that, as we have seen, is foundational to doctrines of patentable subject matter. In this arena of jurisprudence, law controls not just practice but also contested theory, even if abstract questions of reality otherwise play little to no role in patent law.

As discussed in the next subsection, other disciplines give us further reasons to be skeptical of the approach to science underlying the law of nature exception. The history of science too, it turns out, is characterized less by rigid, unchanging beliefs than by theories and ideas developing over time.

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[82] We classify a huge variety of things as "discoveries"—from a previously unidentified beetle or moon of Jupiter to a new account of how gravity works. It is probably misleading to group all "discoveries" into one bucket, as if they were held together by a common epistemic or ontological thread. It is nearly as grave an error to divide scientific products into distinctive buckets. One error, of course, does not excuse another.

2. Science in History

One need not commit to a radical theory of what science is to accept that perhaps the most enduring, even universal, facet of scientific theories is their tendency to change. Regardless of how we describe science, the notion that theories, ideas, and abstract principles evolve, that they are modified and replaced over time—and with them our understanding of natural phenomena—is a commonplace for scientific researchers, historians, and sociologists alike. It is a pattern upon which even Alan Sokal and Bruno Latour might agree.[83]

Historians have written about science for as long as they have written histories, but the modern academic discipline of the history of science has attracted interdisciplinary attention in part because of what it suggests about science as a historic, and thus human, enterprise.[84] I do not even attempt to summarize the discipline here, but suffice it to say that it paints a subtler and more dynamic picture of the development of science than a mere accumulation of static truths or a ranking of great minds. In this context, two disciplinary themes are worth reciting.

First, the history of science brims with narratives of how scientific ideas and commitments—most pointedly, those once held to be core truths—have changed over time. Thomas Kuhn is the historian most associated with this insight,[85] but he is by no stretch alone in advancing it. Popper and the pragmatists presumed the point; arch-positivists would be loath to disagree.[86] Even the paradigmatic "laws of

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[83] Alan Sokal and Bruno Latour have contrasting views of what science does. Latour is a sociologist famous for his excursions into laboratories as a self-described anthropologist of science. *See, e.g.*, BRUNO LATOUR & STEVE WOOLGAR, LABORATORY LIFE: THE CONSTRUCTION OF SCIENTIFIC FACTS (1979) (reporting on Latour's two-year study of the practices of scientists at the Salk Institute for Biological Studies). Sokal, in one of the initial volleys of the so-called "science wars," sent an essay of high-fashioned gobbledygook to a prominent sociology of science journal. *See* Alan D. Sokal, *Transgressing the Boundaries: Toward a Transformative Hermeneutics of Quantum Gravity*, SOC. TEXT, Spring/Summer 1996, at 217. To his astonishment, the piece was published as a cover article, leading him to write a tell-all ridiculing the journal and its discipline. *See* ALAN SOKAL & JEAN BRICMONT, FASHIONABLE NONSENSE: POSTMODERN INTELLECTUALS' ABUSE OF SCIENCE (1998).

[84] *See generally* History of Sci. Soc'y, Guide to the History of Science, http://www.hssonline.org/guide (last visited Apr. 15, 2009) (cataloguing "people, institutions, organizations, and publications pursuing science history").

[85] *See* THOMAS S. KUHN, THE STRUCTURE OF SCIENTIFIC REVOLUTIONS (1962).

[86] Indeed, Kuhn was approached to write *The Structure* by positivists, who did not consider his account of science to be any sort of mortal threat to their worldview. *See* STEVE FULLER, THOMAS KUHN: A PHILOSOPHICAL HISTORY FOR OUR TIMES 285-86

nature" in patent jurisprudence—Einstein's and Newton's theories—have been modified and illuminated over time.[87] The history of science cannot tell us whether a standing theory is or is not fact, but it can suggest a better way of viewing those theories: as highly useful, if provisional, understandings, likely to be reconsidered and replaced as time passes.

Second, histories of science frequently detail how scientific theories can be shaped by forces other than slavish empiricism or hard-and-fast "method." Critical scientific debates have at times been informed by political and social structures,[88] gender norms,[89] aesthetic commitments, ideological principles,[90] and so on. This is not to say that every scientific theory is a product of such forces, or even that scientific theories are any less valid in some sense when they are. But such observations do suggest that the history of science has not been a teleological march to the drumbeat of empirics. If there is an ambitious conclusion to be extracted from this observation, it may come from the insistence of historians and sociologists that science is a human endeavor—that theories and abstract ideas are as much human tools or confabulations as are hammers and widgets.

3. Reconsidering Laws of Nature

Law is a practical and frequently derivative discipline, an engineering of the humanities. Like "industry," as imagined at that grand museum in Chicago, law takes innovations, ideas, and principles from other fields and applies them to the needs of society. There is, consequently, an inevitable lag between the emergence of insights in eco-

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(2000) ("Kuhn's positivist patron, Rudolf Carnap, . . . complimented Kuhn on having provided a historical grounding . . . for his own distinction between questions that are decidable within the terms of a given conceptual framework and those that require the introduction of extramural factors.").

[87] For an overview of these developments in modern physics, see PETER GALISON, EINSTEIN'S CLOCKS, POINCARÉ'S MAPS: EMPIRES OF TIME (2003).

[88] *See, e.g.*, STEVEN SHAPIN & SIMON SCHAFFER, LEVIATHAN AND THE AIR PUMP: HOBBES, BOYLE, AND THE EXPERIMENTAL LIFE 332 (1985) (arguing that "the history of science occupies the same terrain as the history of politics").

[89] *See, e.g.*, KATHARINE PARK, SECRETS OF WOMEN: GENDER, GENERATION, AND THE ORIGINS OF HUMAN DISSECTION 37 (2006) (arguing that a fascination with "secrets of women" in medieval and Renaissance Italy "played a central role in the history of anatomy").

[90] *See, e.g.*, STEPHEN JAY GOULD, THE MISMEASURE OF MAN (rev. ed. 1996) (challenging biological determinism's explanations of the differences between races, classes, sexes, and other groups).

nomics, physics, history, ethics, or biology and their fixation into the legal literature. There is also a confounding, if quite intentional, inertia to the law—best embodied, perhaps, by adherence to stare decisis and precedent—that discourages quick appropriation of new extra-disciplinary ideas and insights and instead favors an incremental crawl.[91] Further, law suffers from chronic translational errors as these ideas and insights are integrated into legal scholarship (though the frequency of such errors is, of course, a contentious topic).[92] This confluence of features—application, lag, inertia, and translation—has almost certainly contributed to the current state of patent jurisprudence. In the case of the law of nature exception, it has sustained a principle unhinged to the practice and wisdom of other disciplines.

This raises the question, if law were to treat discoveries as something other than laws of nature, what might its account look like? We would want foremost to avoid replacing one categorization error with another. There is great variety in the class of insights that we call "discoveries." Drawing artificial and suspect lines between different types of scientific products is no better or worse than artificially compressing everything that scientists produce into the unitary and undifferentiated category of "discovery." Such a move would be incongruous with the literature we have just explored. John Dewey, as one example, went so far as to argue that certain types of discoveries are actually quite common and recurring: schoolchildren make discoveries daily, though these tend to reflect insights with which the rest of us have been long familiar.[93]

Bearing this caution in mind, the contours of a solution may emerge from the material above. Discoveries, laws of nature, and abstract principles may all be viewed as provisional tools for answering

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[91] *See* Jack Knight & Lee Epstein, *The Norm of* Stare Decisis, 40 AM. J. POL. SCI. 1018 (1996) (arguing that stare decisis constrains judges who may otherwise seek to fully align the law with their own policy preferences); Victor E. Schwartz et al., *Toward Neutral Principles of Stare Decisis in Tort Law*, 58 S.C. L. REV. 317, 319 (2006) ("For more than two hundred years, courts in the United States have developed tort law through common law judicial decisions. This process has an important guardian: the doctrine of stare decisis. Stare decisis enhances the stability and predictability of tort law by ensuring that change is gradual.").

[92] Richard Posner argues that this effect of interdisciplinary scholarship is magnified by both the lack of a peer-review process in most American law reviews and the fact that legal scholarship often draws heavily from fields outside of law. Richard A. Posner, *Against the Law Reviews*, LEGAL AFF., Nov.–Dec. 2004, at 57.

[93] JOHN DEWEY, DEMOCRACY AND EDUCATION 354 (1916) (outlining a theory of individual discovery in education turning both on a student's discovering the meaning of a concept and the "freshness" with which the student reached that realization).

questions that we have about the world around us. Whether theories are actually true, or are somehow extractions of nature, is a wholly separate and incidental inquiry. Their relevant characteristic would be their functionality: their ability to answer questions that we want answered and to provide solutions to technical and cosmological dilemmas of genuine concern. They would be considered tools like any other, though perhaps less tangible tools than, say, hammers or widgets (but no less tangible than mathematical algorithms). This formulation may not appeal to every philosopher of science, and it would certainly fly in the face of standing patent jurisprudence, but as a common-sense approach to what it is that scientists do and to how we think about science, it holds many advantages over law of nature metaphysics.

The Supreme Court has already suggested that theories and ideas can be viewed as tools for the purposes of patent doctrine. A particularly telling instance is the Court's opinion in *Gottschalk v. Benson*.[94] Quoting *Le Roy v. Tatham*'s brute characterization of a principle as an "original cause,"[95] the majority opinion continued, "Phenomena of nature, though just discovered, mental processes, and abstract intellectual concepts are not patentable, as they are the basic tools of scientific and technological work."[96] Here, the Court was alluding to the dangers of granting a monopoly on a critical concept that is essential for moving science forward. But in so doing, the Court affirmed that the core feature of principles in scientific research is not their alleged status as "motives" or "original causes," but rather their functionality as tools of a trade (in this case, the trade of scientific research). Just like any other tools—including those to which we grant patents—scientific principles serve concrete purposes but may break down or become obsolete over time. We replace them when needed. The same, of course, should hold for outdated legal principles.

