Harvard Journal of Law & Technology
Volume 25, Number 2 Spring 2012

DO PATENTS DISCLOSE USEFUL INFORMATION?

*Lisa Larrimore Ouellette**

TABLE OF CONTENTS

---

* Yale Law School, J.D. 2011; Cornell University, Ph.D. (Physics) 2008; Swarthmore College, B.A. 2002. This Article received the Benjamin Scharps Prize for the best paper by a third-year student at Yale Law School. For helpful comments, I'd like to extend sincere thanks to Ian Ayres, Heather Gerken, Daniel Hemel, Tim Holbrook, Jeanne Fromer, Amy Kapczynski, Nick Ouellette, Michael Risch, Talha Syed, Heidi Williams, Daniel Winik, and participants at the George Washington Law School IP Speaker Series, the Intellectual Property Scholars Conference, the Yale Law Teaching Series, and the Yale Law Information Society Project. I am also grateful to nanotechnology researchers Markus Brink, Luke Donev, Paul McEuen, Ethan Minot, Vera Sazonova, and Xinjian Zhou, as well as the over two hundred researchers who took the time to respond to my survey and share their insights. Finally, I thank Tan Mau Wu for generous advice based on his experience as a nanotechnology researcher and patent agent. This Article was written before I began a clerkship on the Court of Appeals for the Federal Circuit, and the opinions expressed are solely my own.

I. INTRODUCTION

Many have lamented the negative impact of patents on the norm of open science and the "commercialization" of basic research as more universities seek patents.[1] Whether these scientific norms are descriptive or aspirational, empirical evidence indicates that patents have decreased openness and sharing among scientists.[2] In theory, however, the standards for obtaining a patent mirror those for publishing in a prestigious peer-reviewed scientific journal: researchers identify discoveries that are useful, novel, and nonobvious, and disclose those discoveries so other researchers can build on them.[3]

The Supreme Court has said that patent disclosures "will stimulate ideas and the eventual development of further significant advances in the art," and that these "additions to the general store of knowledge are of such importance" that they are worth the "high price of . . . exclusive use."[4] Under this disclosure theory, patents are awarded as a quid pro quo for disclosing the invention (rather than keeping the information secret, such as with trade secrets). Although disclosure theory remains popular with courts, scholars have criticized its prominence as a justification for the patent system.[5] Their most

---

1. *See, e.g.*, Robert P. Merges, *Property Rights Theory and the Commons: The Case of Scientific Research*, *in* SCIENTIFIC INNOVATION, PHILOSOPHY, AND PUBLIC POLICY 145, 145–47 (Ellen Frankel Paul et al. eds., 1996); Rebecca S. Eisenberg, *Proprietary Rights and the Norms of Science in Biotechnology Research*, 97 YALE L.J. 177, 180 (1987); Arti Kaur Rai, *Regulating Scientific Research: Intellectual Property Rights and the Norms of Science*, 94 NW. U. L. REV. 77, 78 (1999).

2. *See* Jeremy M. Grushcow, *Measuring Secrecy: A Cost of the Patent System Revealed*, 33 J. LEGAL STUD. 59 (2004); Wei Hong & John P. Walsh, *For Money or Glory? Commercialization, Competition, and Secrecy in the Entrepreneurial University*, 50 SOC. Q. 145 (2009); Fiona Murray & Scott Stern, *Do Formal Intellectual Property Rights Hinder the Free Flow of Scientific Knowledge? An Empirical Test of the Anti-Commons Hypothesis*, 63 J. ECON. BEHAV. & ORG. 648 (2007).

3. *Cf.* 35 U.S.C. §§ 101–103, 112 (2006), *amended by* Leahy-Smith America Invents Act, Pub. L. No. 112-29, §§ 3(b)–(c), 4(c), 125 Stat. 284, 285, 296 (2011).

4. Kewanee Oil Co. v. Bicron Corp., 416 U.S. 470, 481 (1974); *see also infra* note 63 (quoting Supreme Court cases that have cited disclosure as a main goal of the patent system).

5. *See* Alan Devlin, *The Misunderstood Function of Disclosure in Patent Law*, 23 HARV. J.L. & TECH. 401, 403 (2010) ("As a primary function of [the patent] system, disclosure is both ineffective and potentially poisonous to larger social goals."); Timothy R. Holbrook, *Possession in Patent Law*, 59 SMU L. REV. 123, 146 (2006) (arguing that "disclosure obligations [are] inconsistent with the theoretical justifications of patent law"); Mark A. Lemley, *The Myth of the Sole Inventor*, 110 MICH. L. REV. 709, 745 (2012) ("Disclosure theory cannot . . . support the modern patent system."); Note, *The Disclosure Function of the Patent System (or Lack Thereof)*, 118 HARV. L. REV. 2007, 2028 (2005) [hereinafter *Disclosure Function*] (arguing that "the primary justification for the patent system is . . . not to encourage . . . disclosure to the public"). Criticisms of the disclosure function of patents are not of recent origin. *See* SUBCOMM. ON PATENTS, TRADEMARKS, AND COPYRIGHTS OF THE S. COMM. ON THE JUDICIARY, 85TH CONG., AN ECONOMIC REVIEW OF THE PATENT

compelling argument is that inventors will only seek patents on inventions that would have been disclosed anyway.[6] Recently, several other legal scholars have defended disclosure theory against these criticisms and called for invigorated disclosure.[7] I argue that this debate should be reoriented: we do not grant patents because of disclosure — we require disclosure because we grant patents.

Although disclosure theory commentators disagree as to whether disclosure should be a central concern of the patent system, they agree that the answer to the question posed in this Article's title is "no": patents do not currently disclose much useful technical information to researchers.[8] Close examination of existing evidence, however, suggests that many researchers do use patents as a source of technical information.[9] This Article adds to the empirical evidence with a new survey of nanotechnology researchers and with more detailed analysis of specific patents. The nanotechnology patent literature is extensive, but most nanotechnology researchers are academics or basic researchers who publish in traditional scientific journals. I find that even for these researchers, patents contain useful, nonduplicative technical information, but my survey data suggest that patents could be even more informative. Because respondents' subfields ranged from nanoe-

---

SYSTEM, STUDY NO. 15, at 33 (Comm. Print 1958) (prepared by Professor Fritz Machlup) [hereinafter MACHLUP REVIEW], *available at* http://www.mises.org/etexts/patentsystem.pdf (summarizing disclosure theory's "poor reception in [the] economic literature"); Rebecca S. Eisenberg, *Patents and the Progress of Science: Exclusive Rights and Experimental Use*, 56 U. CHI. L. REV. 1017, 1028–30 (1989) (describing why disclosure theory has not been particularly popular with commentators).

6. *See infra* notes 80–83 and accompanying text.

7. *See* Jeanne C. Fromer, *Patent Disclosure*, 94 IOWA L. REV. 539, 542 (2009) ("I disagree with this scholarship [that criticizes patent disclosure] and . . . argu[e] in favor of its centrality in the patent system."); Sean B. Seymore, *The Teaching Function of Patents*, 85 NOTRE DAME L. REV. 621, 627 (2010) (arguing in favor of strong disclosure and stating that "[i]t is now time to transform the patent into a readable teaching document"); *cf.* Dan L. Burk, *The Role of Patent Law in Knowledge Codification*, 23 BERKELEY TECH. L.J. 1009, 1012 (2008) (arguing that "many familiar provisions of the patent statute may be viewed as incentives for codification of otherwise tacit knowledge"). Although some earlier scholars had argued that the disclosure function is successful — see, for example, Robert P. Merges, *Commercial Success and Patent Standards: Economic Perspectives on Innovation*, 76 CALIF. L. REV. 803, 808–09 (1988) — Fromer and Seymore were the first scholars to offer a strong theoretical defense against disclosure critics.

8. *See, e.g.*, Devlin, *supra* note 5, at 403 ("[T]he extent to which patent documents successfully teach the inner workings of cutting-edge technologies is quite limited."); Fromer, *supra* note 7, at 560 ("[A] good deal of evidence suggests that technologists do not find that [the patent document] contains pertinent information for their research."); Lemley, *supra* note 5, at 745 ("[I]nventors don't learn their science from patents."); Seymore, *supra* note 7, at 626 (arguing that patents are often not easily reproducible or have "little technical value" because they are "unreadable"); *Disclosure Function*, *supra* note 5, at 2023 (stating that "patent disclosures and the patent database as a whole are poor media for communicating technical information to engineers"); *cf.* Mark Lemley, *Ignoring Patents*, 2008 MICH. ST. L. REV. 19, 21 (arguing that "researchers . . . simply ignore patents"). *But see* Merges, *supra* note 7, at 808 n.9 ("There is a significant amount of evidence showing that inventors in many fields rely on published patents for technical information.").

9. *See infra* Part II.C.

lectronics to drug delivery to energy, the results suggest that patent disclosures have informational benefits across a broad range of technologies.[10]

The legal debate has focused on whether disclosure is a *justification* for the patent system, but this leads to the conclusion that because disclosure is a weak justification, patent disclosures are unimportant except as necessary to claim the invention. Given that we have a patent system, however, the relevant question is whether the benefits of strong disclosure outweigh its costs — and this Article demonstrates that disclosure has stronger benefits than previously appreciated. These benefits probably outweigh any incremental loss in innovation incentives caused by further strengthening disclosure. I suggest that enforcing and expanding upon the current disclosure requirements, and making patenting more like publishing in a premier scientific journal like *Nature* or *Science*, will help resolve the tensions between science and patent law.

This Article makes a number of distinct contributions to the growing literature on patent disclosure. First, after summarizing existing disclosure requirements and examining the current debate over disclosure theory, Part II presents the first comprehensive review of existing surveys of the technical value of patent disclosures and concludes that, contrary to the claims of previous commentators, many researchers do use patents as a source of technical information. But these surveys did not include non-patenting researchers, and most of them predate the availability of patents online, so there is a need for new empirical work in this area.

Second, Part III presents the results from my nanotechnology patent survey: in October 2010, 211 nanotechnology researchers provided their thoughts on patents as a source of technical information. Nanotechnology — the interdisciplinary study of systems on the nanometer (one billionth of a meter) scale — is still an early-stage technology, and most of the respondents were academics who focus more on publications than on patents, so one would expect patents to be less useful to the respondents than to more applied industrial researchers. Surprisingly, 64% of respondents have read patents, and of these respondents, 70% looked to patents for technical information. Of those reading patents for scientific (rather than legal) reasons, 60% found useful technical information, indicating that patents are serving a useful disclosure function for these early-stage researchers.[11] The value of patent disclosures, however, could be improved: only 38% of the

10. For a discussion of the extent to which these results can be generalized to other fields, *see infra* notes 112–113 and accompanying text.

11. Only 30% of *all* respondents (64 out of 211) have found useful technical information in a patent; the difference is that many respondents have never even tried to use patents in this way. For a discussion of ways to increase the number of researchers who look to the patent literature, *see infra* Part V.

patent-reading respondents believed that the patents they were reading were reproducible, which raises serious questions about whether the current enablement standard is generally being met.

Third, this Article examines specific patents in detail — a surprising novelty in the patent literature. The case studies in Part IV support the findings from Part III by showing that while patents contain useful technical details that are not found in the scientific literature, they also omit some experimental details that would be necessary to replicate the inventions without significant effort.

Finally, Part V discusses the implications of this Article's results for patent policy and offers several novel reforms to help bridge the growing tension between patents and the open scientific culture. Disclosure's weakness as a *justification* of the patent system suggests that disclosure only needs to be sufficiently adequate to claim the invention. But this Article reframes the debate to look at disclosure's independent costs and benefits and suggests that disclosure should be even stronger. Access to existing disclosures should be improved, which could occur in at least three ways.

First, the U.S. Patent and Trademark Office ("USPTO") and the courts should more stringently enforce current disclosure requirements, and they should require patentees to respond to good-faith questions about enablement. Second, the courts or Congress should eliminate legal barriers to using patents as technical sources by clarifying willful infringement rules, broadening the experimental use exemption, and requiring at least some patent applications to be published more rapidly. Third, the benefits of patent disclosures can be promoted through peer production and increased mixing of the technical and patent literature.

Each of the changes discussed in Part V would help bridge the divide between patents and science, further increasing the importance of patents as a source of technical information. Patents should be something that academic scientists are proud to list on their websites, next to their *Science* and *Nature* publications.[12] And just as scientists will benefit from this increased access to information, patent law will benefit from the increased attention from the research community.

---

12. Most academic nanotechnology researchers do not list their patents on their websites along with their publications. In a survey of fifty such websites, I found only one exception. *See* Vivek Subramanian, *Publications*, UNIV. OF CALIF., BERKELEY, DEP'T OF ELEC. ENG'G & COMPUTER SCIS., http://www.eecs.berkeley.edu/~viveks/pubs.htm (last visited May 3, 2012).

II. THE DISCLOSURE JUSTIFICATION FOR PATENTS

A. Legal Requirements and Judicial Interpretation

To orient the debate over the disclosure justification for patents, this Part briefly reviews the current legal standard for disclosure in the United States as interpreted by the Court of Appeals for the Federal Circuit.[13] Patentees in the United States must satisfy the disclosure requirements of 35 U.S.C. § 112, which sets forth three independent conditions known as (1) written description, (2) enablement, and (3) best mode.[14] The recent America Invents Act makes only technical changes to this section,[15] which, as amended, reads:

> The specification shall contain a *written description* of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to *enable* any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the *best mode* contemplated by the inventor or joint inventor of carrying out the invention.[16]

The patent specification must also include drawings "where necessary for the understanding of the subject matter,"[17] and it must "conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the inventor or a joint inventor regards as the invention."[18] No substantive changes may be made to the disclosure without changing the filing date.[19] A typical patent application will be published eighteen months after filing.[20]

---

13. The Court of Appeals for the Federal Circuit is the quasi-specialized court that has jurisdiction over patent appeals. Although the Supreme Court has made general statements about the value of disclosure theory, *see infra* note 63, it has not addressed the specific disclosure requirements under the Patent Act.

14. 35 U.S.C. § 112 (2006), *amended by* Leahy-Smith America Invents Act, Pub. L. No. 112-29, sec. 4(c), § 112, 125 Stat. 284, 296 (2011).

15. America Invents Act, sec. 4(c), § 112, 125 Stat. at 296.

16. 35 U.S.C. § 112 (emphasis added); America Invents Act sec. 4(c) (striking "of carrying out his invention" and inserting "or joint inventor of carrying out the invention").

17. 35 U.S.C. § 113.

18. *Id.* § 112; America Invents Act sec. 4(c) (striking "applicant regards as his invention" and inserting "inventor or a joint inventor regards as the invention").

19. 35 U.S.C. § 132(a) ("No amendment shall introduce new matter into the disclosure of the invention."). But changes to make the disclosure more enlightening could be made if the USPTO and Federal Circuit "adopt a more flexible view of what constitutes 'new matter.'" Seymore, *supra* note 7, at 643 n.105.

20. 35 U.S.C. § 122(b) (allowing certain exceptions, including patents that are only filed in the United States or that have been withdrawn).

Enablement is the only disclosure requirement mandated by the international Agreement on Trade-Related Aspects of Intellectual Property Rights ("TRIPS").[21] The skilled person of § 112 is known in the patent literature as the "person having ordinary skill in the art" ("PHOSITA"),[22] and the disclosure must enable the PHOSITA to practice the invention without "undue experimentation."[23] Typically, if an invention depends on biological materials that cannot be made without undue experimentation, the inventor must place samples of these materials in a public depository.[24]

The Federal Circuit recently reaffirmed that the written description requirement is separate from enablement, and that "the test for sufficiency is whether the disclosure of the application relied upon reasonably conveys to those skilled in the art that the inventor had possession of the claimed subject matter as of the filing date."[25] This "possession" test is analytically distinct from enablement. The disclosure need not provide "examples or an actual reduction to practice; a constructive reduction to practice that in a definite way identifies the claimed invention" is sufficient.[26] The court gave chemical and biological examples of disclosures that would enable one skilled in the art to make an invention, but that do not describe the invention sufficiently to show that it was possessed by the inventor.[27]

21. *See* Agreement on Trade-Related Aspects of Intellectual Property Rights art. 29, Apr. 15, 1994, Marrakesh Agreement Establishing the World Trade Organization, Annex 1C, 1869 U.N.T.S. 299, 33 I.L.M. 1197 [hereinafter TRIPS] ("Members *shall* require that an applicant for a patent shall disclose the invention in a manner sufficiently clear and complete for the invention to be carried out by a person skilled in the art . . . ." (emphasis added)).