4. An Unsustainable Principle

The law of nature exception—partitioning research products into boxes based on their hypothetical relationship to a hypothetical Truth in nature—is an anachronism of scientific theory and practice. A more sensible approach to discoveries would be to take stock of the insights of scientists and the fields—particularly history, sociology, and

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[94] 409 U.S. 63 (1972).
[95] 55 U.S. (14 How.) 156, 175 (1853).
[96] *Gottschalk*, 409 U.S. at 67.

philosophy—that study the endeavor of science. Such a view has long held valence in the law, but it has rarely been embraced or articulated in full. Perhaps that is because of the practical difficulties of fashioning an intellectual property regime capable of recognizing rights to fundamental discoveries.[97] This is the topic to which we now turn.

II. OBJECTIONS TO A SCIENTIFIC PROPERTY RIGHT

Critiques of law of nature metaphysics are nothing new. They qualify as banalities in other disciplines, a yawn for scientists and intellectual historians. Yet law has not always been so deeply anomalous. Modern patentable-subject-matter jurisprudence obscures the pedigree of such objections. This legacy has been all but forgotten, alternately lost and discarded in legal circles. Let us briefly revisit it as a frame for the practical challenges that have been raised against proposals for a scientific property right.[98]

A. *Post-War Context*

The heyday of the movement for a "scientific property" right occurred after World War I, an era of displacement and reconstruction.[99] In this milieu, scientific researchers with fixed incomes from European institutes and foundations found themselves impoverished and unprotected during a period of crippling inflation.[100] Hungry intellects bristled at the worldly successes—or, at least, nonimpoverished status—of their colleagues in industry and the written arts, and questioned the justice of an intellectual property regime that fostered haves and have-nots by differentially apportioning rights to different sorts of innovations. "While authors enjoyed copyright and inventors

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[97] Fashioning such a regime is not the only alternative in play. Other solutions to patent law's problem of untenable demarcation may include doing away with monopoly rents altogether or simply drawing more sustainable lines between categories of research products.

[98] The most comprehensive account of this history is 3 STEPHEN P. LADAS, PATENTS, TRADEMARKS, AND RELATED RIGHTS §§ 1005-1027 (1975). Though other sources have retold Ladas's account, his material remains the most exhaustive of the available published narratives, and so is the one that I will reference most frequently in the pages that follow.

[99] *See, e.g.*, Merges, *supra* note 42, at 152-53 (tracing the movement's roots to post–World War I France).

[100] *See* Thomas R. Ilosvay, *Scientific Property*, 2 AM. J. COMP. L. 178, 180-81 (1953) ("In 1919, when the scientists, mostly employed by foundations and with fixed incomes, were seriously affected by the fall of the German and French currencies, the topic [of a scientific property right] attracted renewed attention.").

could obtain patents," explained Stephen Ladas in the definitive legal history of this movement, "scientists and, generally, persons making scientific discoveries could claim no economic benefits from the industrial progress based on these discoveries."[101] It was a cruel and seemingly inexplicable irony that great scientific innovators remained "in poverty while others were enriched by using their creative work."[102]

Few, if any, advocates of a scientific property right imagined folding discoveries into existing patent monopoly systems. They were as aware as commentators today of the intuitive and normative objections to granting monopolies on basic knowledge. The vast majority of advocates proposed reforms that may not have been ultimately successful, but were certainly not naïve.

Most proposals involved granting either royalty awards or direct compensation for worthy insights. For instance, one advocate proposed a tiered system granting either a percentage claim on royalties for inventions based on a discovery or a "patent of principle" providing a right to grant compulsory licenses to use a discovery.[103] Others envisioned a scientific property right along the lines of "a right of author" in artistic works, which would be granted upon "sufficient publication."[104] This right amounted to a royalty determined either by the interested parties or, failing that, the courts. Another version of this proposal suggested a royalty "on the money value which [a] discovery was likely to acquire by means of its practical application and its industrial utilization, within a specified period of time."[105] This right was to last for a period roughly akin to literary or artistic copyrights. Other advocates envisioned centralized funds—sponsored by the state or by industries profiting from discoveries—that would distribute financial

[101] 3 LADAS, *supra* note 98, § 1005.

[102] *Id.*

[103] *See id.* § 1006 (discussing the proposal of Professor J. Barthélemy).

[104] *See id.* § 1008 (discussing the proposal of the Confédération des Travailleurs Intellectuels).

[105] *Report on Scientific Property*, League of Nations Doc. A.38 1923 XII § 13(II) (1923) (*submitted by* Sen. F. Ruffini).

awards to discoverers.[106] These funds would pay out years after a discovery to accurately estimate its actual value over time.[107]

Arguments for a so-called "scientific property right" were styled, in the fashion of the time, to echo familiar natural rights rhetoric. But they were based on that most elemental principle of justice: treating likes alike. Commentators saw grave injustice in extending property rights to one class of scientific research products but not another. For instance, one of the central intellects of the reform movement—the French academic J. Barthélemy—argued, in Ladas's words, that "if a person, by his intellectual activity, has made possible benefits which otherwise would be impossible, justice requires that he obtain a share in these benefits."[108] This theme was reiterated by Senator Ruffini of Italy, who "rel[ied] unhesitatingly and without scruple upon the common feeling of justice, that profound and infallible feeling which tells us that there is a wrong which must be righted."[109] Such arguments found currency among American jurists as well. The opinion in *Katz v. Horni Signal Manufacturing Corp.*, for instance, saw irony in denying patent protection to great scientific minds who articulate new discoveries while protecting the works of "those lesser geniuses who put such discoveries to practical use."[110]

To complement their arguments about comparative justice, the post-War movement for a scientific property right questioned, too, the underlying logic and content of divisions between types of research products. The doctrinal arguments that attempted to categorically distinguish inventions from discoveries often alluded to the "character of creations"—a character attributed to inventions and artistic works but found lacking in discoveries and scientific conceptions.[111] Such differences—alternately described as "the element of creation" or "creative elements" or "the character of true creation"—bear more

[106] 3 LADAS, *supra* note 98, § 1015. Such a system is not dissimilar from the manner in which many grant-giving institutions and political bodies treat research today. State commissions frequently dole out awards for meaningful scientific contributions or otherwise base research grants to scientists on their track record of scientific innovation and insight. *See infra* subsection III.B.1.

[107] I will briefly revisit these championed reforms—reforms that ultimately sputtered out as the post-War economic crisis attenuated—in the next Section. What bears mention at present are the analytical contentions that propelled the movement forward.

[108] 3 LADAS, *supra* note 98, § 1006.

[109] *Report on Scientific Property*, *supra* note 105, § 6.

[110] 145 F.2d 961, 961 (2d Cir. 1944).

[111] *See* 3 LADAS, *supra* note 98, § 1011 (summarizing and commenting on Ruffini's survey of the field).

than a passing resemblance to the language and motifs of standing patent doctrines. Unsurprisingly, Ruffini's survey found them "dominated by . . . the crudest utilitarianism, empiricism unhappily disguised in scientific nebulosity, and, finally, the most disconcerting arbitrariness."[112]

Ruffini also addressed familiar, general objections to granting property rights to discoveries. These objections included the difficulties of identifying a lone discoverer, given the cooperative context in which discoveries often occur, prospective roadblocks created by monopoly power over critical insights, and alleged excess of attaching economic incentives to that which would inevitably be produced. Ruffini easily dismissed these as quibbles, noting that they were functionally equivalent to familiar, and long-dismissed, objections to property rights for authors and inventors raised at other points in history.[113] Even if, as some argued, "a scientific idea was in the air"—a metaphysical assumption that we see today in discussions of the law of nature exception—"it was caught by someone and revealed to the public. In this respect inventions are in no way different from discoveries."[114]

In this post-War period, several organizations, ranging from France's Confédération des Travailleurs Intellectuels[115] to the Committee on Intellectual Cooperation of the League of Nations, emerged with proposals for a scientific property right.[116] We should not underestimate the sophistication and creativity of this movement: the scope and originality of its reform proposals remain unmatched by any contemporary discussion of the topic. Ultimately, the movement petered out not due to a deficit of persuasive advocates or intellectual firepower, but rather because of a changed economic climate in Europe and strategic errors among the movement's leaders.[117] Simply, the

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[112] *Report on Scientific Property*, *supra* note 105, § 6, *quoted in* 3 LADAS, *supra* note 98, § 1011.

[113] *Id.*; *see also* 3 LADAS, *supra* note 98, § 1011.

[114] 3 LADAS, *supra* note 98, § 1017.

[115] *See id.* § 1008.

[116] *See id.* § 1019; *Report on Scientific Property*, *supra* note 105.

[117] Ladas writes that

> the whole movement rested on a political or pragmatic approach to the recognition of the value of the work of scientists in scientific or technological progress but not on a clear understanding of the relationships involved and of the scheme of interests and claims to be recognized, reconciled, and satisfied.

3 LADAS, *supra* note 98, § 1021; *see also* Stojan Pretnar, *Contemporary Problems of the Rights of the Authors of Scientific Discoveries*, 1 INDUS. PROP. 286, 297 (1962) (attributing the failure of the movement to proposals that "aimed too high").

drive for reform proved largely conditional on the social and financial needs of scientists. As their lot improved during the interwar period, the movement lost its urgency.[118]

Though the movement for a scientific property right largely dissipated in Western Europe by 1930, similar arguments have since surfaced intermittently in the United States. In that same year, Northwestern University's Linthicum Foundation published a study by Professor Hamson entitled *Patent Rights for Scientific Discoveries*,[119] arguing for just such a right.[120] By and large, Hamson's argument went nowhere, evincing no significant changes to, or sustained discussion within, American law. A similar fate befell a 1971 report by the American Bar Association's Committee on Patent System Policy Planning, which tentatively suggested an "extension of intellectual property protection to scientific discoveries."[121]

These ideas continue to re-emerge every so often: a report by the United Nations Educational, Scientific and Cultural Organization (UNESCO) in one decade,[122] one by the Organisation for Economic Co-operation and Development (OECD) in another.[123] Most recently, the Nobel Prize–winning economist Joseph Stiglitz proposed creating "science prizes" for basic medical research to replace the patent monopolies that currently drive profitability—and, in Stiglitz's view, dubious research priorities and pricing models—in the pharmaceutical industry.[124] Strikingly, throughout most of the mid–twentieth century,

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[118] In France, however, scientific groups continued to discuss the question, eventually leading to the creation of the Medal of Scientific Research. 3 LADAS, *supra* note 98, § 1021.

[119] C.J. HAMSON, PATENT RIGHTS FOR SCIENTIFIC DISCOVERIES (1930).

[120] 3 LADAS, *supra* note 98, § 1022.

[121] H. Hume Mathews, *Report of Committee No. 108: Patent System Policy Planning*, 1971 A.B.A. SEC. PAT., TRADEMARK AND COPYRIGHT L. REP. 105, 108.

[122] *See* LADAS, *supra* note 98, § 1023 (describing UNESCO's canvassing of member states' views on expanding intellectual property protection and appointment of a committee to study potential expansion).

[123] The OECD prepared a report in 1960, arguing that "it is no longer possible to consider fundamental research as completely isolated from the goals and purposes of a society or industry," and that "the manner of bringing new knowledge into practical use may well be altering." *Id.* § 1024.

[124] *See* Joseph Stiglitz, *A Better Way to Crack It*, NEW SCIENTIST, Sept. 16, 2006, at 20 ("A prize fund for medical research would be one alternative [to patents]. . . . It would provide strong incentives for research but without the inefficiencies associated with monopolisation.").

the topic received the most sustained attention in socialist states, in which private property was ideological anathema.[125]

B. *Objections to a Scientific Property Right: An Impractical Right*

Most critiques of a scientific property right have challenged its plausibility and applicability, rather than attempting to defend the metaphysical distinctions of our intellectual property system. The presumption that we have no viable alternative to the present system has deeply informed the debate over a scientific property right, perpetuating the distinction between natural principles and man-made products beyond its usefulness.

We have surveyed the reforms championed by movements for a scientific property right. By and large, these proposals involved licensing schemes or compensatory awards drawn from a centralized fund. Merges has identified four broad objections to these proposals, objections that have arisen time and again over the last century:

> First, it is very often difficult to trace the scientific origins of a particular industrial application. Second, there is a significant lag time between the disclosure of a scientific discovery and the development of the first application . . . . Third, very often it can be assumed that a scientific disclosure will be missed by industrialists; they will thus end up paying royalties for a scientific discovery which in fact was not relied upon in creating their industrial application. And finally, the very significant burdens on scientific communication that a system of property rights would create represent perhaps the most severe problem.[126]

Beyond these barriers, Merges has articulated a fifth objection: such a right would be gratuitous.[127] The presumption is that scientific research has and will continue to thrive without property rights protection. Thus, extending monopoly rents on research products would almost certainly prove inefficient. "On this view," Merges explains, "granting patents for discoveries that scientists *would have made anyway*

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[125] *See* LADAS, *supra* note 98, § 1025. Czechoslovakia helped spur this movement by recommending a form of eminent domain for discoveries, with both inventors and discoverers transferring their rights to the state in "exchange for a monetary remuneration calculated on the saving in production costs brought about by the invention." *Id.* § 1025, at 1876. These governments, writes Ladas, "were naturally led to recognize and grant a remuneration for scientific discoveries because of their indirect effect on production through the inventions based on them." *Id.*

[126] Merges, *supra* note 42, at 154.

[127] *Id.* at 155.

would be socially wasteful."[128] Judge Jerome Frank is the jurist most frequently identified with this position,[129] having argued in *Katz v. Horni Signal Manufacturing Corp.* that

> [e]poch-making "discoveries" of "mere" general scientific "laws," without more, cannot be patented. So the great "discoveries" of Newton or Faraday could not have been rewarded with such a grant of monopoly. Interestingly enough, apparently many scientists like Faraday care little for monetary rewards; generally the motives of such outstanding geniuses are not pecuniary. Perhaps (although no one really knows), the same cannot be said of those lesser geniuses who put such discoveries to practical use.[130]

These objections can be further refined into two broad classes. The first relates to the presumed impracticality of schemes establishing a scientific property right. The second involves normative concerns about whether such a right is necessary and frets about its disruptive influence on basic research.

Given the many forms that a scientific property right could take, it is striking to note the broad contemporary consensus that, in any iteration, application and enforcement of such a right would be impracticable. The transaction costs, many argue, would simply be unsustainable.[131] Among the practical objections to a scientific-property-rights regime is the difficulty of defining criteria for such rights. What standard would we use to validate a discovery's status as significant enough to merit property protection? What adjudicative body would make that determination? What of codiscovery and the difficulties of identifying a lone "discoverer" given the collaborative nature of scientific research?

These are perplexing questions, as yet unresolved. And so I do not intend to be flippant by pointing out, like Ruffini, that they are largely indistinguishable from objections raised against creating patent, copyright, and trademark regimes throughout legal history.[132]

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[128] *Id.*

[129] *See, e.g.*, Eisenberg, *supra* note 1, at 186 n.45 ("Judge Frank has offered another rationale [for the law of nature exception]: Great scientists are not motivated by pecuniary gain, so the prospect of a patent monopoly will not enhance their productivity.").

[130] 145 F.2d 961, 961 (2d Cir. 1944) (footnote omitted).

[131] *See, e.g.*, Merges, *supra* note 42, at 155 ("If it is true that property rights are increasingly essential to the research endeavor, it is no less true that these rights will bring with them a host of problems. It is these problems—which I would describe as an entire family of new *transaction costs*—which drive the discussion . . . concerning policy solutions to the imposition of property rights in science.").

[132] *See supra* note 113 and accompanying text.

Moreover, existing scientific institutions have developed solutions for many of these dilemmas. Peer-reviewed journals manage far better than law reviews, and certainly better than patent boards, at distinguishing critical from marginal insights.[133] Panels of experts associated with such grand names as Nobel and Fields have over the past century identified individuals and discoveries meriting unique distinction.[134] Indeed, much of the organizational structure and culture of contemporary science—from tenure committees at universities to grant reviewers at the National Institutes of Health (NIH)—is dedicated to addressing precisely these questions.[135]

Skeptics also raise difficult questions about enforcing a scientific property right and making it meaningful. Critics and proponents alike have worried about estimating the value of discoveries in award and licensing schemes. The goal of such schemes is to compensate discoverers fairly and efficiently: that is, neither to overcompensate and chill further research, nor to undercompensate and create market distortions (though undercompensating seems preferable to failing to compensate at all). This difficulty is especially pronounced when a discovery's significance and range of applications becomes clear only years after the initial insight.[136] In a similar vein, critics voice concerns about over- and underenforcement.[137] Would a flurry of suits over alleged infractions paralyze the courts? How could we possibly know when industry, or really anyone for that matter, applies a basic insight? Enforcement in such conditions could become a nightmare.

Barthélemy, the French champion of a scientific property right, dismissed such concerns as ultimately inconsequential, arguing, in Ruffini's words, that "complications and progress necessarily go hand-

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[133] *See, e.g.*, Posner, *supra* note 92.

[134] Indeed, the most common critique of these committees is not that they have gotten things wrong—either in associating certain people and not others with celebrated innovations or in choosing certain innovations for distinction—but rather that many individuals of great merit (the Prousts and Kafkas) failed to receive fair recognition before their deaths. *See, e.g.*, Alex Duval Smith, *A Nobel Calling: 100 Years of Controversy*, INDEPENDENT (U.K.), Oct. 14, 2005 (listing "the academy's astonishing omissions").

[135] Tenure promotions and grant awards are in principle speculative investments, based on the prospective accomplishments of a scientist or lab. However, the reality is that scientists with a proven track record of published work have a smoother path to attractive grants and departmental promotions.

[136] For this reason many proposals put forth by advocates in the post-War movement for a scientific property right oriented around retrospective grant awards, as discussed *supra* Section II.A.

[137] *See, e.g.*, Merges, *supra* note 42, at 154-55.

in-hand and, consequently, the justice meted out to men of science would obviously be more complicated than the brutal injustice of which they had hitherto been the noble and uncomplaining victims."[138] Such idealism holds appeal. Yet the fact that scientific property rights have never been protected in American law—nor in the legal system of any other country[139]—is a testament to the profound conceptual difficulties at play. There is little reason, however, to presume them necessarily insurmountable.

I have already suggested that existing political, legal, and scientific institutions have long addressed and often surmounted these practical problems. I will return to this topic in Part IV. At present, it may be worth briefly highlighting several legal solutions already in place. As Burk and Lemley have argued, we need not discard standing property rights principles like inherency in conceiving of, and applying, a right to scientific property.[140] Limitations of this sort were familiar and widely accepted by even strident advocates for reform in post-War Europe, encapsulated most clearly in Dean Wigmore's reservation to Ruffini's and Barthélemy's proposals.[141]

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[138] *Report on Scientific Property*, *supra* note 105, § 4.

[139] France and several socialist states did, however, seriously flirt with the idea. *See supra* notes 118 & 125.

[140] Burk & Lemley, *supra* note 35, at 406-08 (arguing that the inherency doctrine could do the work of the law of nature exception "by providing a rationale for identifying those modified products of nature that are worthy of patents").