22. *See, e.g.*, Sean B. Seymore, *Heightened Enablement in the Unpredictable Arts*, 56 UCLA L. REV. 127, 132–34 (2008) (describing the PHOSITA standard and explaining why "the PHOSITA's precise identity is crucial to enablement").

23. *In re* Wands, 858 F.2d 731, 737 (Fed. Cir. 1988). Factors to determine whether "undue experimentation" is necessary include:

> (1) [T]he quantity of experimentation necessary, (2) the amount of direction or guidance presented, (3) the presence or absence of working examples, (4) the nature of the invention, (5) the state of the prior art, (6) the relative skill of those in the art, (7) the predictability or unpredictability of the art, and (8) the breadth of the claims.

Id. Jeffrey Lefstin has argued that most patent claims have effectively infinite scope, making it impossible to satisfy the requirement that "disclosure must enable the 'full scope' of the patent claims." Jeffrey A. Lefstin, *The Formal Structure of Patent Law and the Limits of Enablement*, 23 BERKELEY TECH. L.J. 1141, 1175 (2008).

24. *Cf.* 858 F.2d at 735; Lisa Larrimore Ouellette, Note, *Access to Bio-Knowledge: From Gene Patents to Biological Materials*, 2010 STAN. TECH. L. REV. N1, ¶¶ 102–103, http://stlr.stanford.edu/pdf/ouellette-access-to-bio-knowledge.pdf (describing the development of international material depositories).

25. Ariad Pharm., Inc. v. Eli Lilly & Co., 598 F.3d 1336, 1351 (Fed. Cir. 2010) (en banc).

26. *Id.* at 1352.

27. *Id.* at 1352–53.

The third disclosure requirement in the United States, best mode, is an optional requirement under TRIPS[28] and is not imposed in Europe.[29] Under the America Invents Act, best mode is still a requirement for receiving a patent, but granted patents may no longer be invalidated for failure to disclose the best mode,[30] which substantially weakens this requirement.[31] The Federal Circuit has used a two-step test to determine whether the best mode requirement is satisfied: Step one is "a subjective inquiry, focusing on the inventor's state of mind" to determine "whether, at the time of filing the application, the inventor possessed a best mode for practicing the invention."[32] Step two is "an objective inquiry" into "whether the written description disclosed the best mode such that one reasonably skilled in the art could practice it."[33] The Federal Circuit has also stated that the best mode requirement does not "demand disclosure of every preference an inventor possesses,"[34] nor does it require "production details."[35] As applied to the facts of a specific case, the Federal Circuit agreed that "[t]here is no requirement in [35 U.S.C. § 112] that an applicant point out which of his embodiments he considers his best mode,"[36] but in his dissent, Judge Mayer called this "the antithesis of the good-faith full disclosure that is mandated by section 112's best mode requirement."[37] This requirement could be strengthened by mandating that patentees identify which example is the best mode, or by creating a duty to supplement the specification if a new best mode is discovered.

---

28. *See* TRIPS, *supra* note 21, at art. 29 ("Members . . . *may* require the applicant to indicate the best mode for carrying out the invention known to the inventor at the filing date or, where priority is claimed, at the priority date of the application." (emphasis added)). TRIPS Article 29 does not similarly specify that members may impose a written description requirement, which raises "the issue of whether the U.S. is meeting its TRIPs obligations" by imposing a separate obligation, but the USPTO has stated that the "clear and complete" requirement of Article 29 "may support both written description and enablement standards." Guidelines for Examination of Patent Applications Under the 35 U.S.C. 1211, ¶ 1, "Written Description" Requirement, 66 Fed. Reg. 1099, 1104 (Jan. 5, 2001).

29. *See* Dale L. Carlson, Katarzyna Przychodzen & Petra Scamborova, *Patent Linchpin for the 21st Century? — Best Mode Revisited*, 45 IDEA 267, 285–86 (2005) (reviewing international application of the best mode requirement).

30. Leahy-Smith America Invents Act, Pub. L. No. 112-29, sec. 15, § 282, 125 Stat. 284, 328 (2011) (to be codified at 35 U.S.C. § 282).

31. *See* Tun-Jen Chiang, *Guest Post on Best Mode*, PATENTLY-O (Sept. 29, 2011, 4:12 PM), http://www.patentlyo.com/patent/2011/09/guest-post-was-congress-dumb-or-was-it-lying-a-reply-to-professor-sheppard.html.

32. Eli Lilly & Co. v. Barr Labs., Inc., 251 F.3d 955, 963 (Fed. Cir. 2001).

33. *Id.* (citations omitted).

34. Bayer AG v. Schein Pharm., Inc., 301 F.3d 1306, 1314 (Fed. Cir. 2002).

35. Teleflex, Inc. v. Ficosa N. Am. Corp., 299 F.3d 1313, 1331 (Fed. Cir. 2002) (citing Young Dental Mfg. Co. v. Q3 Special Prods., Inc., 112 F.3d 1137, 1144 (Fed. Cir. 1997)).

36. Randomex, Inc. v. Scopus Corp., 849 F.2d 585, 589 (Fed. Cir. 1988) (first alteration in original) (quoting Ernsthausen v. Nakayama, 1 U.S.P.Q.2d 1539, 1549 (B.P.A.I. 1985).

37. *Id.* at 591 (Mayer, J., dissenting). Donald Chisum notes that this decision may have been driven by the specific facts of the case and says that "[t]ypically, drafters of patent specifications explicitly state that particular parameters are the preferred implementations." 3 DONALD S. CHISUM, CHISUM ON PATENTS § 7.05(f) (2010).

But the weakening of the best mode requirement under the America Invents Act makes these changes unlikely.[38]

It is striking (and surprising to many scientists) that an inventor can receive a patent without doing an experiment or building a model to see if her invention works the way she thinks it should. Satisfying the disclosure requirements of § 112 is treated as "constructive reduction to practice," a doctrine that is described by the leading patent law treatise as "a curious balance in terms of policy" because it "dispenses altogether with actual reduction to practice," which "has long been viewed as of primary importance in establishing the date of invention."[39] The Supreme Court has effectively accepted this doctrine: writing for a unanimous Court in *Pfaff v. Wells Electronics*, Justice Stevens noted that "[i]t is well settled that an invention may be patented before it is reduced to practice."[40] Sean Seymore has summarized the problems with constructive reduction to practice (and the resulting "prophetic examples"[41]) and argued that "at least for complex inventions, an actual reduction to practice must become the standard of disclosure."[42]

The § 112 requirement that patented inventions be reproducible by a PHOSITA without undue experimentation are similar to the standards of scientific publication.[43] An editorial in *Nature Cell Biology* noted that "[a]n essential part of the process [of research] is that scientific papers are sufficiently detailed to allow for assessment of

38. *Cf.* Chiang, *supra* note 31 and accompanying text. Also, allowing supplementation of best mode information would require a flexible interpretation of "new matter" in 35 U.S.C. § 132(a). *See supra* note 19 and accompanying text.

39. 3A CHISUM, *supra* note 37, § 10.05.

40. Pfaff v. Wells Elecs., Inc., 525 U.S. 55, 61 (1998). The Court held that an inventor who marketed his invention (a computer chip socket) over a year before submitting a patent application was barred from patenting his invention on novelty grounds, even though he had not reduced the invention to practice. *Id.* at 57–58, 68–69. For a thorough discussion of *Pfaff*, including the observation that the *Pfaff* Court never referenced 35 U.S.C. § 112, see Timothy R. Holbrook, *The More Things Change, the More They Stay the Same: Implications of* Pfaff v. Wells Electronics, Inc. *and the Quest for Predictability in the On-Sale Bar*, 15 BERKELEY TECH. L.J. 933, 969–71 (2000).

41. *See* 3A CHISUM, *supra* note 37, § 10.05 (Supp. 2010) ("Consistent with the doctrine of constructive reduction to practice, an applicant for a patent may include one or more 'prophetic' examples, that is, specific illustrations of the invention that have not, in fact, been carried out.").

42. Seymore, *supra* note 7, at 628–32, 641; *see also* Christopher A. Cotropia, *The Folly of Early Filing in Patent Law*, 61 HASTINGS L.J. 65, 119–28 (2009) (arguing that actual reduction to practice should be required to prevent problems with early patent filing); Michael Risch, *A Surprisingly Useful Requirement*, 19 GEO. MASON L. REV. 57, 95–97 (2011) (arguing that constructive reductions to practice that lack evidence of operability should be considered under utility, not disclosure).

43. *Cf.* Joshua R. Nightingale, *The Researcher Rat's Culture and Ease of Access to the Publication Lever: Implications for the Patentability of University Scientific Research*, 113 W. VA. L. REV. 521, 541 (2011) ("Patent law's enablement requirement finds a close analogue in the peer review system's goal of determining the validity of data and conclusions presented.").

the data and for independent reproduction of experiments,"[44] and the *Nature* journals require authors to share data and materials so that others can "replicate and build upon the authors' published claims."[45] *Science* has a similar policy,[46] as do many other journals that publish data-driven results.[47] Federal grant agencies also impose disclosure requirements: the National Science Foundation ("NSF") expects grant recipients to "promptly" publish their findings and to share "data, samples, physical collections and other supporting materials created or gathered in the course of work,"[48] and the National Institutes of Health ("NIH") requires sharing to aid "the advancement of further research."[49]

B. Is Disclosure a Compelling Justification for Patents?

The patent system exists "[t]o promote the Progress of Science and useful Arts,"[50] and courts and commentators have almost uniformly embraced this utilitarian theory.[51] Utilitarian justifications for patents have been divided broadly into arguments that patents provide incentives for (1) innovation and (2) disclosure.[52]

Under innovation incentive theories, patents encourage new inventions by preventing appropriation by competitors, and we accept

44. Editorial, *Reproducibile Methods*, 11 NATURE CELL BIOLOGY 667, 667 (2009).

45. *Availability of Data and Materials*, NATURE, http://www.nature.com/authors/editorial_policies/availability.html (last visited May 3, 2012) (explaining *Nature* journals' editorial policy regarding authors and referees).

46. *See General Information for Authors*, SCIENCE, http://www.sciencemag.org/site/feature/contribinfo/prep/gen_info.xhtml (last visited May 3, 2012) (requiring authors to share "data necessary to . . . extend the conclusions of the manuscript" and to fulfill "all reasonable requests for data and materials").

47. *See, e.g.*, *The* American Economic Review*: Data Availability Policy*, AM. ECON. ASS'N, http://www.aeaweb.org/aer/data.php (last visited May 3, 2012); Victoria Stodden et al., *Reproducible Research*, COMPUTING SCI. & ENG'G, Sept.–Oct. 2010, at 10–11 (giving other examples of journals that require authors to make their data and code publicly accessible).

48. NAT'L SCI. FOUND., GENERAL GRANT CONDITIONS (GC-1) 34 (2010), *available at* http://www.nsf.gov/pubs/gc1/oct10.pdf.

49. NAT'L INSTS. OF HEALTH, U.S. DEP'T OF HEALTH AND HUMAN SERVS., NIH GRANTS POLICY STATEMENT, at IIA-87 (2010), *available at* http://grants.nih.gov/grants/policy/nihgps_2010/nihgps_2010.pdf.

50. U.S. CONST. art. I, § 8, cl. 8.

51. *See, e.g.*, Aronson v. Quick Point Pencil Co., 440 U.S. 257, 262 (1979) (stating that the purposes of the patent system are (1) "to foster and reward invention," (2) to "promote[] disclosure of inventions," and (3) "to assure that ideas in the public domain remain there" (citing Kewanee Oil Co. v. Bicron Corp., 416 U.S. 470, 480–81 (1974))); Graham v. John Deere Co., 383 U.S. 1, 9 (1966) ("The patent monopoly was not designed to secure to the inventor his natural right in his discoveries. Rather, it was a reward, an inducement, to bring forth new knowledge."); Dan L. Burk & Mark A. Lemley, *Policy Levers in Patent Law*, 89 VA. L. REV. 1575, 1597 (2003) ("To a greater extent than any other area of intellectual property, courts and commentators widely agree that the basic purpose of patent law is utilitarian . . . .").

52. *See* Eisenberg, *supra* note 5, at 1024; Katherine J. Strandburg, *What Does the Public Get? Experimental Use and the Patent Bargain*, 2004 WIS. L. REV. 81, 104.

the deadweight loss caused by the exclusive patent grant (which can be substantial, depending on the elasticity of demand and the availability of substitutes) in exchange for an increase in innovation.[53] There is much theoretical confusion, however, about exactly how patents promote innovation. For example, the traditional reward theory states that patents reward ex ante investments in innovation,[54] while commercialization or prospect theory states that exclusive property rights are needed to encourage development *after* the patent is granted.[55] Others have theorized that anticommons problems and patent thickets actually *hinder* innovation.[56]

Empirical support for any of these innovation theories is mixed, with a number of surveys indicating that outside the drug industry, patents are a less effective means of appropriating market exclusivity than secrecy or lead time.[57] James Bessen and Michael Meurer state

---

53. *See* F. SCOTT KIEFF ET AL., PRINCIPLES OF PATENT LAW 57–65 (4th ed. 2008) (providing an overview of deadweight loss caused by patents).

54. *See* MACHLUP REVIEW, *supra* note 5, at 33 (summarizing the reward theory and noting that it is "widely accepted"). A variation on reward theory is racing theory, under which the reward "is not the promise of a payoff, but the threat of being taxed or even excluded from the market entirely if they lose the race." Lemley, *supra* note 5, at 756. *See generally* Michael Abramowicz, *The Uneasy Case for Patent Races over Auctions*, 60 STAN. L. REV. 803 (2007) (analyzing the patent system from a racing theory perspective).

55. *See generally* Edmund Kitch, *The Nature and Function of the Patent System*, 20 J.L. & ECON. 265 (1977) (introducing the new prospect theory of patents); Michael Abramowicz, *The Danger of Underdeveloped Patent Prospects*, 92 CORNELL L. REV. 1065 (2007) (arguing that early prospect patenting leads to undeveloped inventions); John F. Duffy, *Rethinking the Prospect Theory of Patents*, 71 U. CHI. L. REV. 439, 445 (2004) (arguing that patent prospects maximize social benefits not by eliminating rivalry but by "approximat[ing] auctions for patent rights, with the winner being the competitor willing to provide the innovation to the public for the least rents").

56. *See* Burk & Lemley, *supra* note 51, at 1624–30; Michael A. Heller & Rebecca S. Eisenberg, *Can Patents Deter Innovation? The Anticommons in Biomedical Research*, 280 SCIENCE 698 (1998).

57. *See* Richard C. Levin et al., *Appropriating the Returns from Industrial Research and Development*, 1987 BROOKINGS PAPERS ON ECON. ACTIVITY 783, 796 (surveying industrial research managers and finding "limited effectiveness of patents as a means of appropriation"); Edwin Mansfield, *Patents and Innovation: An Empirical Study*, 32 MGMT. SCI. 173, 174 (1986) (surveying one hundred U.S. firms — excluding very small firms — and reporting that "patent protection was judged to be essential for the development or introduction of 30 percent or more of the inventions in only two industries — pharmaceuticals and chemicals"); Wesley M. Cohen, Richard R. Nelson & John P. Walsh, *Protecting Their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (or Not)* 9 (Nat'l Bureau of Econ. Research, Working Paper No. 7552, 2000), *available at* http://www.nber.org/papers/w7552.pdf (surveying research and development managers and finding that "patents are unambiguously the least central of the major appropriability mechanisms overall" and that "in no industry are patents identified as the most effective appropriability mechanism"). Patenting may be more important for smaller firms. *See* Stuart J.H. Graham et al., *High Technology Entrepreneurs and the Patent System: Results of the 2008 Berkeley Patent Survey*, 24 BERKELEY TECH. L.J. 1255, 1292, 1294 (2010) (surveying early-stage technology companies and finding that patenting is "the most important appropriability strategy" among biotechnology firms and that "venture-backed IT hardware firms rank patenting at least as important as secrecy"). In 1958, after arguing that reward theory was the most compelling justification for the patent system and reviewing its function in practice, Fritz Machlup famously concluded:

that "we can safely conclude that during the late 1990s, the aggregate cost of patents exceeded the aggregate private benefits of patents for United States public firms outside the chemical and pharmaceutical industries," implying that "patents very likely provided a net *dis*incentive for innovation."[58] Reports from the Federal Trade Commission and the National Academy of Sciences have expressed concern about patents hindering innovation and have recommended significant reform.[59] As noted by Nancy Gallini:

> Recent research has called into question . . . the effectiveness of patents as a tool for stimulating innovation . . . . Even if patents do not stimulate innovation, policies that promote strong patents may be justified. A second purpose of patents is to promote disclosure, a benefit that remains intact under the modern dynamic theory of patents.[60]

As discussed in the remainder of this Part, if patents provided no innovation incentive, I do not believe that the disclosure incentive alone would be sufficient to justify the patent system. But given that we do have an entrenched international patent system[61] — whether it promotes innovation or not — this Article will probe whether strong disclosure should be a central goal of that system.

Disclosure theory focuses on the quid pro quo of the patent system: the inventor receives the exclusive patent right in exchange for fully disclosing the invention to society, rather than keeping the in-

---

> If we did not have a patent system, it would be irresponsible, on the basis of our present knowledge of its economic consequences, to recommend instituting one. But since we have had a patent system for a long time, it would be irresponsible, on the basis of our present knowledge, to recommend abolishing it.

MACHLUP REVIEW, *supra* note 5, at 80. Our understanding of the economic effects of the patent system has not significantly improved in the past fifty years.

58. JAMES BESSEN & MICHAEL J. MEURER, PATENT FAILURE: HOW JUDGES, BUREAUCRATS, AND LAWYERS PUT INNOVATORS AT RISK 141 (2008). *But see* Glynn S. Lunney, Jr., *On the Continuing Misuse of Event Studies: The Example of Bessen and Meurer*, 16 J. INTELL. PROP. L. 35, 54 (2008) (arguing that event studies, such as the one conducted by Besson and Meurer, "consistently overreact to certain kinds of unexpected bad news" in a way that "fatally undermine[s] Bessen and Meurer's ultimate conclusion that patents have become a net disincentive for most industries").

59. *See* FED. TRADE COMM'N, TO PROMOTE INNOVATION: THE PROPER BALANCE OF COMPETITION AND PATENT LAW AND POLICY (2003), *available at* http://www.ftc.gov/os/2003/10/innovationrpt.pdf; NAT'L ACAD. OF SCIS., A PATENT SYSTEM FOR THE 21ST CENTURY (Stephen A. Merrill et al. eds., 2004), *available at* http://www.nap.edu/catalog.php?record_id=10976.

60. Nancy T. Gallini, *The Economics of Patents: Lessons from Recent U.S. Patent Reform*, 16 J. ECON. PERSP. 131, 132 (2002).

61. The U.S. patent system is required to meet minimum standards set by both TRIPS, *supra* note 21, and the Paris Convention for the Protection of Industrial Property, Mar. 20, 1883, 21 U.S.T. 1583 (last amended Sept. 28, 1979).

vention secret (such as with trade secret protection).[62] The Supreme Court has often cited disclosure as one of the main purposes of the patent system.[63] Many patent law theorists, however, are more skeptical; as noted by Rebecca Eisenberg, "[t]he incentive to disclose argument . . . has been more popular with the courts than with commentators,"[64] although there have been some recent defenders in the latter group.[65] Critics of disclosure theory argue that society receives little benefit in the quid pro quo exchange because (1) actual patents contain little valuable technical information, (2) willful infringement rules cause innovators to avoid reading patents, and (3) only inventions that would be disclosed anyway are patented.[66] I examine these arguments and their counterarguments in turn.

---

62. *See, e.g.*, Gallini, *supra* note 60, at 132. An alternative line of scholarship, which might be considered a branch of disclosure theory, argues that patents are valuable not because they *require* disclosure in the patent, but because they *allow* disclosure outside the patent. Patents allow inventors to license their ideas to the most efficient manufacturers, see WILLIAM M. LANDES & RICHARD A. POSNER, THE ECONOMIC STRUCTURE OF INTELLECTUAL PROPERTY LAW 329–30 (2003), and they allow academically oriented scientists to satisfy their desire to publish while protecting the rights of their commercially oriented funders, see Joshua S. Gans, Fiona E. Murray & Scott Stern, Contracting over the Disclosure of Scientific Knowledge: Intellectual Property and Academic Publication 2–3 (Apr. 8, 2011) (unpublished manuscript), *available at* http://ssrn.com/abstract=1559871. But these theories have little to say about the benefit of disclosure in the patent itself, and will thus not be explored in this Article.

63. *See, e.g.*, Bilski v. Kappos, 130 S. Ct. 3218, 3252 (2010) ("[W]e interpret ambiguous patent laws as a set of rules that 'wee[d] out those inventions which would not be *disclosed* . . . but for the inducement of a patent' . . . ." (quoting Graham v. John Deere Co., 383 U.S. 1, 11 (1966)) (second alteration in original) (emphasis added)); Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co., 535 U.S. 722, 736 (2002) ("[E]xclusive patent rights are given in exchange for disclosing the invention to the public."); J.E.M. Ag Supply, Inc. v. Pioneer Hi-Bred Int'l, Inc., 534 U.S. 124, 142 (2001) ("The disclosure required by the Patent Act is 'the *quid pro quo* of the right to exclude.'" (quoting Kewanee Oil Co. v. Bicron Corp., 416 U.S. 470, 484 (1974))); Pfaff v. Wells Elecs., Inc., 525 U.S. 55, 63 (1998) ("[T]he patent system represents a carefully crafted bargain that encourages both the creation and the public disclosure of new and useful advances in technology, in return for an exclusive monopoly for a limited period of time.");Bonito Boats, Inc. v. Thunder Craft Boats, Inc., 489 U.S. 141, 151 (1989) ("'In consideration of [the invention's] disclosure and the consequent benefit to the community, the patent is granted.'") (quoting United States v. Dubilier Condenser Corp., 289 U.S. 178, 186 (1933))); *Kewanee Oil*, 416 U.S. at 481 (stating that additions from patent disclosures "to the general store of knowledge are of such importance to the public weal that the Federal Government is willing to pay the high price of 17 years of exclusive use for its disclosure"); Sinclair & Carroll Co., Inc. v. Interchemical Corp., 325 U.S. 327, 331 (1945) ("[The patent system's] inducement is directed to disclosure of advances in knowledge which will be beneficial to society; it is not a certificate of merit, but an incentive to disclosure."); Grant v. Raymond, 31 U.S. (6 Pet.) 218, 247 (1832) ("[A] correct specification . . . is necessary in order to give the public . . . the advantage for which the privilege is allowed, and is the foundation of the power to issue a patent.").

64. Eisenberg, *supra* note 5, at 1028.

65. *See supra* note 7 and accompanying text.

66. See *supra* note 5. These critiques that patents do not (or should not) disclose information to future inventors are different from arguments that patents themselves block future innovation. For some of the challenges in designing a patent system to foster cumulative innovation, see, for example, Suzanne Scotchmer, *Standing on the Shoulders of Giants: Cumulative Research and the Patent Law*, J. ECON. PERSP., Winter 1991, at 29.

The first critique of disclosure theory is that patents do not disclose useful information; rather, patent disclosures are often inadequate or opaque, or are more clearly described in other technical literature.[67] Even the Supreme Court, in a rare expression of skepticism about disclosure theory, has noted that "in light of the highly developed art of drafting patent claims so that they disclose as little useful information as possible — while broadening the scope of the claim as widely as possible — the argument based upon the virtue of disclosure must be warily evaluated."[68]

This Article evaluates the empirical validity of this critique. Part II.C examines previous surveys of the value of patent disclosures, which show that patents do provide useful information to at least some inventors, and Parts III and IV present new survey evidence from nanotechnology researchers and case studies of specific nanotechnology patents. Even the defenders of disclosure theory have not grappled with the existing empirical evidence. Some commentators have simply assumed that patents adequately disclose inventions,[69] while others agree that disclosure is currently poor but argue that the solution is to improve disclosure, not to abandon the theory.[70]

The second critique of disclosure theory is that even if patent disclosures are enlightening, inventors do not read them because of concerns about willful infringement.[71] The Patent Act allows courts to

67. *See* Devlin, *supra* note 5, at 403 ("The information conveyed by many specifications is inadequate and, in practice, fails to reflect the legislative requirements of § 112."); Lemley, *supra* note 5, at 746 ("[T]he fact that many of those patents obfuscate the technology at issue, deliberately or because we lack a clear language for communicating some types of inventions, means that the payoff from reading those applications is often dubious."); *Disclosure Function*, *supra* note 5, at 2025–26 (arguing that "[m]any patented inventions cannot be recreated or put into use based on the information in the patent itself" and that legal rules "create incentives for patent applicants to draft their disclosures opaquely").

68. Brenner v. Manson, 383 U.S. 519, 534 (1966). The Supreme Court adopted a narrowed definition of utility — "specific benefit [that] exists in currently available form" — without concern that this definition would limit the dissemination of new information. *Id.* at 534–35. The Federal Circuit generally ignored this "high water mark" for utility and "lower[ed] the bar back toward the more lenient standards of utility espoused pre-*Manson*." JANICE M. MUELLER, AN INTRODUCTION TO PATENT LAW 159, 161 (2003).

69. *See, e.g.*, Vincenzo Denicolò & Luigi Alberto Franzoni, *The Contract Theory of Patents*, 23 INT'L REV. L. & ECON. 365, 368 (2004); Ronald E. Myrick, William P. Skladony & Ram Nath, *The Technological Innovation Process: Patent Documentation as a Source of Technological Information*, 9 SANTA CLARA COMPUTER & HIGH TECH. L.J. 355, 357–59 (1993); Suzanne Scotchmer & Jerry Green, *Novelty and Disclosure in Patent Law*, 21 RAND J. ECON. 131, 134 (1990).

70. *See* Fromer, *supra* note 7, at 563 (arguing that patents do not "do nearly enough to convey information useful to stimulate inventive activity" and explaining "how the patent document can be restructured to vitalize its relevance"); Seymore, *supra* note 7, at 626–27 (arguing that patents are often "indecipherable" or do not fully disclose inventions and that "[i]t is now time to transform the patent into a readable teaching document").

71. *See* Devlin, *supra* note 5, at 404; Holbrook, *supra* note 5, at 142–43; Mark A. Lemley & Ragesh K. Tangri, *Ending Patent Law's Willfulness Game*, 18 BERKELEY TECH. L.J. 1085, 1100–01 (2003); Lemley, *supra* note 5, at 746 (explaining that "lawyers often advise engineers not to read competitor patents for fear of becoming a willful infringer"); Doug

award treble damages and attorney fees,[72] and the Federal Circuit has held that enhanced damages may only be awarded in cases of willful infringement.[73] Under earlier interpretations of the willfulness doctrine, to avoid liability for enhanced damages, any company that learned of a potentially relevant patent had to spend $20,000 to $100,000 per patent for an attorney opinion stating that the patent is invalid or not infringed — leading many companies to advise researchers to avoid reading patents and to look elsewhere for technical information.[74]

Jeanne Fromer argues that "it is vital to remove — if not reverse — the penalty of willful infringement as applied to reviewing patents to inform follow-up innovation."[75] The Federal Circuit recently took a step in this direction by raising the standard for willful infringement from negligence to "at least . . . objective recklessness" and "reemphasiz[ing] that there is no affirmative obligation to obtain opinion of counsel."[76] Sean Seymore claims that this "suggests that simply reading a patent will not trigger the doctrine,"[77] although others believe the doctrine is unclear.[78] Research organizations can at least take some assurance from then-Federal Circuit Chief Judge Paul Michel: "People sometimes extrapolate wildly from what [a Federal Circuit] case actually held or even what the court said, other than perhaps in blatant dicta. The people who say, 'Don't read your rival company's patents because you'll get hung for willful infringement' — I think that's ridiculous."[79]

Lichtman, *Substitutes for the Doctrine of Equivalents: A Response to Meurer and Nard*, 93 GEO. L.J. 2013, 2023 & n.42 (2005) (claiming that "very few people read patents outside of the litigation and licensing contexts" because "[t]he risks [of willful or contributory infringement] are just too high," and concluding that the "common misconception . . . that the patent system promotes disclosure and dissemination through the written patent document" is therefore "clearly not right"); *Disclosure Function*, *supra* note 5, at 2019–20 ("Faced with this calculation [of the risk of enhanced damages], many innovators have ceased using patents as a research tool . . . .").

72. 35 U.S.C. § 284 (2006) ("[T]he court may increase the damages up to three times the amount found or assessed."); *id.* § 285 (2006) ("The court in exceptional cases may award reasonable attorney fees to the prevailing party.").

73. *See In re* Seagate Tech., LLC, 497 F.3d 1360, 1368 (Fed. Cir. 2007) (en banc). A finding of willful infringement is also sufficient to award attorney fees. *See* Knorr-Bremse Systeme Fuer Nutzfahrzeuge GmbH v. Dana Corp., 383 F.3d 1337, 1347 (Fed. Cir. 2004) (en banc).

74. *See* Lemley & Tangri, *supra* note 71, at 1092, 1100–01.

75. Fromer, *supra* note 7, at 588. *See also* Lemley & Tangri, *supra* note 71, at 1125 (arguing that a "narrower willfulness doctrine" would "more faithfully serve the purposes of patent law").

76. *Seagate*, 497 F.3d at 1371.

77. Seymore, *supra* note 7, at 625.

78. *See, e.g.*, Pan C. Lee, Note, *A Matter of Opinion: Opinions of Counsel Remain Necessary After* In re Seagate, 25 BERKELEY TECH. L.J. 33, 36 (2010) (referring to the "unsure post-*Seagate* landscape").

79. Paul Michel, Chief Judge, U.S. Court of Appeals for the Federal Circuit, Address at Fordham University School of Law (Nov. 2009), *in Innovation, Incentives, Competition,*

The survey evidence in Part III of this Article shows that my respondents — both academic and industrial researchers — are not avoiding patents because of legal concerns like willful infringement. In Part V.B, however, I argue that rather than keeping legal rules that are widely ignored, we should change the rules to match the norms and expectations of the scientific culture. Basic researchers should thus have a broader experimental use exemption and should not be threatened with enhanced damages for turning to the patent literature as a source of technical information.

Finally, the third, and most compelling, critique of disclosure theory is that patents are only sought on inventions that are relatively cheap to reverse engineer (generally but imprecisely referred to as "self-disclosing" inventions) or that would soon be invented by others.[80] Under this theory, an inventor will only patent a "non-self-disclosing" (i.e., expensive to reverse engineer) invention — rather than protecting it as a trade secret[81] — if it seems likely that others will recreate the invention before the patent expires.[82] In such a case, "the invention was inevitably coming to the public regardless of the patent disclosure."[83]

A problem with this critique is that few inventions are "self-disclosing" at zero cost. Jeanne Fromer notes that "[e]ven when the information is sometimes available elsewhere, it is normally not available widely."[84] She argues that "[m]uch of the information contained in — or that ought to be in — patents is not published elsewhere," and that "it typically takes a long time after patent publication before the invention becomes available for theoretical reverse-engineering," if the invention is commercialized at all.[85] Similarly, Alan Devlin notes that reverse engineering involves wasted expense

---

and Patent Law Reform: Should Congress Fix the Patent Office and Leave Litigation Management to the Courts?, 20 FORDHAM INTELL. PROP. MEDIA & ENT. L.J. 1135, 1168 (2010).