[141] Wigmore contrasted the discoveries of previous generations, which "consisted in discovering principles which explained obvious facts of human life," with modern discoveries, like radium, which go "beyond the explanation of the obvious practices of human activity" and "enable us to enter upon activities which the human mind had never been able to contemplate." *Report on Scientific Progress*, *supra* note 105, annex. As Ladas summarized one of Ruffini's "guiding principles," "[t]his new aspect of scientific discoveries should lead to recognition of a right of scientists in their creations. But those discoveries of the present day which have the same character as the old ones should be clearly distinguished." 3 LADAS, *supra* note 98, § 1014. In other words, explaining a heretofore mysterious (or misunderstood) mechanism at work in an invention or industrial product does not create a claim to either. Explicating "why" is different from empowering to, except, perhaps, in the case of empowering to understand why. That is, a fundamental concept or idea most resembles a tool or invention when it is used in labs and other fora of basic scientific research, since professional livelihood and success depend on applying insights qua insights (such as when the theory of evolution threw open a whole new set of approaches to studying the world around us). Existing property rights doctrines—such as the experimental-use exception—shed light on how accessible we would choose to make scientific insights to other researchers. Yet at some point an experimental-use exception covering an entire area of intellectual property becomes something other than an exception: it becomes a form of communism (in the nonpejorative, Mertonian sense) or an uncompensated taking (in the pejorative sense).

Whether these are satisfying legal responses is a topic for an essay more concerned than this one with championing particular reforms. My point is different: even if creating a legal regime to protect scientific property is as impractical and quixotic as some have suggested, these pragmatic concerns alone do not transform the epistemic and ontological status of discoveries. Put another way, that we are unable to protect a property right does not necessarily make it any less of a right, or our lack of protection of it any less troubling.[142] This point was the focus of the previous Section: determining whether metaphysical distinctions between scientific research products that we consider to be intellectual property, and those that we do not, are defensible. A more difficult challenge in this respect is the one to which we now turn: whether perhaps we fail to protect scientific property rights because they are somehow normatively undesirable.

C. *Objections to a Scientific Property Right: An Undesirable Right*

There are two common normative objections in law to a scientific property right. Let us address them in turn.

1. The (Ir)relevance of Money for the Starving Scientist

The first objection, identified with Judge Frank, holds that scientists are simply not motivated by crass financial gain.[143] "Great" researchers, according to this account, are driven solely by passion to do science for science's sake. Compensating researchers for their discoveries would thus be deeply wasteful.

It is easy to ridicule this position as presuming that scientists are inhuman saints. Indeed, this is precisely the sort of description a lawyer who has never spent a day of his life in a lab might make of scientists. But there is something to it. As any aspiring Ph.D. will attest, the notion that scientific researchers are primarily "in it for the money" is implausible. They make far too little of it in their academic posts, and their skills are highly marketable in other, far-better-paying industries. That said, Judge Frank's point remains, by and large, silly.

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[142] This depends, of course, on how we define the content of property rights; a right unprotected and unrecognized by government is arguably no right at all. Yet if we are to classify some products of scientific research as intellectual property, then we should want the boundary between what is and is not property to be reasonably coherent. We should at least try to treat likes alike.

[143] *See* Katz v. Horni Signal Mfg. Corp., 145 F.2d 961, 961 (2d Cir. 1944).

First, Frank's account, even if once vaguely compelling, is dated. As Merges has written, Frank's assumption is "far less defensible in today's environment of tight federal budgets. Regardless of what *motivates* a scientist, . . . he or she cannot make any progress in the vast majority of scientific disciplines without a great deal of money."[144] Scientists frequently require absurdly expensive equipment to do their research, equipment that they must incessantly upgrade and replace. Research also demands a vast array of resources and materials and involves subsidizing graduate students' protracted, expensive educations. All of these things require large sums of money, burdening researchers at every turn with grant applications to a baffling array of idiosyncratic funding bodies. The notion that financial support from a scientific property right would somehow be gratuitous is thus woefully misguided.[145]

Yet even if scientists are altruistic *übermenschen*, less motivated by financial incentives than are lowly nonscientists (particularly inventors), that is a far cry from saying that financial considerations have *no impact whatsoever at the margins*. Why, after all, does a prospective graduate student choose to pursue her education at one school rather than another? Certainly the faculty makes a difference, as does proximity to family, the academic environment, the prestige of the degree, and even the quality of the school gymnasium. But financial considerations—in the form of student aid and scholarships, access to specialized equipment and resources, financial support for research, compensation for teaching, and so forth—are absolutely critical. The same holds for researchers pursuing academic appointments.

So too with the research projects that scientists pursue. A researcher may want desperately to study a particular scientific issue. She may even believe that she has an approach capable of shaking the field, assuring her tenure and a constellation of other glories. But without sufficient funding or access to key resources and equipment (or, at the very least, the potential to recoup her investments), her suspicion will remain unexplored.

Mundane salary matters are similarly relevant, despite what lawyers want to believe about scientists. Grade-school economics tells us

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[144] Merges, *supra* note 42, at 155.

[145] Merges writes, "Far from being redundant—an unnecessary reward, heaped on a researcher who would have done the same work without it—[property rights] may well be essential." *Id.* He also observes that "since adequate funding is essential to science, society will not receive the results of scientific research without either extensive public support or some other revenue source [like monopoly rents]." *Id.*

that small changes in projected income can make a difference, however marginal, in career decisions. Even if we believe this to be less true (or consider the effect to be smaller) for scientists, we would be fooling ourselves and committing a Frankian mischaracterization of our peers across campus to assume that differences of, say, $20,000, $40,000, or—for associate professors who could take jobs in consulting or the pharmaceutical industry—$100,000, are of no moment.

2. Norms of Science Under Assault

A more perplexing critique of scientific property rights builds on a view of science that enjoys great currency in legal circles, and so holds more than a few parallels to law of nature metaphysics. The stance hinges on so-called "norms of science," as envisioned and articulated by the sociologist of science Robert Merton in the 1940s.[146] Recitations of this critique in the legal academy tend to echo an influential article on the topic by Rebecca Eisenberg in the late 1980s.[147] Eisenberg largely introduced Merton's writings to legal scholarship[148] at a moment when the line between basic and applied research in biotechnology was becoming blurred by vexed courts.[149]

The account runs roughly as follows. Merton identified four interrelated norms of science, reinforced by the academy's reward structure: universalism, communism, disinterestedness, and organized

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[146] *See generally* ROBERT K. MERTON, THE SOCIOLOGY OF SCIENCE (Norman W. Storer ed., 1973) [hereinafter MERTON, SOCIOLOGY] (collecting Merton's earlier writings).

[147] *See* Eisenberg, *supra* note 1.

[148] *See, e.g.*, Rebecca S. Eisenberg, *Patents and the Progress of Science: Exclusive Rights and Experimental Use*, 56 U. CHI. L. REV. 1017, 1046-51 (1989) (discussing Merton's work); Peter Yun-hyoung Lee, *Inverting the Logic of Scientific Discovery: Applying Common Law Patentable Subject Matter Doctrine to Constrain Patents on Biotechnology Research Tools*, 19 HARV. J.L. & TECH. 79, 84-85 (2005) ("Eisenberg has described a model where scientists freely exchange findings while university lawyers haggle over rights and licensing agreements."). *But see* Arti Kaur Rai, *Regulating Scientific Research: Intellectual Property Rights and the Norms of Science*, 94 NW. U. L. REV. 77, 79 n.12 (1999) (criticizing Eisenberg's and Merges's characterizations of scientific research norms as outdated). Legal academics have repeatedly echoed Eisenberg's take on Merton. While this is a testament to the quality of her essay, it is also worrying. Merton is not the only sociologist of science to have written about "norms of science," and more recent scholarship has complicated his account. Yet in surveying the legal literature, one would get the impression that Merton is the first and last word in the sociology of science. That is simply not the case. Merton is, instead, the scholar who has been most written about by legal academics, and so is easiest for legal academics to write about. We have seen such intradisciplinary inertia before: in our discussion of law of nature metaphysics.

[149] *See supra* notes 49-54 and accompanying text.

skepticism.[150] The communism norm has attracted the most sustained attention from patent scholars. Lawyers commonly contrast communism in research—encouraging an unimpeded flow of information between scientists, and unbridled collaboration among them—with the ostensibly monopolistic, individual-rights-based ethos of intellectual property law. Property rights, in this view, disrupt the "natural" ebb and flow of scientific research and collaboration, impeding scientific progress more generally.[151]

One can question whether Merton's claims are descriptively valid; many argue that they have little to do with entire fields of scientific research.[152] But assume his positivistic account was more or less correct.[153] Even if we accept that basic research hinges on openness and

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[150] *See* Robert K. Merton, *A Note on Science and Democracy*, J. LEGAL & POL. SOC., Oct. 1942, at 115, *reprinted as The Normative Structure of Science*, *in* MERTON, SOCIOLOGY, *supra* note 146, at 267, 270-78 [hereinafter Merton, *Science and Democracy*] (describing four norms of science); *see also* Eisenberg, *supra* note 1, at 182-83 (same). Merton's famous paper on the reward system in science is Robert K. Merton, *Priorities in Scientific Discovery: A Chapter in the Sociology of Science*, 22 AM. SOC. REV. 635 (1957), *reprinted in* MERTON, SOCIOLOGY, *supra* note 146, at 286. Merton argued that recognition—receiving credit as the first person to come up with an idea—was the essential form of reward in science, and so too the dominant property right attached to scientific discoveries. *Id.* at 297-305.

[151] Eisenberg argues that "although there are substantial parallels between [patent doctrine and scientific norms], the conjunction [between them] may nonetheless cause delay in the dissemination of new knowledge and aggravate inherent conflict between the norms and the reward structure of science." Eisenberg, *supra* note 1, at 180. However, as both Mark Lemley and Eisenberg have pointed out, property rights regimes that require disclosure may actually encourage more openness than alternatives turning on secrecy between competing research groups or corporate interests. *See id.* at 206.