80. *See* MACHLUP REVIEW, *supra* note 5, at 32 (stating that "economists have shown considerable skepticism" of disclosure theory because of both "the unwillingness of firms to patent what they think they may be able to keep secret" and "the inability of manufacturers to keep secret most of the technology they use and, consequently, society's munificence in granting monopolies for the disclosure of what would become known in any case"); Devlin, *supra* note 5, at 418; Eisenberg, *supra* note 5, at 1028–29; Holbrook, *supra* note 5, at 133–34; *Disclosure Function*, *supra* note 5, at 2014–16.

81. *See generally* Michael Risch, *Trade Secret Law and Information Development Incentives*, *in* THE LAW AND THEORY OF TRADE SECRECY: A HANDBOOK OF CONTEMPORARY RESEARCH 152, 167–74 (Rochelle C. Dreyfuss & Katherine J. Strandburg eds., 2011) (discussing the tradeoffs between patents and trade secrets); Mark A. Lemley, *The Surprising Virtues of Treating Trade Secrets as IP Rights*, 61 STAN. L. REV. 311, 332–37 (2008) (same).

82. Holbrook, *supra* note 5, at 134–35.

83. *Id.*

84. Fromer, *supra* note 7, at 554.

85. *Id.* at 554, 558. "As an empirical matter, it appears that less, probably much less, than half of all patented product inventions are commercialized." Ted Sichelman, *Commercializing Patents*, 62 STAN. L. REV. 341, 362 (2010).

and even "if fruitful, may give rise to proprietary information that will only be shared indirectly with the public."[86] Vincenzo Denicolò and Luigi Franzoni also refute this critique through an economic model — although their model assumes that patents adequately disclose inventions to other innovators.[87]

This Article will show that patents do actually improve access to information, but I agree with the critics that disclosure is not a compelling *justification* for the patent system. Under a pure disclosure theory, one should consider an invention that *already exists* and ask whether we want to offer a patent (and its associated inefficiencies) in exchange for information about that invention. This bargain would only benefit the public if the public could not independently obtain the same information (such as through easy reverse engineering) for less than the cost of granting a patent (including deadweight loss and administrative costs) — in which case the inventor might rationally prefer trade secrecy over patents.

But whether or not disclosure justifies the patent system is moot because disclosure theory need not support the patent system on its own — the international patent system is not going away,[88] and it probably does promote innovation, at least in some cases. The more relevant question about disclosure is whether, given our existing system, we want to enforce robust disclosure requirements. Are the benefits of full disclosure underappreciated? Are current disclosure requirements being enforced? Are any legal changes necessary to make disclosures more useful to follow-on innovators? Would stronger disclosure requirements hurt innovation? These questions are addressed in Part V, but first I examine the existing evidence about the utility of patent disclosures as a source of technical information.

C. Previous Surveys of the Value of Patent Disclosures

Both advocates of a strong disclosure function and those who believe disclosure should not be central to our patent system agree that patents currently do not disclose much useful information.[89] The empirical evidence cited by these sources, however, does not support this

86. Devlin, *supra* note 5, at 405. Devlin argues, however, that these benefits of disclosure are subsidiary to the innovation incentive. *Id.* at 406.

87. Denicolò & Franzoni, *supra* note 69, at 367–68.

88. *See supra* note 61 and accompanying text.

89. *Compare Disclosure Function*, *supra* note 5, at 2007, 2028 (claiming to present "a variety of evidence showing that the patent system largely fails at its disclosure function" and arguing that disclosure is not "the primary justification for the patent system"), *with* Fromer, *supra* note 7, at 560, 563 (agreeing that "there is evidence that most inventors spend little to no time reading others' patents to inform their research" but arguing that "patent disclosure is so important to the patent system's key purpose" that we should "invigorate disclosure"). For additional references, see *supra* note 8.

strong conclusion. Some of the cited evidence is anecdotal,[90] and a few sources cite a model based on gross patenting data,[91] but most of the evidence comes from surveying people involved in research (though often not the innovators themselves) about the technical value of patent disclosures. This Part reviews these surveys and concludes that, counter to the claims of legal commentators, many innovators are currently using patents as a source of useful technical information.

One of the most cited studies concerning the utility of patents as sources of technical information is a survey — conducted by Wesley Cohen and colleagues — of managers of research and development units of U.S. manufacturing firms in 1994.[92] Mark Lemley cites it to support the claim that "[e]mpirical research suggests that scientists don't in fact gain much of their knowledge from patents, turning instead to other sources,"[93] and other scholars cite the study to support similar claims.[94] But what the study actually found is that 49.1% of

---

90. For example, a *Harvard Law Review* Note on disclosure theory cites individual testimony from the 2002 Federal Trade Commission ("FTC") hearings on intellectual property. *See Disclosure Function*, *supra* note 5, at 2025 n.106 (describing conflicting evidence on whether engineers read patents). For transcripts from the FTC hearings, see *Competition and Intellectual Property Law and Policy in the Knowledge-Based Economy*, FED. TRADE COMM'N, http://www.ftc.gov/opp/intellect (last modified Sept. 28, 2007).

91. *See* Ashish Arora, Marco Ceccagnoli & Wesley M. Cohen, *R&D and the Patent Premium* (Nat'l Bureau of Econ. Research, Working Paper No. 9431, 2003), *available at* http://www.nber.org/papers/w9431. This working paper has been cited as showing that patent disclosures do not impact information flows between U.S. firms. *See* Fromer, *supra* note 7, at 562 n.110; *Disclosure Function*, *supra* note 5, at 2014 n.41. However, the paper notes that it is "unclear whether patent disclosures truly have little effect on the information flows from others that affect firms' R&D productivity, or whether the lack of an observable effect reflects that our measures are too imprecise to discern it." Arora et al., *supra*, at 17. This result is also deleted from the peer-reviewed version of this study. *See* Ashish Arora, Marco Ceccagnoli & Wesley M. Cohen, *R&D and the Patent Premium*, 26 INT'L J. INDUS. ORG. 1153 (2008). Other researchers have claimed that their models show that patents do not increase knowledge spillovers between firms. *See, e.g.*, James Bessen, *Patents and the Diffusion of Technical Information*, 86 ECON. LETTERS 121 (2005) (showing that in a simple theoretical model with complete information and no transaction costs, information diffusion is not necessarily greater under a patent system); Tobias Schmidt, *An Empirical Analysis of the Effects of Patents and Secrecy on Knowledge Spillovers* 16 tbl.1 (Zentrum für Europäische Wirtschaftsforschung GmbH, Discussion Paper No. 06-048, 2006), *available at* http://ssrn.com/abstract=920403 (modeling survey results to show a correlation between (1) reported "lack of information on technology" as a barrier to innovation and (2) reported "[i]mportance of patent protection" for a firm's industry). If these models are accurate, they provide support for my conclusion that disclosure theory alone is insufficient to justify the patent system. As noted earlier, however, rather than focusing on this broader question, I am taking the current patent system as a given and questioning whether strong disclosure should be a goal of that system. *See supra* Part II.B.

92. Wesley M. Cohen et al., *R&D Spillovers, Patents and the Incentives to Innovate in Japan and the United States*, 31 RES. POL'Y 1349 (2002).

93. Lemley, *supra* note 8, at 22 n.16.

94. *See* Fromer, *supra* note 7, at 560 & n.101 (citing it to support the statement that "there is evidence that most inventors spend little to no time reading others' patents to inform their research"); Seymore, *supra* note 7, at 624 (citing it for the proposition that patents "are not often viewed as an important channel for information flow"); *Disclosure Function*, *supra* note 5, at 2014 (citing it for the proposition that "U.S. firms most often use

U.S. respondents indicated patents were "moderately" or "very" important as a source of information for a recent R&D project — less than the 61.8% who said the same of publications or the 51.3% for informal exchange, but still almost half the sample.[95] Patents were the third most important information source, ahead of public meetings or conferences, competitors' products (via reverse engineering), joint ventures, trade associations, recent hires, licenses, and contracts with other firms.[96]

Furthermore, Cohen and colleagues found that in Japan, patents were by far the most important information source for recently completed projects, with 85.4% of respondents ranking them as "moderately" or "very" important — significantly more than the 64.7% of respondents who said the same of publications, the next most important information source.[97] One of the Cohen study's authors, John Walsh, collaborated with Sadao Nagaoka to survey patentees in the United States and Japan in 2007.[98] They again found that Japanese firms "rely more heavily on the patent literature than do American firms," but they also found "some evidence that inventors in both countries are looking at the same scientific literature" — U.S. patents and U.S. or international publications — so that the difference was not caused by Japanese patents being more useful than U.S. patents.[99] (They do not discuss the language barrier, but most Japanese researchers are used to publishing and reading technical information in English.[100]) The results of these two surveys indicate that patents do currently serve a useful disclosure function for many innovators, including in the United States, and that Japanese researchers are finding even more useful information in U.S. patents than U.S. researchers are — suggesting that U.S. researchers might underexploit the technical content of patents.

The 2003 survey of the Intellectual Property Owners Association ("IPO") has been cited as "evidence that most inventors spend little to no time reading others' patents to inform their research" because it found that "65% of [respondents] do not always read patents before

---

sources other than patent disclosures to learn about the most recent technological advances in their industry").

95. Cohen et al., *supra* note 92, at 1363 fig.6.

96. *Id.*

97. *Id.*

98. John P. Walsh & Sadao Nagaoka, *How "Open" Is Innovation in the US and Japan?: Evidence from the RIETI-Georgia Tech Inventor Survey* (Research Inst. of Econ., Trade & Indus., Discussion Paper No. 09-E-022, 2009), *available at* http://www.rieti.go.jp/jp/publications/dp/09e022.pdf.

99. *Id.* at 12–13.

100. *See* Robert S. Cutler, *A Comparison of Japanese and U.S. High-Technology Transfer Practices*, 36 IEEE TRANSACTIONS ON ENGINEERING MGMT. 17, 19 (1989) (surveying Japanese researchers in three high-technology fields and finding that 94% could read and write in English and 85% published in and read English language journals).

embarking on research, development, or product development."[101] But the 35% of respondents (primarily "senior legal staff"[102]) whose companies *always* read patents before beginning new research projects is still a substantial minority, and the number who *sometimes* read patents must be larger. Furthermore, the survey also found that patents are more important than publications as a source of technical ideas,[103] and that 66% of respondents routinely monitor their competitors' intellectual property activity for technology ideas.[104]

Adam Jaffe and colleagues found that U.S. inventors who received patents in 1993 were not very familiar with patents cited in their patents.[105] But this does not reveal much about whether those cited patents contain useful technical information. More telling is their finding that patent citations do provide a statistically significant signal of knowledge "spillover" — i.e., that patentees are learning from roughly half the patents they cite.[106] The patentees were also asked what sources had a "significant influence" on the development of their invention: only about 5% of respondents indicated the patent literature and only about 15% indicated the technical literature.[107] It is unclear why these responses differ so markedly from the earlier surveys discussed in this Part, but it may be because patentees view their work as novel (and thus may view prior work as informative but not a "significant influence") or because these respondents had less access to the patent and technical literature (both because the inventions were made in the pre-web 1980s and because the respondents were less likely to be professional scientists at large organizations). Still, despite their reported lack of interest in the patent literature, these 1993 patentees did obtain knowledge spillovers from other patents.

---

101. Fromer, *supra* note 7, at 560, 61 & n.104 (citing IAIN M. COCKBURN & REBECCA HENDERSON, SURVEY RESULTS FROM THE 2003 INTELLECTUAL PROPERTY OWNERS ASSOCIATION SURVEY ON STRATEGIC MANAGEMENT OF INTELLECTUAL PROPERTY (2003), http://www.ipo.org/AM/Template.cfm?Section=Home&Template=/CM/ContentDisplay.cfm&ContentID=8564).

102. COCKBURN & HENDERSON, *supra* note 101, at A.1.

103. *Id.* at D.1 ("Patent documents are rated more important than competitors, in-licensing, professional publications or government and university partnerships, and roughly equivalent to partnerships and joint ventures.").

104. *Id.* at D.5. Other relevant statistics are that only 5% of respondents reported a negative impact from the earlier publication of applications at the application stage, 26% said that product lifecycles are typically shorter than the time for a patent to issue, and 75% thought that patents do not disclose too much valuable information to competitors. *Id.* at B.1, C.8, C.10.

105. Adam B. Jaffe, Manuel Trajtenberg & Michael S. Fogarty, *The Meaning of Patent Citations*, *in* ADAM B. JAFFE & MANUEL TRAJTENBERG, PATENTS, CITATIONS, AND INNOVATIONS: A WINDOW ON THE KNOWLEDGE ECONOMY 379, 389 & fig.4, 390 & fig.5 (2002); *see also* Fromer, *supra* note 7, at 561 & nn.105–06 (citing the study for these points).

106. Jaffe et al., *supra* note 105, at 394 & tbl.1, 400.

107. *Id.* at 388 fig.3.

Other surveys have been conducted outside the United States. A 1997 survey of small and medium-sized companies in the United Kingdom found that 25.2% of companies searched the patent literature for technical reasons.[108] Follow-up interviews revealed that not knowing where to find patents and the cost of patent searches were significant barriers to access, and that the possibility of searching patents online "was greeted with considerable enthusiasm."[109] A different survey of small firms in the United Kingdom in 1996 found similar results for the number of firms doing technical patent searches.[110] An even earlier survey in Australia, conducted from 1980 to 1981, found that many respondents indicated that their main reason for consulting patents was technical: the percentages ranged from 32% for small companies to 61% for respondents in higher education.[111]

Overall, the survey results discussed in this Part show that even before patents became readily accessible through web searches, patents were a useful source of information for a significant minority of innovators. One would expect them to become more useful as they have become more accessible.

---

108. *See* Matthew Hall, Charles Oppenheim & Margaret Sheen, *Barriers to the Use of Patent Information in UK Small and Medium-Sized Enterprises. Part I: Questionnaire Survey*, 25 J. INFO. SCI. 335, 339–40 (1999) (reporting that 56.4% of companies conduct patent searches, of which 40.7% do so for commercial and technical reasons, and 3.9% do so for technical reasons only).

109. Matthew Hall, Charles Oppenheim & Margaret Sheen, *Barriers to the Use of Patent Information in UK Small and Medium-Sized Enterprises. Part 2 (1): Results of In-Depth Interviews*, 26 J. INFO. SCI. 87, 94 (2000).

110. *See* Stuart Macdonald, *Bearing the Burden: Small Firms and the Patent System*, J. INFO. L. & TECH., July 4, 2003, http://www2.warwick.ac.uk/fac/soc/law/elj/jilt/2003_1/macdonald (finding that "[a]bout half of these small firms regularly conduct patent searches," of which over 40% of patenting firms and 20% of non-patenting firms do so to keep abreast of technological developments, and that firms also looked to patents to avoid duplicating research, to acquire information to solve problems, to uncover new products, and (in very small numbers) to stimulate creativity). Another survey in the United Kingdom found that 18% of users of the British Library Patent Information Centre in 2000 cited finding technical information as their main reason for reading patents, and that the percentage was higher among those using patents every one to six months (rather than multiple times a month). *See* David Newton, *A Survey of Users of the New British Library Patent Information Centre*, 22 WORLD PAT. INFO. 317, 321 & fig.3 (2000). But since many respondents were patent attorneys or professional patent searchers, *id.* at 320 tbl.1, it is unclear what this reveals about patent use by researchers.