[152] Scientific research can be far more competitive than the word "communism" suggests. Instances of competitive behavior abound and are, in some cases, the stuff of legend. *See, e.g.*, JAMES D. WATSON, THE DOUBLE HELIX (1968) (recounting the scientific competition involved in the discovery of DNA). Only so many grants, academic posts, and scientific prizes exist, creating competitive dynamics that complicate Mertonian norms. Legal Mertonians frequently reply that norms do not necessarily describe *how* scientists act, but rather identify what actions the "scientific community" *considers to be acceptable*—they are aspirational ideas rather than practiced realities.

[153] The sociology of science, no less than any other academy, has changed significantly since the 1940s and 1950s, but let us again bracket law's anachronisms for the sake of argument. Peter Godfrey-Smith writes sympathetically that "Merton's sociology is often seen as the 'old' style of sociology of science, a style that was superseded nearly thirty years ago. But there are some good ideas here, especially in the treatment of rewards." GODFREY-SMITH, *supra* note 63, at 125. Mertonian sociology of science has been largely superseded by the "strong program" of the sociology of science and its progeny. *See, e.g.*, LATOUR & WOOLGAR, *supra* note 83; SHAPIN & SCHAFFER, *supra* note 88; *see also* GODFREY-SMITH, *supra* note 63, at 125-28 (describing the development of the strong program).

collaboration—"communism," in the Mertonian parlance—there is, as Merton himself eloquently noted, fierce competition for recognition among scientists, particularly for credit in being first to bring a new insight to light.[154] Merton considered this credit to be a form of property, tethered as it often is to grant funding, scientific prizes, and academic appointments.[155] An expanded scientific property right—covering mandatory licensing, a financial grant, or a shiny medal—could well increase competition and further discourage openness, causing researchers to be even more secretive than they are today.[156]

Still, this critique assumes that we cannot create a right with reasonable exceptions (such as a broad experimental-use exception) or limited transaction costs capable of mimicking the status quo. It is worth asking, with post-War advocates, whether a well-designed rights regime could give scientists the same access to ideas and discoveries that they currently enjoy in our competitive world of academic posts, lucrative grants, and high-stakes publications. After all, creating exceptions and taking property for the commons are not unfamiliar motifs of jurisprudence.[157] But a still more basic point can be made about law's relationship to basic research.

Law has already intervened. Law's influence on science has long passed the point of some original sin, a juncture that almost certainly predates even the ancient Venetian patent statutes. Scientific norms—as well as the scientific academy's reward systems—have developed in the shadow of law's demarcations and their economic consequences. Legal regimes cannot and do not wholly determine the course of the scientific enterprise, but they almost certainly have a

[154] Merton, *Science and Democracy*, supra note 150, at 286-93. As Godfrey-Smith points out, such competition—which can become fierce between research groups and particular scientists—runs counter to Merton's claim that disinterestedness is, in fact, a basic norm of scientific research. GODFREY-SMITH, *supra* note 63, at 125-28.

[155] Merton, *Science and Democracy*, *supra* note 150, at 293-96.

[156] This expansion may already be occurring, as patents are increasingly applied to innovations that had once been classed "basic research." *See infra* subsection III.B.1. However, rights regimes may in fact encourage more openness than the alternative. As Lemley has pointed out, "in the commercial world, after all, patents encourage more openness than the secrecy regimes that would exist in their absence." Letter from Mark Lemley to author, *supra* note 54.

[157] The experimental-use exception has long been in decline and arguably is at a nadir in American jurisprudence. *See, e.g.*, Eisenberg, *supra* note 148, at 1019 ("[T]he experimental use defense has been frequently raised but rarely sustained."); Katherine J. Strandburg, *What Does the Public Get? Experimental Use and the Patent Bargain*, 2004 WIS. L. REV. 81, 84 ("[R]ecent decisions . . . threaten to shrink the experimental-use exemption to extinction."). The same, however, cannot be said for takings jurisprudence.

nontrivial impact on it. Is that not, after all, the very premise of our patent system?

Legal academics speak of scientific norms and basic research as if scientists and researchers, rather than the lawmakers and jurists of yesteryear, decided what research products should be patentable. But this is rationalization, not history. The status quo is no natural default or ethereal ideal. Rather, it is a product of particular legal and political choices that have been made regarding science, and particular accounts of science that have come to dominate legal thinking over the centuries. Genius inventors, after all, have long enjoyed recognition from their peers and been rewarded with grants and professorships, all alongside the economic fruits of their patents.[158] All of these elements, we seem to believe, are needed to encourage an "efficient" level of invention. Yet in the same breath, the legal academy asserts that savant scientists only *need* grants, professorships, and the like, for their norms made it so! With Panglossian nerve, lawyers argue that it is beside the point that scientists *cannot* seek the latter. I argue in the next Part that this is very much the point.

III. DEFAULTS AND INTERVENTIONS: RECONSIDERING SCIENCE IN INTELLECTUAL PROPERTY LAW

Patent scholars have long wondered what it means to label a pace of innovation and invention as "efficient."[159] From the preceding discussion, we could add several more questions: What does it mean to call a level of innovation in basic research "efficient?" How could we ever know when we have reached a point approaching optimality? What is it that individual scientists and inventors "need," and why do we believe their needs do, or should, diverge? Or, perhaps more precisely, what are the consequences of extending legal rights to one type of scientific research product that we withhold from another? Since

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[158] Indeed, long before modern patent regimes, inventors were often subsidized by patrons who saw great practical and social value in their work. Da Vinci's reliance upon Italian families of wealth and prestige is perhaps the most famous instance of such an arrangement. *See, e.g.*, CHARLES NICHOLL, LEONARDO DA VINCI: FLIGHTS OF THE MIND (2004). Systems of patronage have persevered in a variety of forms over the centuries. *See generally* RICHARD DRAYTON, NATURE'S GOVERNMENT: SCIENCE, IMPERIAL BRITAIN, AND THE "IMPROVEMENT" OF THE WORLD (2000); R. FOX ET AL., THE PATRONAGE OF SCIENCE IN THE NINETEENTH CENTURY (G. L'E. Turner ed., 1976).

[159] *See, e.g.*, Kimberley A. Moore, *Worthless Patents*, 20 BERKELEY TECH. L.J. 1521, 1549 (2005) ("Literature on intellectual property rights and patent policy ask [sic] whether the patent system is an effective incentive mechanism for spurring innovation and disclosure . . . .").

law does not just reflect how science is done, but can also shape its course, what are the foreseeable consequences for which it should account? In Part I, I observed that law's metaphysical distinctions between natural principles and man's contrivances were themselves deeply unsatisfying contrivances. In Part II, I surveyed practical and qualitative objections to a scientific property right. We now turn to the implications. Assuming that we can live with law's tenuous metaphysics and cannot fathom a workable scientific property rights regime, what are the consequences of intellectual property law's present interventions on the scientific enterprise, in the form of the patent system? If the status quo is not a default but an intervention on an entire field of human inquiry, then what is it that law conjures?

One consequence explored in the remaining pages of this Article involves rethinking the nature and function of government support for scientific research and, more broadly, political involvement in the scientific enterprise. Such a perspective may encourage a shift from the desultory "largesse/social capital" discourse surrounding government support of the sciences to more sustained and serious discussions of economic efficiency and just compensation in research science.

A. *A Default that Is No Default*

It is difficult to prove that law works efficiently in granting patents to inventions but not extending similar rights to basic-research products, at least in part because modern American law knows no other system of intellectual property. Perhaps patent law is well founded in its presumption that the ambit of patentable-subject-matter jurisprudence is efficient—the past few centuries have, after all, witnessed remarkable technological achievement. But past experience—the history of technology in the United States—is ultimately an unsatisfying reference point if we are making bold claims about efficiency, which is an inherently relative concept.[160] Reasoning from history to argue that the demarcations of patentable subject matter are somehow optimal ultimately reduces to a counterfactual assertion—a Panglossian presumption lacking the sorts of reference points that might prove

[160] Efficiency is one of many economic metrics—including, for instance, Pareto optimality—that require reference points of comparison to be meaningful. Before we can call something efficient, we must give it some context—efficient for whom and compared to what known (or hypothetical) alternative. *See generally* AVINASH K. DIXIT, OPTIMIZATION IN ECONOMIC THEORY (2d ed. 1990).

such striking claims of optimality.[161] Indeed, there are good reasons to believe that law's demarcation of scientific research products into two categories bearing drastically different legal consequences is far less than ideal, both economically and socially.

1. Science as a Vocation

Consider a graduate student in the sciences, trying to decide if she should devote her career to academic research. Scientists make professional tradeoffs, no less than the rest of us. Aspiring academics and researchers may enter other vocations for reasons of skill, intellectual interest, or financial well-being. The presence of such attractive, lucrative alternatives adds an important dimension to discussions about the structure of patent law because it adds an important dimension to our hypothetical graduate student's plans for the future.

We extend monopoly rents to certain types of research products to spur greater levels of innovation within that class of products. But what would inventors be doing if that financial spur was not in place? We grant patents so inventors will invent more, but as opposed to doing what else?

We may answer that inventors choose to invent as opposed to becoming insurance agents, novelists, or management consultants. Not all inventors, after all, are scientists. Or we may answer that inventors choose to invent as opposed to taking on lower-risk projects, less ambitious forays into innovation. What a dull, listless, underdeveloped world of technology we might face without patent protection.[162] (So goes, at least, the standard view.) But our graduate student faces other choices still: she may conduct other types of (now relatively less profitable) research or go into (now relatively less profitable) fields of science—applying and patenting, in short, rather than researching and discovering.

We do not know what a scientific property right would do to the allocation of private investment and financing, to the size and scope of science departments at universities, to the development of philanthropic research institutes, or to the ambitions of grant-giving institu-

[161] The legions of scholars currently pressing for reform in patent law represent one locus of skepticism towards claims of optimality. As a matter of necessity, few, if any, would argue that our current patent regime is the best of all possible patent regimes. *See, e.g.*, Kesan & Gallo, *supra* note 44 (using game theory to explain the prevalence of incorrectly granted patents in the marketplace).

[162] *See supra* Section II.A (discussing the conventional rationales for patent protection).

tions.[163] Nor do we know with any measure of certainty what patent rights have done over the decades to apportion such resources within the spectrum of applied- and basic-research projects. But we would be fooling ourselves to presume that there has been no effect whatsoever.

These consequences are legally significant and deserve consideration because law bears at least partial responsibility for bringing them about.[164] There are at least four ways in which intellectual property law could apportion rights within the universe of scientific research products. We could extend rights to both applied- and basic-research products, to applied but not basic, to basic but not applied, or we could be stingy and deny rights to both. The first and last alternatives would blur categorical divisions between classes of scientific products. The second and third alternatives would perpetuate divisions on the basis of any number of rationales. (The second, of course, represents a rough description of the patent system with which we are most familiar.) Yet only the last of these four alternatives could possibly be described as any sort of nonintervention or default.[165]

2. Patents and Distortions

Patent law does not spur general innovation in science, but rather a particular type of innovation in science. It encourages scientists to do some things in lieu of others. This is no market default. Patent law is, and was never intended to be anything but, a distortion. Its very aim is to differentially price the projects and careers that indi-

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[163] Some critics have assailed the phenomenon of university patenting for driving academics away from basic research and toward applied research. *See, e.g.*, David C. Mowery & Bhaven N. Sampat, *University Patents and Patent Policy Debates in the USA, 1925–1980*, 10 INDUS. & CORP. CHANGE 781, 785-86 (2001) (collecting sources explaining this criticism of university patenting). Arguably, treating applied- and basic-research products similarly—rather than exacerbating existing differences by categorically divorcing the two in intellectual property law—could help mitigate the trend.

[164] This theme is commonly reiterated by the British Royal Society for the Encouragement of Arts, Manufactures and Commerce (RSA) which, like Stiglitz, has argued for replacing patent monopolies with research prizes for worthy inventions and discoveries. Writing in the *RSA Journal*, Kenneth Neil Cukier asks rhetorically, "what is intellectual property, and why is it so controversial? In essence," he answers, "it is a fiction created by law. Intellectual property is simply a metaphor for the granting of a 'property right' on ideas." Kenneth Neil Cukier, *In Defence of Creativity*, RSA J., Dec. 2005, at 18, 19.

[165] Even the final alternative would be a stretch, ignoring as it does the broader context of a market economy that has already been irrevocably shaped by the regulatory structure of our patent regime, the conceptual assumptions behind our intellectual property system, and the ambit of patentable subject matter.

viduals and institutions pursue, with a clear aim in mind. Our patent system, we should remember, is instrumental at core—concerned less with natural rights principles than with yielding particular social ends.[166]

Even in the absence of patent rights, products of applied research would often remain more lucrative, or at least more broadly marketable, than products of basic research. Innovative refrigerators, after all, hold more commercial potential than, say, groundbreaking equations in quantum mechanics. Yet in tying monopoly rights to applied-research products but not to those of basic research, patent law necessarily exacerbates that difference. Perhaps the effect is negligible and limited to the margins. But it is an effect no less,[167] one that legal scholarship has been loathe to acknowledge.[168] It is an inevitable facet of intellectual property's demarcation of science—in theory and reward—propounded and sustained by the instruments and common law quirks of patent law.

Of course, this distortion is not untrammeled. Many actors in our political economy indirectly dampen patent law's distortions in the scientific job, grant, and research markets. For instance, private philanthropies and endowments, among them the Howard Hughes Medical Institute and the Gates Foundation, extend generous support for pet areas of research. Their financial commitments create incentives for basic research that are otherwise un- or underprovided by the market alone (particularly in the absence of intellectual property protection). Even more significant in impact and sheer financial heft is government funding, in the form of NIH grants, professorships at public universities, and so forth. The role of the private sector in funding basic research is even greater still, though corporations tend to hide the fruits of their basic research from public view.[169] (This is a reasonably predictable result of placing basic research beyond the

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[166] *See supra* note 16.

[167] Picking up on a theme sounded in decades past by advocates of a scientific property right, Nobel Prize–winning economist Joseph Stiglitz has invoked the under-compensated basic researcher as a paradigmatic instance of positive externality. Stiglitz writes that "[t]he outcome of R&D is an example of a positive externality, where ideas make others better off, perhaps enabling the production of goods at lower cost; however, in research, the originator of the ideas may not be fully compensated." Joseph E. Stiglitz, *Global Public Goods and Global Finance: Does Global Governance Ensure that the Global Public Interest Is Served?*, *in* ADVANCING PUBLIC GOODS 149, 151 (Jean-Philippe Touffut ed., 2006).

[168] *See supra* subsection III.A.1.

[169] *See* EISEMAN ET AL., *supra* note 2, at 18-21.

ambit of patentable subject matter. Private sector actors turn to trade secrecy as they have little to gain, and potentially much to lose, from sharing such insights with the public; unlike their academic counterparts, corporations gain little from academic accolades.[170])

To be sure, public debates over funding priorities rarely, if ever, cast research funding in distortionary or efficiency terms. Most often, we construe scientific research as largesse and social investment—which is to say, essentially voluntary and of hypothetical value.

Regardless of the constellation of reasons inspiring private and public actors to support basic research, their support acts as a counterbalance. It has the effect of realigning incentives in the science markets, diminishing the distortions foisted upon those markets by law's wholly voluntary and deeply consequential patent system. This effect offers an arguably novel rationale for maintaining, if not greatly expanding, public support for basic research: mitigating the longstanding distortions created by legal doctrines that have attached patent monopolies to some types of research products but not to others. Such a rationale does not require that we reconstruct our view of basic research to, for instance, define basic research as property or not property or even to challenge canons of patentable subject matter. The rationale merely demands that we acknowledge the practical effects of those obscure legalistic canons, the lived consequences of calling some scientific research products property and others nonproperty.

[170] So goes the essential tradeoff of our patent system: we exchange monopolies for public disclosure of new inventions. *See also* Eisenberg, *supra* note 148, at 1028-30 (discussing the role of patents in promoting disclosure as an alternative to the information hoarding of trade-secrecy regimes). For the private sector, the absence of intellectual property rights attaching to basic-research products may have several implications. First, companies will arguably tend to invest relatively less money than they otherwise might in basic research. Second, they have little incentive to share research findings with the public. If and when companies achieve a significant innovation, it makes sense for them to keep it secret since there is rarely something to be gained financially from sharing it with the public—and their competitors. This is true both of those innovations that have clear commercial uses and of those that do not. In the case of the former, the public at least manages to reap the downstream benefits of an innovation in the applied marketplace (even if they are unaware of what they are reaping). But it is likely, in the case of the latter, that potentially significant innovations (of profound academic significance or with unseen implications for other industries) will languish in the file cabinets of corporate R&D departments.

B. *If Scientific Research Is a Form of Property*

1. Private Property, Just Compensation

Scientists are almost certainly driven to pursue knowledge largely for its own sake, but accolades—academic awards, prizes, grants, and tenure posts—remain highly sought after and are rarely turned down.[171] They are arguably as important for many scientists as being recognized as having priority in discovering a contested principle or idea.[172] We have already noted that Merton identified priority as a form of property, however idiosyncratic it may seem.[173] The same holds for awards, grants, and tenure appointments. Public funding is not always implicated in these forms of property, but it often plays an essential role in fostering and sustaining them.

For instance, private universities use their increasingly monumental endowments to sponsor professorships in the sciences, and innumerable private organizations dole out awards for researchers whose work constitutes particularly striking contributions to a particular field or to "science" more generally (the MacArthur Grant and the Nobel Prize are two examples among many). But, as the legal academy grudgingly acknowledged in regards to the Solomon Amendment,

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[171] Indeed, the "reclusive Russian topologist" Grigory Perelman received much unwanted international press after he turned down the Fields Medal and its $13,500 purse in 2006. He had earned the recognition for solving Poincaré's conjecture. Perelman's decision was considered particularly incongruous given that, unlike earlier instances of such behavior—for example, Marlon Brando's turning down an Oscar or Jean-Paul Sartre's turning down the Nobel—he was not driven by any clear political or personal agenda. *See* George Johnson, *The Math Was Complex, the Intentions, Strikingly Simple*, N.Y. TIMES, Aug. 27, 2006, § 4 (Week in Review), at 3.

[172] These forms of property are often highly intertwined. Being recognized as the original "discoverer" of an important principle can open the door to tenure, lucrative grants, and celebrated awards. But it is not always a precondition for those distinctions. Oftentimes, a significant paper—or even several minor papers in secondary journals that manage to incrementally push a discipline forward—is enough to bring accolades aplenty to a researcher or to earn tenure for a junior faculty member. Grant awards and postdoctoral positions may at times have little to do with prominent past outputs—young researchers often enjoy them by virtue of their affiliation with a preeminent researcher or an established lab, rather than because of any particular insight they have already contributed to their field. In many instances, these forms of property are prospective grants hedging that a promising young scientist will realize her potential at some future moment. In this sense, *priority* alone is just one of many forms of property (or quasi property) at play in the world of basic scientific research. Being recognized by one's peers as having priority may certainly make it easier to access these resources, but it is not the only pathway.