111. *See* Thomas Mandeville, *Australian Use of Patent Information*, 5 WORLD PAT. INFO. 79, 80 tbl.1 (1983) (showing that 42% of large companies, 37% of medium companies, 32% of small companies, 53% of government respondents, 61% of higher education respondents, and 38% of individual engineers reported that their main reason for consulting patent information was to assess the state of the art, to consider new products, or to solve technical problems). Note that respondents could only check one option, so respondents whose secondary reason for consulting patents was technical were not included. *Id.*

III. UTILITY OF PATENTS FOR NANOTECH RESEARCHERS

As described in the previous Part, existing evidence suggests that many researchers do use patents as a source of technical information. Most of the earlier surveys are ten to twenty years old, predating the ready availability of patents online. The earlier surveys also focused either on patentees or on managers and legal officers at technology companies and thus might not reflect the view of typical researchers.[112]

This Part adds to this empirical evidence with a survey of nanotechnology researchers that focused specifically on patent disclosures. Nanotechnology is the interdisciplinary study of systems on the nanometer scale,[113] and it has many potential applications: "Science and technology research in nanotechnology promises breakthroughs in areas such as materials and manufacturing, nanoelectronics, medicine and healthcare, energy, biotechnology, information technology, and national security. It is widely felt that nanotechnology will be the next Industrial Revolution."[114]

Because of these potential applications, there is an extensive nanotechnology patent literature.[115] Still, most nanotechnology researchers are academics or basic researchers who generally do not have to rely on patents for technical information because most advances are published in scientific articles. Because nanotechnology is still an exciting new field, it is easy for nanotechnology researchers to find scientific journals that will publish their work, and there are high-impact nanotechnology specialist journals like *Nano Letters* and *Nature Nanotechnology* that help researchers keep abreast of the field. One would therefore expect patents to be less useful to nanotechnology researchers than to industrial researchers in more applied scientific fields.

To be sure, even though the survey respondents work on a broad range of technologies, one might be concerned about the extent to which these results can be generalized. Respondents' subfields ranged from nanoelectronics to drug delivery to energy, suggesting that patent disclosures have informational benefits across a broad range of technologies. But one might be concerned that because many nano-

---

112. The only survey that interviewed researchers who were not patentees was Mandeville's study, which surveyed professional engineers in Australia in 1980–1981, though it did not indicate the response rate or many details about the survey. *Id.* at 79.

113. It is hard to fathom how small a nanometer (a billionth of a meter) is. If you zoomed in so that a nanometer was as big as the diameter of one of your hairs, then your head would be roughly 10 miles in diameter.

114. Bharat Bhushan, *Introduction to Nanotechnology*, *in* SPRINGER HANDBOOK OF NANOTECHNOLOGY 1, 1 (Bharat Bhushan ed., 3d ed. 2010).

115. *See* Mark A. Lemley, *Patenting Nanotechnology*, 58 STAN. L. REV. 601, 604–05 (2005).

technology researchers are academics who are less concerned about willful infringement, they might be more likely than industrial researchers to read patents. Yet my survey found that even industrial researchers did not avoid patents for fear of infringement.[116] Another concern is that nanotechnology patent disclosures might be better than in other fields, although there is no clear evidence to support this.[117] My hypothesis is that these results are more representative of other hard science fields, rather than fields like software patents — although there is anecdotal evidence that software patents can also contain useful information that is not available elsewhere in the prior art.[118] In future work, I will survey a broader range of researchers to test these questions directly. But even if my nanotechnology survey cannot be generalized to fields like business methods, it is still important that patents disclose useful information in at least some fields.

This Part presents the results from my survey of nanotechnology researchers. Part III.A describes the survey method and some basic summary statistics. Part III.B explains why the respondents choose to read patents (or choose to avoid them). Part III.C presents results on whether the researchers find useful technical information in the patents they read. Part III.D describes whether respondents feel that most patents are reproducible by a skilled researcher. Finally, Part III.E presents results about whether researchers avoid reading patents because of concerns about willful infringement.

The quotations provided throughout this Part are representative,[119] and the data in this Part (and in the supplementary tables in the Appendix) are presented separately from the analysis (which is generally saved for Part V).

A. Survey Method and Summary Statistics

I developed and conducted the survey to determine how nanotechnology researchers use patents as a source of technical infor-

116. *See infra* Part III.E.

117. A recent study by Ocean Tomo found nanotechnology to be the "number one technology class for patent quality" according to a "patented method of patent quality valuation . . . that is statistically based," OCEAN TOMO, OCEAN TOMO USPC PATENT QUALITY BENCHMARK STUDY (2011), but the patented method appears to define quality in terms of validity and enforceability, rather than quality of disclosure, see U.S. Patent No. 6,556,992 (filed Sept. 14, 2000). I am unaware of any non-anecdotal data that compares the quality of patent *disclosures* across technology classes.

118. *See* Andrew Schulman, *Open to Inspection: Using Reverse Engineering To Uncover Software Prior Art, Part 1*, NEW MATTER, Summer 2011, at 26, 27 (noting that "Microsoft described in a patent application from 2001 an otherwise-undocumented Windows interface known as DirectUI, and as early as a 1994 patent application provided an appendix disclosing an interface (well-known among programmers at the time both for its importance and lack of formal documentation) to create so-called 'namespace extensions,'" and arguing that developers should "more regularly consult the patent literature").

119. I have grouped the comments by topic and reported a few from each topic.

mation.[120] I e-mailed the survey in October 2010 to 1078 researchers who were listed as the corresponding authors on high-impact nanotechnology publications or who were listed on corporate nanotechnology research websites.[121] I received responses from 214 researchers by December 2010, giving a response rate of 20%; the representativeness of the respondents is explored below. Three respondents were eliminated from the data presented here because they did not have degrees in the natural sciences, so the following percentages were calculated out of 211 respondents.[122]

All the tables of results are displayed in the Appendix.[123] Table 1 shows detailed statistics for the respondents, which are briefly summarized here. Most respondents work in academic laboratories (76%); a smaller number work in government labs (13%) or industry (8%). Most respondents are experimentalists (90%), not theorists (10%), and far more characterized their research as basic (49%) than applied (15%) (with the rest conducting an equal mix of basic and applied research).[124]

The most common departments in which respondents received their PhDs were physics or applied physics (46%), followed by chemistry or biochemistry (22%); only 2% of respondents indicated that they did not have a doctoral degree. Most respondents received their highest degree in the 1990s (36%) or 2000s (40%); the oldest respondents received their degree in the 1960s (4%). Only 10% of respondents were female (4% did not indicate their gender). About a quarter (24%) of respondents worked outside the United States.

With a 20% response rate (which is on the low end but within the range of response rates to other patent-related surveys of individual

---

120. The survey is online. NANOTECHNOLOGY PAT. SURV., https://spreadsheets.google.com/viewform?formkey=dFpZeHJrbERqaU5ObHJlQU5XT1pFYnc6MA (last visited May 3, 2012).

121. The e-mail addresses for corresponding authors in the ISI Web of Knowledge database were recorded for (1) articles in *Nature* or *Science* since 2006 with "nano* OR graphene OR 'single molecule'" in the title (293 addresses, after ignoring articles that were not related to nanotechnology); (2) articles in *Nature Nanotechnology* since 2006 (496 addresses); (3) articles in *Nano Letters* since 2009 with U.S. authors (835 addresses). *See* ISI WEB OF KNOWLEDGE, http://apps.isiknowledge.com (last visited Oct. 29, 2010). Eliminating duplicate or defunct e-mail addresses resulted in 1057 addresses for corresponding authors. To increase the number of respondents from industry, an additional 21 nanotechnology researchers whose e-mail addresses were listed on corporate research websites were also contacted, for a total of 1078 surveys distributed. Respondents were not offered any reward.

122. Two are academics with doctoral degrees in anthropology and political science, respectively. The third has a bachelor's degree in business, works in industry, and claimed to have read approximately 500 patents over the past year, mostly to gain "competitive intelligence" about other companies.

123. The data is available online. *See Legal Writing and Research*, LISA LARRIMORE OUELLETTE, http://pages.physics.cornell.edu/~larrimore/web/Law.html (last visited May 3, 2012).

124. Basic research focuses on fundamental principles, whereas applied research focuses on specific applications. Both experimental and theoretical research can be either basic or applied, although no respondents characterized their work as both theoretical and applied.

researchers[125]), one always needs to be concerned that the respondent sample might not be representative of the larger population. To look for response bias, Table 2 compares the 211 respondents with a random sub-sample of one hundred researchers out of the 1078 researchers contacted.[126] The only statistically significant difference between the respondents and the random sample is in the number of peer-reviewed papers published in the past two years: the survey respondents do not include the scientists who get their names on the highest number of papers. This discrepancy may be because those scientists are both very busy managing their large laboratories and are more likely to be writing in multiple fields (and thus less likely to be interested in a survey pitched to nanotechnology researchers).[127] There is no significant correlation between the number of published papers and whether a researcher reads patents, wants patents, thinks patents are useful, or thinks patents are enabled, so this bias should not affect the other results reported in this Part. But it is worth noting that the respondents are not perfectly representative in this aspect.

---

125. *See* AM. ASS'N FOR THE ADVANCEMENT OF SCI., INTERNATIONAL INTELLECTUAL PROPERTY EXPERIENCES: A REPORT OF FOUR COUNTRIES 7–8 (2007), http://sippi.aaas.org/Pubs/SIPPI_Four_Country_Report.pdf (reporting response rates of 19% from Japanese scientists and approximately 16% from U.K. scientists for a web-based survey); STEPHEN A. HANSEN ET AL., AM. ASS'N FOR THE ADVANCEMENT OF SCI., INTELLECTUAL PROPERTY EXPERIENCES IN THE UNITED STATES SCIENTIFIC COMMUNITY 59 (2007), http://sippi.aaas.org/Pubs/SIPPI_US_IP_Survey.pdf (reporting a response rate of 27% from U.S. scientists for the same web-based survey); Zhen Lei, Rakhi Juneja & Brian D. Wright, *Patents Versus Patenting: Implications of Intellectual Property Protection for Biological Research*, 27 NATURE BIOTECHNOLOGY 36, 36 (2009) (reporting a response of 25% to a postal mail survey of agricultural biology faculty); John P. Walsh, Wesley M. Cohen & Charlene Cho, *Where Excludability Matters: Material Versus Intellectual Property in Academic Biomedical Research*, 36 RES. POL'Y 1184, 1186 (2007) (reporting response rates of 40% and 34% for two samples of academic biomedical researchers who were sent a postal mail survey).

126. The current affiliation and gender of each researcher were determined through a web search. The number of papers that a researcher published during the previous two years was determined by searching for last name and first initial in ISI Web of Knowledge; affiliation was used to narrow the results for common names. *See* ISI WEB OF KNOWLEDGE, *supra* note 121. The number of patents that a researcher submitted in the past two years could not be directly compared because patents are not published until eighteen months after submission, so the number of patents that a researcher published in the past two years was used instead. This was determined by searching the USPTO patent application database for full names; state or country was used to narrow the results for common names. *See Patent Application Full Text and Image Database*, U.S. PAT. & TRADEMARK OFF., http://appft.uspto.gov/netahtml/PTO/search-adv.html (last visited May 3, 2012). For use of a similar method to measure response bias in a patent survey of biomedical researchers, see Walsh et al., *supra* note 125, at 1186 n.6, 1201 tbl.A1.

127. The most prolific scientist in my random sub-sample was Klaus Müllen, a director of the Max Planck Institute for Polymer Research. Because his name goes on almost every paper from his over-eighty-person laboratory, he had 154 publications in 2009 and 2010. *See Publications of AK Müllen*, MAX PLANCK INST. FOR POLYMER RES., http://www.mpip-mainz.mpg.de/groups/muellen/Publications (last updated Jan. 10, 2012). Only a few of those publications focus on traditional nanotechnology subfields; Dr. Müllen is more likely to consider himself a synthetic chemist than a nanotechnology researcher.

On average, respondents have published fourteen papers and submitted two U.S. patents in the past two years. The first two columns of Table 5 contain regression coefficients, which illustrate how the number of papers and patents vary across different types of respondents.[128] Coefficients that are statistically significant at least at the ten percent level show that industry researchers and women tend to have fewer published papers, while older researchers and those outside the United States tend to have more.[129] The second column shows that basic researchers and those outside the United States tend to have fewer patents, while industry researchers, experimentalists, and older researchers tend to have more.

Table 1 also shows that although 86 respondents (41%) have not had a patent submitted on their behalf in the past two years, almost all respondents (92%) indicated that if they discover patentable inventions in the future, they would like to have patents on them. The third column of Table 5 illustrates that basic researchers and physicists are less likely to want patents, while older researchers are more likely to want patents.[130]

Finally, Table 1 shows that 135 respondents (64%) have read at least part of a patent (other than their own) for a research purpose,[131] and the fourth regression in Table 5 shows that reading patents is less common among basic researchers and more common among industry researchers, experimentalists, and chemists. Respondents were directed to separate follow-up questions based on whether they have or have not previously read patents.

---

128. Regressions allow you to see how different variables are correlated, controlling for other variables. For example, the first coefficient in Table 5 is negative (-0.34), which means that industrial researchers tend to have fewer papers than the average respondent. This coefficient also has one asterisk, which indicates that it is statistically significant at the ten percent level: there is only a ten percent chance that there is *not* a negative correlation between working in industry and the number of papers published. For an overview of regressions, statistical significance, and other basic statistical tools written for federal judges, see generally David H. Kaye & David A. Freedman, *Reference Guide on Statistics*, *in* FED. JUDICIAL CTR., REFERENCE MANUAL ON SCIENTIFIC EVIDENCE 83 (2d ed. 2000). The coefficients in the first two columns of Table 5 are based on quasi-maximum likelihood Poisson regressions because the dependent variables (the number of papers and patents) are nonnegative count variables.

129. "Older" does not refer to the biological age of respondents but is shorthand for respondents who completed their PhDs or other highest degree longer ago. Age and date of degree are highly correlated, but the survey collected time since PhD to measure more accurately what stage respondents were at in their professional careers.

130. The coefficients in the last four columns of Table 5 are based on logistic regressions because the dependent variables are dummy variables. Linear regressions produce very similar results.

131. I did not ask whether these were granted patents or patent applications because the scientists I consulted about my survey design claimed they do not typically know which they are reading.

B. Why Do Scientists Read Patents (or Not)?

1. Reasons Researchers Avoid Patents

The minority (36%) of researchers who have *not* read a patent was asked why, and Table 3 summarizes these responses. The most common response, checked by 86% of these patent-avoiding researchers, was "I do not think patents contain information that would be useful to me." A significant number (29%) also indicated that they do not know how to find relevant patents. Of the seventeen respondents (22%) who gave other reasons, five complained about "unreadable" or "obscurified" language in patents, five expressed skepticism about the "quality of science" in them, and two suggested that patents are duplicative of journal publications, which are "more informative."

The patent-avoiding researchers were also asked to explain which of their reasons for not reading patents is the most significant. Some responses indicated that the respondents had at least seen patents in the past; other respondents just gave their general impressions, which may reflect scientists' stereotypes of patents — one researcher candidly admitted, "I have not looked into any of these assumptions . . . and could be entirely incorrect." Six concerns about patents emerged from the responses, with respondents arguing that patents are (1) confusingly written; (2) unreliable; (3) duplicative of journal articles; (4) out of date; (5) difficult to find; and (6) in conflict with the open culture of science. These concerns are elaborated below.

First, the largest number of complaints involved the style in which patents are written — patents were called "vague," "legal jargon," "incomprehensible," and lacking "technical detail." A number of respondents expressed sentiments similar to this industry researcher:

> Patents contain too little useful information compared with the time it would take to extract it. They are written by people who are not interested in sharing, and they are not designed to be useful for other researchers. There may be many pages of boilerplate hiding the useful parts . . . . Another problem is the legal language used to write patents. As far as I can tell the main purpose of having this special language is to ensure that lawyers are needed to generate it.

Second, some respondents viewed patents as unreliable because of the lack of peer review. One nonprofit researcher wrote that "[p]atenting is not as scientifically rigorous as peer-reviewed papers," and a government researcher called patents "garbage" and said they "provide no guidance of what really has been or what really could be done." An academic from materials science wrote: "I have read patents describing results in my area that I know to be completely wrong, that don't cite the literature appropriately and that make little effort to be rigorous. This makes me pretty nervous about other patents where I am less expert in the results."