[173] *See supra* note 155 and accompanying text.

such research is nearly always dependent on public funding running the gamut from NIH grants to summer science programs to government scholarships for graduate students.[174]

Public funding invariably plays a role in rewarding scientists for their efforts (if and when they are rewarded), prospectively encouraging them to devote their careers to research or empowering them to take on new projects. Stanford University may offer a promising young biochemist a tenure-track post, but her work could not be sustained without significant public support for her research—regardless of whether that support is directly transferred in the form of government grants or indirectly apportioned through her university affiliation. In turn, the Fields Medal may be entirely drawn from private funds, but the accomplishments that it recognizes are only rarely achieved in the absence of direct or indirect public support for research in math and science. And, of course, the link between public moneys and scientific research is unambiguous at state universities and institutions like the NIH or RAND.

These varieties of public support are often portrayed as voluntary largesse, particularly when applied to fields of science—like particle physics—that mystify the overwhelming majority of us, or others—like NASA's manned-spaceflight program—for which the public benefit can be difficult to articulate.[175] Alternately, government support of scientific research is construed as a form of investment in social and human capital—channeling resources into science education and research for the downstream effects that they have on economic metrics

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[174] The importance of public resources for the work of scientists even at private universities was highlighted by *Rumsfeld v. Forum for Academic and Institutional Rights, Inc.*, 547 U.S. 47 (2006), in which the Supreme Court upheld the Solomon Amendment, 10 U.S.C. § 983 (2006), which conditioned the receipt of federal funding by universities on their allowing the military to recruit on campus. It is telling that upon the Court's decision, law schools—including those petitioning on the side of FAIR—uniformly abdicated to the dictates of the Solomon Amendment, rather than soldiering on with their principles and suffering the ensuing economic consequences. Given the choice between principles and potentially bringing scientific research at their universities to an immediate halt upon cutoff of federal research funding, law schools had little choice at all.

[175] For a well-publicized critique of NASA's increasingly directionless manned-shuttle program, see 1 COLUMBIA ACCIDENT INVESTIGATION BOARD REPORT 11 (2003), *available at* http://caib.nasa.gov/news/report/pdf/vol1/full/caib_report_volume1.pdf, in which the Investigation Board reported that it was "convinced that the management practices overseeing the Space Shuttle program were as much a cause of the accident as the foam that struck the left wing."

like GDP or political priorities like national defense.[176] It may be worth considering, however, whether the critical role of public funding in the progress of science betrays a further underlying function. Perhaps grants, research awards, and tenure promotions should not merely be viewed as gifts or public largesse or even investments in human capital, but rather as another type of expenditure altogether: a form of compensation for that which we have long failed to formally compensate.

Courts have consistently construed state takings of private property without just compensation or for a nonpublic use as core constitutional concerns.[177] The manner in which we reward scientists with grants and prizes is today undoubtedly more ad hoc than the careful, particularized circumstances in which eminent domain is (supposed to be) exercised by states and the federal government.[178] Moreover, even if we believe that products of basic scientific research deserve status as a form of intellectual property, it is not necessarily the state

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[176] *See, e.g.*, NAT'L SCI. BD., THE FEDERAL ROLE IN SCIENCE AND ENGINEERING GRADUATE AND POSTDOCTORAL EDUCATION (1998), *available at* http://www.nsf.gov/nsb/documents/1997/nsb97235/nsb97235.pdf ("At the conclusion of World War II in 1945, Vannevar Bush argued persuasively in his report, *Science—the Endless Frontier*, that the Federal government should continue to support science and engineering research and post-secondary education in peacetime and that this investment would contribute to national security, economic growth, health, and the quality of life.").

[177] The Supreme Court's recent decision in *Kelo v. City of New London*, 545 U.S. 469 (2005), brought the contours of the public-use requirement to the fore of academic and media debates about the proper scope of the state's eminent domain powers. Governmental appropriations (with commensurate compensation) to make discoveries and basic research freely accessible to the public would likely qualify as a valid public use if such research products were accorded property rights.

[178] The operative inquiry in takings jurisprudence often relates to the sorts of state actions that "effectively destroy" a property right, classically due to physical occupation or appropriation of property. *See, e.g.*, Loretto v. Teleprompter Manhattan CATV Corp., 458 U.S. 419, 435-38 (1982) (holding that a permanent physical occupation "effectively destroys" "the rights 'to possess, use, and dispose of'" the affected territory (quoting United States v. Gen. Motors Corp., 323 U.S. 373, 378 (1945))). In *Lucas v. South Carolina Coastal Council*, the Supreme Court extended this principle beyond physical occupations to "total" destructions of value that are akin to physical appropriations. 505 U.S. 1003, 1027-31 (1992). It would be difficult to argue that government neglect of a property right constitutes a physical taking. In the case of unrealized scientific property rights, basic research products and discoveries are often tethered to other forms of property and quasi property—such as grants, awards, and tenure posts—as well. As a result, merely transforming an insight into a public good (that is, failing to protect it as a form of property) does not eliminate the value of a discovery altogether. Whether this depreciation in value actually can be said to occur—and the extent of that supposed depreciation—is a question for economists. But whether we should want to remedy it through mechanisms of law and policy is a question of real resonance for lawyers and policymakers.

that unfairly appropriates that property. It is, rather, other scientists, researchers, textbooks, inventors, and industries that most frequently invoke, apply, and benefit from basic insights and discoveries without a second thought. For these reasons, the sorts of tradeoffs inherent to the formulations of takings jurisprudence—between a property right of some sort and state appropriation of, and compensation for, it—may not be immediately apparent.[179]

If, however, we believe that research products are a form of property or that patent law's distinctions between patentable and unpatentable research products are unsatisfying (violating the justice principle of treating likes alike), then a tradeoff becomes more apparent. From this perspective, when our intellectual property system distinguishes patentable "inventions" from unpatentable "discoveries," it effectively transforms the latter into a public good.[180] This is a familiar narrative, but one rarely applied to intellectual property law: the government, unwilling or unable to protect a property right, simply ignores it or appropriates it for the commons.

2. A Takings Perspective

My aim here is not to squeeze patent law's approach to basic research into the takings doctrine through some unwieldy legalistic con-

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[179] However, our current approach to basic research is arguably akin to the stance of legal and political institutions toward private property before the fixation of a vibrant takings jurisprudence in colonial America. William Michael Treanor writes that

> [i]n colonial America, government routinely acted in ways that affected private property, and the political process determined when compensation was due. No judicially enforceable compensation requirement existed during this period. Even after the establishment of a compensation requirement, it applied only to interference with physical ownership, and government routinely acted in ways that diminished the value of private property without providing compensation.

William Michael Treanor, *The Original Understanding of the Takings Clause and the Political Process*, 95 COLUM. L. REV. 782, 785 (1995).

[180] Of course, one could argue that no such transformation occurs. Since arguments for a natural right to property for discoveries and basic research rarely hold sway, the act of transformation likely occurs when government attaches monopoly rights to inventions—that is, when it makes certain research products patentable. *See supra* Section II.A. I return, then, to the question of what constitutes a legal default and what constitutes a legal intervention. I presume, here, a default of property protection. For better or worse, law has taken the general stance of affording property rights to a world of creative products—be they novels, inventions, or trademarks. Basic research products construed to be beyond the patentable pale by the law of nature exception thus represent a significant departure from the law's default of property protection.

tortion. I do, however, propose that we reconsider how we talk about grants, tenure posts, and other forms of public funding for the sciences. Discoveries and basic research create tremendous value for individuals, industries, and society more broadly. Yet our intellectual property regime prohibits researchers and scientists from extracting some of that value through monopoly rents, in marked contrast to its long-standing munificence towards inventors. In light of this favoritism, government funding of basic research can be justified on quite different grounds from the popular tropes of political largesse and social investment that have come to dominate political debates on the matter.

Once we honestly account for the effect that highly artificial intellectual property regimes have on scientific research, at least two independent, relatively novel, and arguably compelling reasons arise for sustaining—or even increasing—such federal funding. We can describe these rationales as compensatory and remedial. It may be both accurate and helpful (and, for interested advocates, politically savvy) to represent science funding as a form of ad hoc compensation for a taking, doled out in lieu of intellectual property rights (transforming discoveries into public goods), and/or as a mechanism to diminish the distortions within science perpetuated by the patent system.

Both rationales emerge from the unsteady relationship between legal and scientific institutions, a relationship mediated heavily by the patent system. But they diverge—and this is what makes them potentially complementary, rather than mutually exclusive—in addressing separate consequences of our intellectual property regime. The compensatory rationale addresses normative concerns: the justice principles and rights claims long associated with takings jurisprudence. We are concerned here with law treating individuals fairly. The remedial rationale, in contrast, is responsive to economic realities. It forces recognition of the structural, demographic, and financial distortions long foisted by the patent system upon the enterprise of science. We are concerned here with acknowledging and potentially accounting for the long-term effects of attaching monopolies to some research products rather than others. Alone, or in tandem, these rationales encourage a view of science funding as obligatory rather than discretionary, as a duty rather than a luxury.

C. *Political Reconstruction of Basic Research*

1. Overvaluing or Undervaluing?

Once we envision public support for the sciences as a duty—to compensate individuals for appropriating property or to remedy distortions fostered by legal interventions—then the architects and would-be reformers of our intellectual property system must ask whether such funding, in scale or form, is sufficient compensation and what it even means to talk about sufficiency in the context of scientific research.

Let us begin with the second question first, for it is one that we have already addressed. We could frame sufficiency in legal terms: do we accord what the law requires? In many respects, this inquiry formed the core of the first two sections of this Article. I have argued that the lines drawn by patentable-subject-matter doctrine between basic and applied research are practically and theoretically unsatisfying, and for those reasons legally untenable.

We might also talk about sufficiency in economic terms: do we provide a level of public support for basic research commensurate in scale with our goals for innovation and progress in the sciences, particularly in light of the tremendously lucrative social support we accord patentable inventions? This is ultimately a question for bona fide economists. It is certainly possible that the current scale of public support for basic research—through grants and scholarships at research institutes and public universities—is, in some sense, efficient (or maybe even overgenerous). Put another way, it is at least feasible that these investments currently yield a level of innovation perfectly commensurate with our collective ambitions.[181] But if we are talking

[181] The challenge here is to determine the shadow price of basic-research products ranging from groundbreaking discoveries to relatively incremental insights. We do not know the true "market value" for these "commodities" because they are not traded in any discernable marketplace. Determining the shadow price of discoveries—as a class or on a discovery-by-discovery basis—is likely to be an involved, complex exercise, one that would also invariably be ad hoc. During more statist times of global politics, economists developed an academic industry to estimate shadow prices for commodities whose prices were controlled by the state. Their inquiries would follow questions along the lines of, "What would have been the market price for waged labor in an economy where a minimum wage was imposed?" Or, "what would have been the market value of butter when the price of butter was controlled?" *See generally* J. Peter Neary, *Trade Liberalisation and Shadow Prices in the Presence of Tariffs and Quotas*, 36 INT'L ECON. REV. 531, 538-40 (1995) (modeling the shadow pricing of both "tariff-

in comparative terms, then it is hard to imagine that we are somehow overvaluing or overcompensating unpatentable basic research and discoveries, given the highly lucrative monopoly rents we uniquely attach to patentable inventions and the hugely profitable industries that those rents have sustained.

Practically speaking, our courts are unlikely to soon eschew centuries of patent metaphysics by creating a property rights regime for products of basic research. In turn, it may be difficult to imagine our legislature soon crafting a regime that could be practically applied and capable of addressing many of the concerns highlighted in Part III.[182] But even if our legal and political institutions fail to meet these inertial and creative challenges, the consequences of law's interventions upon science potentially represent powerful arguments for advocates of basic scientific research in debates over political priorities and budgetary policy.

2. Views of Basic Research

A common trope of political conversation questions the judgment of political leaders who support continued or even increased investments in basic science before "resolving" ostensibly more pressing human needs. This perspective construes feeding the poor and building superconducting supercolliders as somehow mutually exclusive.[183] Though the hurdles to creating a scientific property regime are considerable, the reasons for even suggesting such reforms represent powerful rejoinders to the presumption that public science funding is relatively extraneous or inessential.

If basic research conjures a form of property that we have long failed to formally recognize or adequately compensate, then our legal and normative commitments may compel us to sustain or enhance public funding of scientific research as a form of ad hoc compensation. Or if, in turn, the patent system distorts the distribution of scientific talent and investment by attaching monopolies to some research products but not others, then economic and social

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constrained" and "quota-constrained" goods); György Simon, *Ex Post Examination of Macro-Economic Shadow Prices*, ECON. PLANNING, Oct. 1965, at 80.

[182] As we have already observed, the problem of improvements is particularly salient, and it may become more acute as we sweep basic scientific insights into novel rights regimes. We would need to craft doctrines and structures capable of ensuring that improvements and applications of basic research would not be stifled.

[183] For a classic discussion of this motif, see Harvey Brooks, *The Practical Uses of Pure Research*, N.Y. TIMES, Jan. 12, 1970, at C78.

considerations suggest that we may want to redress that imbalance by making basic research relatively more lucrative, attractive, and feasible than it currently is. Correcting this imbalance would diminish the incentive gap that the law now projects between research products in basic and applied science. From this perspective, public support of science becomes a normative and economic mandate, rather than a matter of political expedience.

Again, these rationales are not mutually exclusive. They can, and should, all play a part in strengthening public commitments to science funding. It is perfectly reasonable to argue for government support of basic research for reasons of social good or national pride, as well as for the sake of just compensation and market efficiency. Only the first of these three categories (largesse/social investment), however, has regularly played a part in our national discourse on the matter.[184]

Arguing for scientific research as a form of social investment is a significant but relatively weak rationale, one that has frequently met its match on Capitol Hill and in other legislative chambers. When we portray science funding as essentially voluntary, it becomes but one of many funding priorities, each of varying political, social, and economic value. When we *choose* to set science budgets, we are *choosing* to invest in research over other essentially voluntary, and often deeply compelling, projects—beefing up border security, for instance, or supplementing Head Start's budget. Given that the return on science investment is often hypothetical (we can hope but not reasonably predict whether that cure to cancer, or that vaccine for malaria, will ever be produced) and frequently esoteric, securing political support for research (let alone maintaining or expanding it) is generally a matter of legislative jockeying, highly sensitive to the whims of party politics.

The discussion changes if science funding is not construed as merely voluntary but is seen instead as a matter of economic necessity (leveling distortions and encouraging market efficiency) or even of constitutional/justice principles (providing fair compensation for a governmental taking). It is the difference between choosing to do something and being committed to it, between largesse and duty, be-

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[184] In the view of modern economics, the second and third approaches are interrelated, compensation being part and parcel of efficiency considerations. That is, while questions of distortion are ultimately positive in nature—suggesting dilemmas of distribution and incentives best left to trained economists—questions of just compensation are basically normative, turning on how we choose to characterize and treat property or even if we choose to call something property in the first place.

tween what is dispensable and what is obligatory. Table 1 summarizes these varying perspectives.

Table 1: A Comparison of Rationales for Public Funding of "Basic" (Unpatentable) Scientific Research

	Largesse/ Social Investment	**Efficiency/ Market Distortions**	**Compensation/ Takings**
Government Research Grants	An uncertain and essentially optional/voluntary investment of public moneys, made alternately for the sake of downstream economic effects, to trump foreign governments in prestige and intellectual capital, or to bring about a desired, if theoretical, good (a cure, vaccine, etc.) that is currently unavailable.	Remedial public moneys to subsidize an area of research undervalued by standing market conditions, conditions which have been fundamentally shaped by the monopolies that government attaches to applied-research products but categorically denies to products of basic research.	Prospective and retrospective compensation for a successful researcher or lab group, in exchange for relinquishing property rights to the past and future products of the research being supported.
Tenure at State Universities	An investment in education, in which the research component is tied to teaching obligations meant to train future generations of research scientists; endows society with the pomp/ grandeur of an internationally prominent domestic academe.	The creation of a space for basic scientific researchers to pursue their work, given the few opportunities to continue their research in the private sector outside of the private academic setting; a remedial measure to balance opportunities in the public sector with those fostered in the private sector by the patent system.	The extension of job security for a public servant who, until this point, has been generating knowledge with paltry personal returns and at the expense of more lucrative alternative career paths; compensation, if not wholly fair compensation, for research findings provided to the public.

	Largesse/ Social Investment	**Efficiency/ Market Distortions**	**Compensation/ Takings**
Basic Innovation/ Discovery	An intermittent return on investment; filler for campaign speeches; cause for a press conference on slow news days; worthy of an occasional medal.	A relatively fortuitous event, which we may not only be underincentivizing, but actually depressing due to the monopoly rents available solely to innovations in applied science; less lucrative, by far, than innovations (real or imagined) that qualify for patent protection.	Private scientific property that government has chosen to make public by creating an exception to standing categories of patentable subject matter; compensable like other forms of private property in the fashion of existing takings jurisprudence.

D. *A Brief Review*

I have argued that patent law constitutes a long-standing intervention upon the scientific enterprise. Yet, centuries old, it has so deeply shaped the nature and development of science that to call it an "intervention" is to gloss over its ubiquity. Patent monopolies have almost certainly altered the landscape of scientific research. Our intellectual property system is not a naturalistic default, but modern science would be something other than modern science without it. In this sense, our patent system has become a framing assumption in discussions about how science is done.

This observation alone should encourage the legal academy to take a fresh, critical look at the ambit of patentable subject matter—for the lines that we draw help define the terrain and trajectory of scientific research. If those lines are arbitrary or analytically tenuous, then our legalistic whims have force far beyond their justifiable influence. In turn, the manner in which the patent system rewards applied research should color the ways in which we understand public support for basic research. Such support, set against generous patent monopolies, may be described as more than largesse or social investment, but also in terms of market correction (with reference to economic analysis) and just compensation (with apologies to takings jurisprudence).

CONCLUSION

Law has long played the part of a polymath in our patent system: at once philosopher, sociologist, psychologist, and economist. Perhaps in an earlier era, law's characterizations of science—how it functions, its diversity of pursuits, its transformations over time, what it is capable of saying about the world—and those of professional researchers, philosophers, engineers, and social scientists converged. But they do not today. Patent law, at a variety of turns, hinges on questionable, idiosyncratic assumptions about the content and contours of the scientific enterprise. It clings to archaic metaphysical notions of science that are largely unfamiliar to professional scientists; it projects impulses, norms, and mindsets upon researchers that, while stirring, strain credulity.

Law's characterizations would arguably be of no moment were they wholly theoretical, isolated from our patent system and incidental to science itself. Yet, as we have seen, they may be profoundly significant for students choosing graduate degrees, doctoral candidates choosing careers, scientists choosing research projects, universities choosing faculty members, industries choosing investments, administrations choosing budgetary priorities, and so on. The doctrines of patentable subject matter inexorably shape, and have long shaped, the legal and economic backdrop of entire fields of science and subjects of inquiry—those fields and subjects that make the cut, but also, critically, those that do not. Even if we cast researchers as slavishly committed to high-minded norms (identified by lawyers), as wide-eyed idealists unsullied by base economic considerations, patent law's distortions of the scientific enterprise remain worthy of attention.

Our patent system is fundamentally an *intervention upon* science, rather than a reflection of some *default in* science. I have suggested in this Article several normative, economic, and political implications of that intervention. A distinction between basic and applied science chiseled into a marble museum rotunda may constitute little more than a platitude or afterthought. Ossified into the institutions and jurisprudence of our patent system, however, it becomes quite consequential indeed.