Third, some respondents thought that even if there is useful information in patents, it is duplicative of the scientific literature. For example, an academic physicist wrote, "Since the number of citations of patents in academic journals is vanishingly small it is evident that there is not information in them relevant to academic research that is not available elsewhere."[132]

Fourth, the timeliness of information in patents was also a concern for a number of respondents. Patents were described as "out of date," "behind the state of art technology," and "released too late for cutting edge research." An academic in electrical engineering wrote that "patents become public so long after the idea is conceived [that] the information in them is no longer really that important scientifically by the time they come out." Another electrical engineer working at a nonprofit said that patents will only be "relevant for research" when they are as "timely" as publications.

Fifth, some respondents said that patents are hard to find, with comments that patents are "not indexed by the scientific databases" or that the researcher "wouldn't know where to find patents." One academic biomedical researcher wrote that "[w]hile [G]oogle brings up patents, it is really hard to find the whole patent," and an academic physicist suggested that "[i]f patents were searchable by ISI along with journals, it might be worth taking a look." A physicist working in a government laboratory wrote: "If patent information was as easy to access as the scientific literature, and searching it were possible with something equivalent to [ISI] Web of Science, I would certainly read patents relevant to my work."

Sixth, and finally, some respondents questioned the role of patents in the open scientific culture, suggesting that "a strong focus on a patenting culture in academia can impede, rather than enhance, innovation." One foreign academic said that patents do not fit with his "naive and idealistic way of sharing science." A government physicist working in computation said that the "intellectual leaders" in his field "most frequently disseminate information in 'open source' format." Another physicist wrote: "As a publicly funded academic, a key part of my 'social contract' . . . is to make results from my research publicly available." A third physicist summarized the problem as follows: "In my opinion patents are generally a hindrance to our research as

132. For more concrete details about the citation of patents by scientific papers, see *infra* notes 269–271 and accompanying text.

they motivate researchers to withhold publication of potentially important results until legal protection is achieved. This is largely counter to the spirit of academic research as it favors secrecy over sharing of information."[133]

The patent-avoiding respondents were also asked if they thought reading a patent later in their careers might be useful, and 47% said "yes." Many respondents indicated that they would read patents for legal reasons, such as to see if their research is patentable. But others said they would look to the technical content of patents to learn about research "that was patented and not published as a research paper" or if they switched research directions to "an area in which patents would be relevant." A number of respondents also indicated that they would read patents for their technical content if changes were made, such as "[i]f it was easier to search for patents' scientific content." One theorist said he would read a patent if it were peer-reviewed and if the "findings [were] presented in a standard scientific format" that was "straightforward" and "easy to read."

2. Reasons Researchers Read Patents

Table 4 summarizes the responses from the 135 researchers who indicated that they *have* read a patent.[134] These researchers were asked to check all of the ways in which they have found a patent. The most common methods were searching the USPTO website (60% of those who read patents)[135] and searching using Google Patents (45%),[136] but many researchers also received patents from someone in a legal department (38%), from other researchers (33%), or from citations (27%).[137] And 29% of researchers stumbled upon a patent during another search, which often happens now that Google displays patent results for many searches.[138] Only 8% of patent readers found patents

---

133. Convincing these respondents to turn to the patent literature for technical information would probably require more than better disclosure rules — it would require a fundamental change in the way academic research is patented.

134. The survey did not ask how often respondents read patents, or how many patents they read compared with papers, which would be interesting directions for future work.

135. *USPTO Patent Full-Text and Image Database*, *supra* note 126.

136. Google introduced patent searches in December 2006. *See* Dennis Crouch, *Search Patents via Google*, PATENTLY-O (Dec. 14, 2006, 10:13 PM), http://www.patentlyo.com/patent/2006/12/search_patents_.html (describing *Google Patents*, GOOGLE, http://www.google.com/patents (last visited May 3, 2012)).

137. The survey did not ask respondents to specify the type of publication in which they found the citation (they simply checked "I found a citation to it in a paper or publication"), but given the relatively low number of citations to patents in technical publications, *see infra* notes 269–271 and accompanying text, many were probably citations from other patents.

138. Patent results are also displayed when a researcher looks for scientific literature using Google Scholar, and after searching for a topic, the "Create email alert" link can be used to get e-mail updates about new patents or papers. *See Google Scholar*, GOOGLE, http://scholar.google.com (last visited May 3, 2012).

using a different method; responses included the World Intellectual Property Organization's patent search,[139] Espacenet (the European Patent Office ("EPO") patent search database),[140] PATSTAT (an EPO statistical database of patents),[141] the Derwent Innovations Index (part of the ISI Web of Knowledge platform),[142] and the Chemical Abstracts Service.[143]

The respondents were also asked the reasons for which they have read a patent. The most common reason, indicated by 62% of respondents who have read a patent, was to determine whether their research was patentable. But a combined 70% of patent-reading respondents (45% of the entire sample) indicated that they have looked to patents for technical information: 40% wanted to see how other researchers solved a particular technical problem, 44% wanted to research a general scientific topic, and 16% wanted to browse information about cutting-edge technologies.[144] The following two Parts examine whether these respondents actually found useful technical information in the patents they read and whether they considered the patents to be enabled.

C. Do Patents Contain Useful Technical Information?

Sixty percent of respondents who looked to patents for technical information indicated that they found useful information there.[145] The researchers were not asked to name the specific patents they looked at, but given the diversity of their research fields, it is highly unlikely that they were reading the same few patents. The regression in the fifth column of Table 5 shows that older respondents were more likely to find patents useful (perhaps because they are more likely to have had their own patents); none of the other variables were statistically significant.

---

139. *Patentscope*, WORLD INTELL. PROP. ORG., http://www.wipo.int/pctdb/en (last visited May 3, 2012).

140. *Espacenet*, EUR. PAT. OFF., http://worldwide.espacenet.com (last visited May 3, 2012).

141. *EPO Worldwide Patent Statistical Database*, EUR. PAT. OFF., http://www.epo.org/patents/patent-information/raw-data/test/product-14-24.html (last visited May 3, 2012).

142. A link for registered customers to access the database is available at *Derwent Innovations Index*, THOMSON REUTERS, http://thomsonreuters.com/products_services/legal/legal_products/a-z/derwent_innovations_index (last visited May 3, 2012).

143. Chemical Abstracts Service is a division of the American Chemical Society, and it "covers patents from around the world." *CAS Coverage of Patents*, CHEMICAL ABSTRACTS SERVICE, http://www.cas.org/expertise/cascontent/caplus/patcoverage/index.html (last updated Dec. 7, 2011).

144. The individual percentages add up to more than 70% because some researchers selected more than one of these options.

145. Patent-reading respondents were asked: "If you have read a patent to gain scientific knowledge (either applied to a particular problem or regarding a general research topic), did you find useful information there?" Sixty-four respondents said yes; forty-three said no.

When asked to elaborate, the respondents who had found useful information primarily cited "useful technical detail" like "clever descriptions and useful recipes." For example, one academic physicist wrote: "I will sometimes look at patents to see how a particular device works. Almost always some piece of lab equipment."[146] A chemist who works in an academic laboratory and for a startup wrote: "'Useful' doesn't mean 'insightful' or 'detailed' but it certainly was useful. The data helped put the ideas and research in context and offered some plausible views as to what we were seeing in our own research." Another chemist, who works in industry, explained: "Patents are a useful source of information on how others have approached particular technical problems and can also help [keep] you from going down a road that has already been traveled."

Some respondents found information in patents that was unavailable in scientific journal articles. For example, an academic in electrical engineering wrote: "Practice details appear in patents by industry which do not get publish[ed] in the usual scientific literature." Another academic expressed the same sentiment: "A paper may contain less details about implementation than a patent in many cases . . . . So if I wanted to see how someone solved a technical issue, I would go through the patent." An academic chemist specified that "protocols or 'recipes' for preparing samples or performing experiments are described that are not found in other published literature." An industry researcher speculated about why this might be true:

> Usually the way a new technology is described is much more reliable and reproducible in a patent than in a scientific paper. Unfortunately many academic researchers purposely remove essential steps for reproducing data, for fear other researchers will catch up with them and publish first. In patents, on the other hand, there are more stringent requirements about reduction to practice, so I trust patents more when I need to try other people's technologies.

A less rosy picture of the value of patents as technical sources was painted by the 40% of researchers who said they did not find useful technical information in patents. These respondents echoed the first four of the six general complaints about patents described in Part III.B: patents are (1) confusingly written ("the language of patents is

146. Note that it is not possible to tell whether the "lab equipment" was the patented invention itself or simply ancillary equipment that is related to the invention. In either case, the patent is providing useful technical information, and the proposals in Part V (like peer review or an obligation to respond to questions about reproducibility) likely would improve the quality of both types of disclosures, as clear information about ancillary equipment would improve reproducibility. I thank Jeanne Fromer for this point.

obscure"); (2) unreliable (patents do not "go through the same level of critical review that scientific articles face"); (3) duplicative of journal articles ("[t]here was no information in the patent that had not already appeared in the scientific literature"); and (4) out of date ("[t]he long time delay between filing an invention disclosure and the public issuance of a patent seems to make it very unlikely that patents will regularly be a useful source of research information in a field as rapidly moving as nanotechnology"). One academic chemist wrote: "[P]atents are often written to prevent people [from] being able to follow the scientific procedure. To a scientist the patent literature looks like an invention of lawyers for the benefit of other patent lawyers."

D. Are Patents Reproducible?

Although 60% of researchers who look for technical information find some useful information, only 38% of patent-reading researchers responded "yes" to a question about whether patents are reproducible: "Were the patents you read worded in such a way that you or another nanotech researcher could recreate the invention without additional information?"[147] And the percentage who think *all* the patents they read are reproducible is even lower because many researchers who said "yes" then qualified their answer with "sometimes" when asked to explain. The regression in the last column in Table 5 shows that while most of the variables do not have a statistically significant effect, industry researchers are more likely to think patents are reproducible, and that chemists are less likely to believe so.

Of the researchers who responded "yes" and then provided additional comments, none were enthusiastic about the ease of reproducing inventions. The most positive comments stated that reproduction is possible once the patent reader gets past the language: one respondent said that "[o]ften patents are impenetrable, but often the front matter (not the claims) give enough details that one can understand the method," and another wrote that "[i]t is possible, but it required efforts to understand [the] language" and that it "gets easier with time." An academic in mechanical engineering qualified his "yes" as follows:

---

147. As noted previously, some of these "patents" may have been patent applications. *See supra* note 131 and accompanying text. But based on data from 1981–2005, 77% to 95% of these specifications will end up in granted patents (when you include continuing applications, which must use the same specification to maintain the earlier priority date). *See* Cecil D. Quillen, Jr. & Ogden H. Webster, *Continuing Patent Applications and Performance of the U.S. Patent and Trademark Office — Updated*, 15 FED. CIR. B.J. 635, 661 (2006). There is no reason to think that respondents were selectively reading patent applications that would be rejected for insufficient disclosure, so this does not affect my conclusion that this result raises serious questions about whether the disclosure requirements are being met for nanotechnology patents.

> But it made you want to pull your teeth. The language is almost purposely abstruse. The figure and figure captions seem to be from a different era. The format of the patents is deplorable — for instance, figures are given early on and the description is usually 10 pages away. Even technical publications from [the] 1800s (an[d] I have read a few) are easier to read! But with difficulty, you can understand most of the patent.

Others indicated that they could only hypothesize about reproducibility: an academic physicist said that she "never actually tried to reproduce" but that she "for the most part . . . found all the critical aspects explained," and a different academic physicist responded: "Never tried to recreate a highly technical [patent]. Most are, once disclosed, technologically obvious."

A few researchers had a particularly skeptical "yes," with comments that a patent is "more vague than a scientific paper" and that "at times the patents required proprietary materials that were not available or clearly left out stages that needed to be re-created." One industry physicist said patents are "mostly" reproducible, but "many nanotechnology patents have not been reduced to practice," and these patents "just try to claim some param[e]ter space on the hopes that some future work will get covered."

Those researchers who responded "no" to the reproducibility question leveled harsher criticisms of patents. Two respondents wrote that "the devil is in the details," which most respondents believe are missing from the patents. One complained that patents "do not contain the subtle tricks and procedures that enable the invention to be reproduced," and another wrote: "We have tried to reproduce the odd result in a patent, but often additional details are needed that have been left out (on purpose)."[148]

A number of respondents echoed this concern that details were deliberately omitted by the patentees, with comments that patents are "worded to confuse rather than to educate" and are "very vague — deliberately so (?) — in detail." Reproducibility is not identical to the legal enablement requirement, but some respondents seemed to believe that patents need not be reproducible by a PHOSITA without "undue experimentation."[149] An academic physicist who owns a spin-off company wrote that reproducibility "is not a requirement," and an academic chemist wrote: "Patents are designed not to enable other researchers to reproduce them. That would be self-defeating as far as I

148. As discussed earlier, other respondents noted a similar problem with scientists leaving details out of published papers. *See supra* Part III.C.

149. *See supra* Part II.A.

can tell. The goal is to protect an idea . . . . A key aspect of this is obfuscation." Another academic chemist expressed a similar sentiment: "Patents are written by attorneys, not scientists. Their purpose is to protect their legal rights, not to educate the reader or facilitate recreation of the experiment."

Finally, in addition to believing that the language of patents obfuscates the invention, some researchers worry that some patents are not reproducible because the patentee never possessed the invention in the first place. For example, an industrial chemist thought that "it was not clear if the inventors ever actually made the invention and saw that it worked as claimed." An academic chemist had the same concern: "[T]here is insufficient reduction to practice. I think every inventor should be obliged to present a working invention before a patent is granted." An academic studying nanomechanics had witnessed the problems this has caused:

> [L]azy people sit in their office and say "we should do this" and the next minute they write a stupid invention disclosure and submit it, which an attorney (rightly) decides would help generate revenue in some form . . . . [T]he problem is such people rarely complete these projects . . . [and] someone who has the same idea will . . . find this patent application and assume it's been done before. I have seen personally many such great ideas not being pursued because of this. I firmly believe that any patent *SHOULD* have a demonstrability clause.

In conclusion, although many nanotechnology researchers have found useful technical details in patents (30% of all respondents and 60% of those who have tried to find information in the patent literature), the majority of them believe that patents do not enable a skilled researcher to reproduce the invention.

E. Do Researchers Worry About Willful Infringement?

The final issue the survey probed was whether researchers avoid reading patents because of concerns about willful infringement, as suggested by a number of legal commentators.[150] The survey shows that among nanotechnology researchers, this is at most an extremely minor concern compared with other reasons for not reading patents. In this aspect, however, nanotechnology researchers are not representative of researchers in general, as many of them probably do not have

150. *See supra* note 71 and accompanying text.

products on the market. It would be interesting to repeat this survey among industrial researchers in more applied scientific fields.

Nanotechnology researchers who indicated in the survey that they have not read a patent were given the option to select "I am worried about negative legal effects of looking at patents" as one possible reason, and only two out of seventy-six respondents (3%) checked this option. Based on their follow-up remarks, it seems unlikely that they were thinking of willful infringement — they seem more concerned about the negative effects of patents on science. The first respondent was a mechanical engineer working in a government laboratory who said he would only read a patent if he "was chained to a chair and water dripped on [his] head." He called patents "stifling to research" and wrote a long diatribe against university patenting. The second respondent was an academic in electrical engineering who criticized the granting of "theoretical patents" because "it is incredibly short-sighted to think that what you expect to happen in the lab is actually going to happen." Researchers were not specifically asked about whether they believe that there is an experimental use exemption to patent infringement, but one respondent commented that he is "only glad that patents cannot be applied to restrict the freedom of academic scientific research."[151]

Researchers who have read patents were specifically asked if they "worry that reading patents could have negative legal effects." Only six out of 134 patent-reading researchers (4%) said "yes," and only three of the six expressed concern about liability for infringement (for example, one researcher said he was concerned "only since you asked this question").[152] An industry chemist said that under his company's policy, "the only time we actually read a patent is if it has been given to us by an attorney to answer a specific question." An industry physicist was concerned about infringement, though misinformed about patent liability for independent creation, writing "if you reinvent . . . without knowledge of the patent then you may not be held accountable for infringement." The most detailed understanding was demonstrated by an academic physicist: "[I]f I can reinvent something on my own, it demonstrates that it is obvious to one skilled in the art, and I could avoid triple damages for knowing infringement." These three respondents (under 2% of the entire sample) are the only ones who might be characterized as avoiding patents because of infringement concerns (willful or otherwise).

---

151. *But see* Lei et al., *supra* note 125, at 37 (2009) (finding that over 80% of eighty-five U.S. agricultural biology faculty disagreed with a statement that academic researchers have a research exemption).

152. The small number of positive responses to this question is even more striking when one considers the potentially leading nature of my survey question.

The majority of patent readers who responded that they did not worry about the negative legal effects of reading patents expressed confusion about the survey question. One academic physicist's response was representative: "Surely I have the right to read patents once they've been issued. It is difficult for me to see how that could have a negative legal effect upon anyone." Only one respondent who said "no" demonstrated some knowledge about willful infringement, but he was excluded from the statistics presented here because he is not a scientist — he has a business degree and works in industry.[153] He wrote: "I do know about the 'dance' of intentionally avoiding patents so as to genuinely not have prior knowledge, but I find in nearly all cases that NOT reading patents would have greater negative [legal] effects than reading them."

IV. NANOTECHNOLOGY PATENT CASE STUDIES

The survey results described in the previous Part show that many nanotechnology researchers do find patents to be a useful source of technical information — though many also have concerns that patents are not reproducible and think that the value of patent disclosures could be improved.

In this Part, specific nanotechnology patents (and pending patent applications) are examined in more detail. The patents chosen were the most relevant to the reviewer's expertise, and I have no reason to believe that they are more or less useful than an average nanotechnology patent. This Part is not a comprehensive or quantitative survey; rather, the aim is to briefly give concrete examples of the kinds of technical information that researchers find in patents that are not present in scientific papers, as well as ways in which patents could be improved.

A. Carbon Nanotube Resonators

Carbon nanotubes are tiny rolled-up sheets of graphene (like in a pencil) with a diameter of about a nanometer.[154] One of the many applications of nanotubes is their use in nanoelectromechanical systems (NEMS), which have the potential for measuring tiny masses, processing radio signals, and exploring quantum phenomena.[155] The first self-detecting nanotube resonator was created by Vera Sazonova and

153. *See supra* note 122 and accompanying text.

154. *See* Lisa Larrimore, *Ask a Scientist! Formation of Carbon Nanotubes Requires Heat, Carbon, Catalyst*, CORNELL CENTER FOR MATERIALS RES. (July 1, 2004), http://www.ccmr.cornell.edu/education/ask/?quid=801 (providing an explanation for non-specialists of what carbon nanotubes are and how they are formed).

155. Vera Sazonova et al., *A Tunable Carbon Nanotube Electromechanical Oscillator*, 431 NATURE 284, 284 (2004).

colleagues and reported in the journal *Nature*.[156] Dr. Sazonova agreed to review four nanotube resonator patents for this Article; I selected these patents based on their relevance to her research and explained the basic requirements of patentability.

Overall, Dr. Sazonova was surprised to learn that it is possible to patent "something that *CAN* be envisioned, given all the technologies of the day (kind of a Gedankenexperiment)," rather than "a particular invention that has been implemented and shown to work." Her comments illustrate the problems with the constructive reduction to practice doctrine, as discussed in Part II.A. She was also "surprised about the scope of the claims . . . since depending [on] how you read them they cover almost any NEMS," which seemed "absurd" to her. Still, she was pleasantly "surprised [by] how easy it was to read the patents," and she picked up some useful information by reading them.

The first patent Dr. Sazonova examined, for a tunable nanotube resonator, is assigned to the California Institute of Technology and has a priority date of 2001 (three years before her *Nature* paper).[157] She thought it was the least informative of the four patents she read. When I asked whether it would have been useful to read this patent in 2001, when she was at the early stages of her research project, she wrote:

> I think it would have been useful to read it, at least to know that we were not alone [in] thinking of building a NT resonator that way. Would it have been useful technically? Not really, he's not describing anything new, all the parts existed in [the] literature already. And he is not giving any solutions to any problems we have encountered on the way.

The fabricated devices proposed in the patent "were very similar" to her own, but she felt that the inventors did not anticipate many problems with measuring the resonators.[158] But for a nanotube expert who wanted to build a nanotube resonator, she thought this patent "is a good place to start, just as good as reading some papers on NEMS."

---

156. *Id.*

157. *See* U.S. Patent No. 6,803,840 (filed Apr. 1, 2002) (claiming priority to provisional applications filed on Mar. 30, 2001).

158. In particular, she said that the patent proposes "to use charge injection to modulate the length," but "that effect will be much smaller than the electrostatic attraction that would be present anyway, something that [the patentees] didn't anticipate." The patent also does not consider: (1) how to prevent "capacitive coupling between electrodes 18 and 28," (2) how to separate "tension induced with the charge injection" from "tension due to the attractive force between the resonating member and the electrode 28," (3) how "the RF signal [will] be read out of a high-impedance resonating member[] without [an] integrated amplifier," or (4) "[w]hat kind of contact resistances are produced with this fabrication method . . . and how will they affect the charge injection."

The second patent Dr. Sazonova reviewed, claiming a NEMS transistor very similar to her own device, was filed in 2005 by an industrial researcher.[159] She wrote: "[I]t is surprising that [the inventor] doesn't [c]ite our paper since his second embodiment, the resonating transistor channel, is identical to ours minus the readout scheme." Like the first patent, she found it "purely speculative," with "absolutely no details on how to implement the invention."[160] But she did think certain technical aspects were useful, and she said that a particular calculation was one of the first of its kind.[161]

The third and fourth patent documents Dr. Sazonova reviewed were patent applications that had not yet been granted; both came from the lab of Alex Zettl, a physics professor at the University of California, Berkeley. The third patent, which has a priority date in 2005, describes a telescoping nanotube resonator, in which one nanotube slides inside another "[l]ike a trombone player shifting notes."[162] Dr. Sazonova liked that "[t]his invention has been implemented and the result is present," and she thought the analysis was "[v]ery interesting." This patent application was thus more useful than the first two patents, but it is also duplicative of the technical literature: most of it is directly copied from two of Zettl's papers,[163] with the fabrication details for both the patent and those two papers coming from three earlier papers.[164]

The fourth patent document was a patent application for a high-frequency nanotube resonator, which has a priority date in 2006.[165]

---

159. *See* U.S. Patent No. 7,579,618 (filed Mar. 2, 2005).

160. In particular, it does not specify the "choice of materials compatible with [nanotube] growth," the "necessary read-out and actuation electronics," or "how . . . the electrical impedance problem [is] resolved." Dr. Sazonova also did not think it was clear why there is "a time-varying electric field in a [nanotube] due to mechanical vibrations" — "if it is capacitively induced, then why will the signal be much larger than the parasitic signal?"

161. For specialists, Dr. Sazonova liked the "calculation of the charge injection vs. electrostatic force" and the fact that the patent acknowledged "the importance of read-out electronics due to high motional impedance." She also "found the discussion about the dynamic resistance of the [nanotube] resonator" very useful, saying that "this calculation is one of the firsts."

162. U.S. Patent Application No. 11/467,422, at [0042] (filed Aug. 25, 2006) (claiming priority to a provisional application filed on Aug. 25, 2005). This application has been granted as U.S. Patent No. 7,915,973 (filed Aug. 25, 2006).

163. *See* K. Jensen et al., *Tunable Nanoresonator*, 786 AIP CONF. PROC. 607 (2005); K. Jensen et al., *Tunable Nanoresonators Constructed from Telescoping Nanotubes*, 96 PHYSICAL REV. LETTERS 215503-1 (2006).

164. *See* John Cumings et al., *Peeling and Sharpening Multiwall Nanotubes*, 406 NATURE 586 (2000); John Cumings & A. Zettl, *Localization and Nonlinear Resistance in Telescopically Extended Nanotubes*, 93 PHYSICAL REV. LETTERS 086801-1 (2004); John Cumings & A. Zettl, *Low-Friction Nanoscale Linear Bearing Realized from Multiwall Carbon Nanotubes*, 289 SCIENCE 602 (2000).

165. U.S. Patent Application No. 12/446,231 (filed Oct. 19, 2007). Note that while this patent application claims priority to a provisional application filed on October 19, 2006, it was not published until August 26, 2010. *Id.*

Although this application also stemmed from a Zettl group paper,[166] Dr. Sazonova believed that it provided information that was nonduplicative of the paper:

> [T]his patent is not a direct copy of the paper, rather it's a[n] elongated version of the paper . . . . The patent gives alternative routes [of fabrication] and gives a list of other materials that could be used in a similar recipe . . . . The actuation/detection method is elaborated on . . . [a]nd there is an additional discussion on the origins of dissipation.

Not only did this patent application contain details that were not in the technical literature, but Dr. Sazonova also believed that it "is the only patent that provides enough information for those skilled in [the] art to reproduce their invention" out of the four patents and patent applications that she reviewed.

B. Carbon Nanotube Sensors

In addition to having amazing mechanical properties for use as resonators, carbon nanotubes also have remarkable electronic properties: some nanotubes are metallic (so that they conduct electricity as tiny wires), while others are semiconducting (so that the current through them is sensitive to their external environment).[167] Coupled with their small size (comparable to a DNA molecule) and ability to operate both in air and under water, nanotube sensors are promising for detecting a variety of chemical and biological molecules.[168] This Part describes my own thoughts on the technical content of some carbon nanotube sensor patents.[169]

The first nanotube sensing results were published by Jing Kong and colleagues in Hongjie Dai's Stanford laboratory; they discovered that the current through a nanotube transistor changes upon exposure

166. *See* H.B. Peng et al., *Ultrahigh Frequency Nanotube Resonators*, 97 PHYSICAL REV. LETTERS 087203-1 (2006).

167. *See* Paul L. McEuen, *Single-Wall Carbon Nanotubes*, PHYSICS WORLD, June 2000, at 31 (summarizing the electronic properties of carbon nanotubes).

168. For an overview of nanotube sensors for non-specialists, see *Probing Biological Systems with Carbon Nanotubes*, NANOBIOTECHNOLOGY NEWS, Mar. 2007, at 1, *available at* http://www.nbtc.cornell.edu/pdf%20files/newsletter%20March07.pdf.

169. For my Physics PhD, I fabricated many carbon nanotube devices for chemical and biological sensing, and I conducted a thorough literature review of other work in the field. *See* Lisa Larrimore Ouellette, Chemical and Biological Sensing with Carbon Nanotubes in Solution (Jan. 2008) (unpublished PhD dissertation, Cornell University), *available at* http://www.lassp.cornell.edu/lassp_data/mceuen/homepage/Publications/Thesis_Larrimore.pdf.

to gaseous nitrogen dioxide or ammonia.[170] Kong and Dai also filed a provisional patent application on their nanotube sensor invention in December 1999, which has grown into a family of at least three patents.[171] For the most part, all the technical details in the paper are also in the patents, and the patents contain some information that is only available through references in the paper. For example, the paper says that nanotubes were grown "from patterned catalyst islands" and cites to earlier works for the details,[172] while the initial patent provides the details of the catalyst recipe and specifies that for this experiment the catalyst islands "are typically 5 microns in size, spaced at a distance of 10 microns apart."[173] The patent also offers some additional suggestions to the fabrication steps in the paper, such as making the electrodes out of titanium and gold.[174]

As might be expected, the patent literature becomes less duplicative when describing industry research. Many of the early nanotube sensing experiments were performed by the company Nanomix, Inc.[175] For some results — including DNA hybridization,[176] protein binding,[177] and starch degradation[178] — Nanomix published in the scientific literature in addition to seeking patent protection. These patents are not simply duplicative of the scientific papers; for example, Dr. Ethan Minot, a physics professor with experience in nanotube biosensors,[179] noted that the DNA hybridization patent contains three detailed examples that are not given in the paper, which "give more thorough step-by-step instructions."[180] Even more significantly, the

170. *See* Jing Kong et al., *Nanotube Molecular Wires As Chemical Sensors*, 287 SCIENCE 622 (2000).

171. The initial nanotube sensor patent was U.S. Patent No. 6,528,020 (filed May 19, 2000). The '020 patent had at least two "child" patents. *See* U.S. Patent No. 7,166,325 (filed Nov. 18, 2002) (continuation-in-part of the '020 patent); U.S. Patent No. 7,416,699 (filed June 18, 2002) (divisional of the '020 patent). All of these patents have the same figures.

172. Kong et al., *supra* note 170, at 623.

173. '020 patent, *supra* note 171, col.3 l.54–55.

174. *See id.* col.4 l.32.

175. *See* Ouellette, *supra* note 169, at 57–61.

176. *See* U.S. Patent Application No. 11/212,026 (filed Aug. 24, 2005); Alexander Star et al., *Label-Free Detection of DNA Hybridization Using Carbon Nanotube Network Field-Effect Transistors*, 103 PROC. OF THE NAT'L ACAD. OF SCI. 921 (2006).

177. *See* U.S. Patent Application No. 10/704,066 (filed Nov. 7, 2003); Alexander Star et al., *Electronic Detection of Specific Protein Binding Using Nanotube FET Devices*, 3 NANO LETTERS 459 (2003).

178. *See* U.S. Patent Application No. 11/259,414 (filed Oct. 25, 2005); Alexander Star et al., *Electronic Detection of the Enzymatic Degradation of Starch*, 6 ORGANIC LETTERS 2089 (2004).

179. *See Minot Research Group: Publications from OSU*, DEP'T PHYSICS OR. STATE U., http://www.physics.orst.edu/~minote/pubs.php (last visited May 3, 2012).

180. Although he was pleased with the technical content of the patent, he told me that he was skeptical of the broad claims: "[F]rom their limited set of three examples using [carbon nanotubes], the patent claims many things, [such as] using any 'nanostructure' to make such a sensor (claim 29). Also, they claim every functionalization chemistry they can think of (claims 36–50). Developing these functionalization schemes is a major challenge — they have only demonstrated a small subset, yet claim many."

Nanomix researchers filed patents on a number of inventions that are not disclosed in any of their scientific papers,[181] including instruments for sensing carbon dioxide,[182] hydrogen,[183] and other gases.[184] Each of these patents displays data from their sensors in addition to describing their experimental setup.

I also came across two other industry patents that contain data from working inventions: one from Molecular Nanosystems, Inc.,[185] and another from Nano-Proprietary, Inc.[186] Although I scoured the scientific literature for nanotube sensing results, I never found these results, or those from Nanomix's patents, even though all of them were published before I completed my dissertation. In other words, the patent contains useful information that is nonduplicative of the scientific literature, even though it does not contain all the details that a researcher might hope to find.

V. IMPLICATIONS FOR PATENT POLICY

The results from Parts III and IV suggest that patents can be useful as sources of technical information, but also that many patents may not be enabled and that disclosure could be improved. This Part highlights some recommendations for patent policy in three key areas.

Part V.A examines the costs and benefits of more robust disclosure and explains how existing disclosure requirements could be more stringently enforced. Part V.B examines potential legal barriers to using the technical information in patents, including the willful infringement doctrine, the narrow experimental use exemption, and the delay in publishing patent applications. Finally, Part V.C explores ways for third parties to improve access to the patent literature.

A. Strengthen Enforcement of Disclosure Requirements

The USPTO and the courts should greatly strengthen enforcement of existing disclosure requirements. The previous evidence presented in Part II.C and the new results presented in Parts III and IV demonstrate that many researchers (in my survey, thirty percent of all respondents and sixty percent of those who have tried to find information in the patent literature) are finding useful technical information in patents that is not available in the scientific literature. But most researchers feel that patents are not reproducible by an expert in

181. *See Publications*, NANOMIX, http://nano.com/news/archives/publications.html (last visited May 3, 2012).
182. *See* U.S. Patent No. 7,547,931 (filed Dec. 20, 2004).
183. *See* U.S. Patent Application No. 11/354,561 (filed Feb. 14, 2006).
184. *See* U.S. Patent Application No. 11/400,038 (filed Apr. 6, 2006).
185. U.S. Patent No. 7,052,588 (filed Nov. 26, 2003).
186. U.S. Patent No. 7,399,400 (filed Sept. 29, 2004).

the field — one even feels that patents are "designed not to ble"[187] — which raises serious questions about whether the enablement requirement is typically satisfied.

Challenging patents for insufficient disclosure will be easier under the new post-grant review proceedings created by the America Invents Act, which will be available for patents filed after March 16, 2013.[188] Previously, the only method of challenging the sufficiency of a patent's disclosure was as a defense in patent litigation, but under the new post-grant proceedings, third parties will be able to raise questions about insufficient disclosure for the first nine months after a patent issues.[189] Proceedings before the USPTO are much less expensive than patent litigation,[190] making post-grant review a more viable option for policing patent disclosures. Still, it is much more common to challenge a patent for anticipation or obviousness,[191] probably in large part because these issues are easier for judges to evaluate, and it is unclear that this will change under the new proceedings.

Many other suggestions have been made for improving the content of patent disclosures, including separating a patent into distinct legal and technical layers,[192] requiring source code for software patents,[193] requiring biotechnology patents to conform to database specifications (like for the Protein Data Bank),[194] creating rebuttable

187. *See supra* Part III.D.

188. Leahy-Smith America Invents Act, Pub. L. No. 112-29, sec. 6, §§ 311–329, 125 Stat. 284, 299 (2011).

189. 35 U.S.C. § 321(b)–(c) (2006), *amended by* America Invents Act, sec. 6(d), 125 Stat. at 306.

190. In 2011, the median cost of a large patent infringement case (one with over $25 million at risk) was $5 million per side, compared with $200,000 for inter partes reexamination through a Federal Circuit appeal. STEVEN M. AUVIL & DAVID A. DEVINE, AM. INTELLECTUAL PROP. LAW ASS'N, REPORT OF THE ECONOMIC SURVEY 2011, at 35–36 (2011).

191. *See* Lisa Larrimore Ouellette, *What Are the Sources of Patent Inflation? An Analysis of Federal Circuit Patentability Rulings*, 121 YALE L.J. ONLINE 347, 357 tbl.1 (2011), http://yalelawjournal.org/2011/12/27/ouellette.html (examining all 324 Federal Circuit patentability rulings from five different years and finding only 15 cases involving enablement, 32 involving written description, and 11 involving best mode, compared with 119 involving anticipation and 167 involving obviousness).

192. *See* Fromer, *supra* note 7, at 569. Fromer offers useful suggestions for constructing the technical layer, though her proposal that it should include dynamic three-dimensional models is probably ahead of its time because there is not currently a standard three-dimensional format and scientists are not used to obtaining information this way. *See id.* at 575.

193. *See* Michael J. Walsh, Comment, *The Disclosure Requirements of 35 U.S.C. § 112 and Software-Related Patent Applications: Debugging the System*, 18 CONN. L. REV. 855, 871 & n.87 (1986) (providing the first suggestion in the legal literature that the USPTO require source code for disclosure of software patents).

194. *See* Helen M. Berman & Rochelle C. Dreyfuss, *Reflections on the Science and Law of Structural Biology, Genomics, and Drug Development*, 53 UCLA L. REV. 871, 898–99 (2006).

presumptions in litigation,[195] and requiring actual reduction to practice[196] and the description of working examples.[197] These suggestions are generally sound, and the survey responses suggest other improvements, such as changing the "deplorable" practice where "figures are given early on and the description is usually 10 pages away."[198] But in this Part, I focus on two other proposals: peer review of patents (both public peer review and traditional peer review)[199] and the novel suggestion of imposing an obligation that patent applicants respond to good-faith questions about reproducibility.

Before addressing the specifics of how stronger enforcement could be accomplished, however, it is important to consider the potential costs of this proposal. Part V.A.1 examines the costs and benefits of stronger disclosure, and Part V.A.2 presents my proposals for improved disclosure.

1. Is Better Disclosure Worth the Cost?

As discussed previously, I agree with critics of disclosure theory that disclosure is not a compelling justification for the patent system, and I think focusing on this question leads to misleading conclusions about disclosure.[200] Rather, I think the relevant question is whether the marginal benefits of stronger disclosure outweigh the resulting marginal costs — and I believe the answer is "yes." These costs and benefits are difficult to quantify. The only commentator to address this tradeoff is Alan Devlin, who reached the opposite conclusion: "one can safely conclude that society is better off with a patent system that incentivizes invention and commercialization without requiring disclosure than with a system that dilutes ex ante incentives and reduces the incidence of invention by demanding as much disclosure as possible."[201] But his argument depends on his premise that the disclo-

195. Timothy Holbrook argues that "the Federal Circuit has removed considerations of the PHOSITA from assessing the sufficiency of patent disclosures," creating "incentives to reduce the technical aspect of the document in favor of creating a more legalistic text." Timothy R. Holbrook, *Patents, Presumptions, and Public Notice*, 86 IND. L.J. 779, 792 (2011). He also argues that a "presumption-based approach would require the courts to readily consider the technological evidence." *Id.* at 825. While I support this general project, I do not think the problem is that "the Federal Circuit has now incentivized vast overdisclosure." *Id.* at 806.

196. *See* Cotropia, *supra* note 42.

197. Seymore, *supra* note 7, at 641–46.

198. *See supra* Part III.D.

199. Jeanne Fromer also discusses the possibility of patent peer review. *See* Fromer, *supra* note 7, at 591–92.

200. *See supra* Part II.B.

201. Devlin, *supra* note 5, at 406.

sure function of patents is not currently working,[202] and he did not provide a quantitative cost-benefit analysis.[203]

My empirical results illustrate some underappreciated benefits of patent disclosures. Patents do disclose information that other researchers find useful, and this Part will address ways to make the information even more valuable. Key information about the invention itself is not always the most useful information in patents — patents can have many audiences and many unintended uses. Further improving the technical content of disclosures would also increase scientists' trust in, and respect for, the patent system. The benefits of strong disclosure are thus substantial.

Stronger disclosure might, however, incur three types of costs. First, disclosure takes time, and asking each inventor (or her patent agent) to rewrite details that are already clearly described in the literature would be inefficient. But the costs of using plainer language or providing a few additional key details about the invention are unlikely to be significant.

Second, if disclosure were strengthened to exclude non-enabling constructive reductions to practice from patentability, non-enabling disclosures would not be in the patent literature at all, even though they may still provide some useful information.[204] But if these patents are truly speculative ones that would require undue experimentation to implement, then it is inefficient to grant these patents and allow these patentees to tax future inventors.

Third, and most significantly, stronger disclosure requirements may weaken innovation incentives. Better disclosure may make it easier for competitors to build on and appropriate inventions, so more inventors might choose trade secret protection over patents or choose not to innovate at all. Similarly, if the disclosed information is valuable enough that someone would have independently paid for it (and, importantly, if the transaction costs are not too high), this will also decrease the patent rents.

These costs to innovation, however, are likely to be minimal. Here, the third critique of disclosure theory as a *justification* for the patent system — that only "self-disclosing" inventions will be patented[205] — cuts against the argument that stronger disclosure would hurt innovation. The inventions most likely to be patented are those that are relatively easy to reverse engineer (compared with their original

202. *See id.* at 403–04 (claiming that disclosure is "ineffective" because specifications are "inadequate" and "inventors simply ignore patents").

203. *See id.* at 419–21 (concluding that there is a tradeoff between disclosure and innovation, but providing no guidance for how to measure the costs or benefits).

204. The first two nanotube resonator patents examined by Vera Sazonova seem to be examples of non-enabling disclosures. *See supra* Part IV.A.

205. *See supra* notes 80–83 and accompanying text.

research cost),[206] and inventors have no other option to protect these inventions.[207] The costs are more difficult to measure for inventions that are easier to protect as trade secrets, but as Alan Devlin acknowledges, creators of these inventions still have many reasons — including risk-aversion — to turn to the patent system.[208]

More importantly, empirical evidence has questioned whether patents actually incentivize much innovation outside the pharmaceutical industry.[209] And stronger enforcement of disclosure requirements would be least likely to incentivize innovation in the drug industry, both because pharmaceutical inventions are relatively easy to imitate (so companies cannot turn to trade secret protection),[210] and because pharmaceutical patents are among the best-described patents.[211] Finally, even if stronger disclosure does weaken the strength of patent protection, this may actually be a benefit, given concerns about patent protection currently being *too* strong.[212]

Lingering concerns about the costs to innovation could be mitigated by a system in which inventors could opt into more stringent enforcement of the disclosure requirements. This would be similar to proposals for a more rigorous "gold-plated" review process that would allow patents to emerge with a higher presumption of validity.[213]

---

206. *See* Burk & Lemley, *supra* note 51, at 1585 (arguing that the "ratio of R&D cost to imitation cost" is a good measure for the importance of patent protection).

207. Devlin draws the confusing conclusion that "given the patent system's ultimate goal of incentivizing the creation and commercialization of valuable technology, scant normative justification exists for allowing inventors of 'self-realizing' discoveries to appeal to patent law for protection." Devlin, *supra* note 5, at 425. If patents were only justified by disclosure, there would be little reason to allow patents on "self-disclosing" inventions (because they would be disclosed anyway). Under the innovation theory, the justification is *strongest* for allowing patents on these inventions because inventors cannot protect these inventions with trade secrets. Absent patent protection, there would be no incentive for their creation.

208. *See id.* at 427–31.

209. *See supra* note 57 and accompanying text. For a summary of why patents work comparatively well in the pharmaceutical industry, see Lisa Larrimore Ouellette, Note, *How Many Patents Does It Take To Make a Drug? Follow-On Pharmaceutical Patents and University Licensing*, 17 MICH. TELECOMM. TECH. L. REV. 299, 302–04 (2010).

210. *See* Ouellette, *supra* note 209, at 302 (comparing imitation to research costs in the pharmaceutical industry).

211. *See* Devlin, *supra* note 5, at 411 n.53 (noting that "the pharmaceutical sector [is] the prime example" of an industry where patents usefully disclose information). This calculus might change, however, for biopharmaceuticals. *See* Gregory N. Mandel, *The Generic Biologics Debate: Industry's Unintended Admission that Biotech Patents Fail Enablement*, 11 VA. J.L. & TECH. 8 (2006), *available at* http://www.vjolt.net/vol11/issue4/v11i4_a8-Mandel.pdf.

212. *See, e.g.*, BESSEN & MEURER, *supra* note 58; MICHELE BOLDRIN & DAVID K. LEVINE, AGAINST INTELLECTUAL MONOPOLY (2008); ADAM B. JAFFE & JOSH LERNER, INNOVATION AND ITS DISCONTENTS: HOW OUR BROKEN PATENT SYSTEM IS ENDANGERING INNOVATION AND PROGRESS, AND WHAT TO DO ABOUT IT (2004).

213. The idea of gold-plated patents was first suggested in a short article for a non-legal audience. Mark Lemley, Doug Lichtman & Bhaven Sampat, *What To Do About Bad Patents?*, REG., Winter 2005–2006, at 10, 12–13. Lemley and Lichtman then developed the idea in more detail. *See* Doug Lichtman & Mark A. Lemley, *Rethinking Patent Law's Presumption of Validity*, 60 STAN. L. REV. 45, 61–63 (2007). Additionally, Jeanne Fromer has

Since inventors could still choose the current review system, it seems unlikely that the availability of heightened scrutiny would reduce innovation incentives or cause inventors to choose trade secret protection. Some have criticized the idea of gold-plated review as prohibitively expensive.[214] But certain proposals (like free peer review) would add little cost for the USPTO, and the improvements in patent quality would probably outweigh these costs.[215] These added costs would also be lower under an opt-in gold-plated review system than under a system in which disclosure requirements are strictly enforced for all patents.

2. How To Strengthen Disclosure

The USPTO is already experimenting with an opt-in system of heightened scrutiny through the Peer To Patent program, which lists patents online and allows the public to submit prior art that might be relevant to novelty or non-obviousness.[216] Although this program does not officially provide a higher presumption of validity, patent blogger Dennis Crouch has suggested that Peer To Patent is analogous to gold plating: "Peer-to-Patent offers a potential mechanism to bolster the credibility of [applicants'] patent rights. I can imagine the patentee's top litigator explaining to the jury that — in addition to the ordinary rigorous examination process — the applicant volunteered its patent

suggested that "the government might offer a sliding scale of patent rights calibrated in part to the quality of disclosure," Fromer, *supra* note 7, at 598, and Kristen Osenga has proposed that different "roads" could lead to different types of patent protection, Kristen Osenga, *Entrance Ramps, Tolls, and Express Lanes — Proposals for Decreasing Traffic Congestion in the Patent Office*, 33 FLA. ST. U. L. REV. 119 (2005).

214. *See, e.g.*, Donald Zuhn, *Presidential "Debate" on U.S. Patent Policy*, PAT. DOCS (Oct. 14, 2008, 11:51 PM), http://patentdocs.typepad.com/patent_docs/2008/10/presidential-debate-on-us-patent-policy.html (reporting that during the 2008 presidential race, the McCain campaign argued that Barack Obama's plan to implement a gold-plated system was too costly).

215. *Cf.* Lichtman & Lemley, *supra* note 213, at 61–70 (suggesting that, despite its added expense, a gold-plated review system would be an overall improvement to the patent system). When examining free peer review from a social welfare perspective, rather than only in terms of the costs to the USPTO, the opportunity cost of the researchers providing the peer review should also be considered. But reviewers might rationally decide that their personal benefit (for example, being closer to cutting-edge technologies) outweighs the value of their lost time.

216. PEER TO PAT., http://peertopatent.org (last visited May 3, 2012). The second pilot, which lasted until September 2011, was announced after the success of the first 2007 to 2009 pilot. *See* Press Release, U.S. Patent & Trademark Office, USPTO Launches Second Peer To Patent Pilot in Collaboration with New York Law School (Oct. 19, 2010), *available at* http://www.uspto.gov/news/pr/2010/10_50.jsp. For an overview of the Peer To Patent concept, see Beth Simone Noveck, *"Peer to Patent": Collective Intelligence, Open Review, and Patent Reform*, 20 HARV. J.L. & TECH. 123, 143–51 (2006). For a discussion of the concept in the context of disclosure, see Fromer, *supra* note 7, at 592 n.245.

for the gold-standard of academic review — public peer-review."[217] Peer To Patent is currently focused only on finding prior art that has bearing on novelty or non-obviousness, not on evaluating whether the invention is adequately disclosed — but there is no reason that it could not be expanded to allow questions about enablement. In fact, peer review would probably be *more* useful for evaluating disclosure than novelty: patent examiners are generally not PHOSITAs, and it is easier for non-experts to locate relevant prior art than to recognize enablement problems.[218]

The USPTO could also send patents out for traditional peer review, rather than (or in addition to) opening them up for public peer review on the Peer To Patent website. I have suggested that getting a patent should be more like getting an article published in a top scientific journal — and journals send their articles for peer review.[219] As described in Part III.B, a number of survey respondents were skeptical of the patent literature because of the lack of peer review. Although the examiners that review patents are scientifically trained, they (like journal editors) have a limited degree of specialization. They could send some subset of patents (either those that they have questions about, or those that are part of an opt-in system) to experts in the field for opinions on disclosures. To help cover the costs, the USPTO could charge an additional fee for peer review, which could be waived if the patentee is able to have the patented idea accepted by a peer-reviewed journal within a year of submitting the patent application.[220]

---

217. Dennis Crouch, *Peer-to-Patent Begins Expanded Pilot*, PATENTLY-O (Oct. 19, 2010, 8:31 AM), http://www.patentlyo.com/patent/2010/10/peer-to-patent-begins-expanded-pilot.html.

218. This problem could also be addressed by having "the burden . . . shift to the applicant to establish patentability" when the application "lacks working examples or is supported by prophetic examples." Seymore, *supra* note 22, at 156.

219. Beth Noveck argues that traditional peer review is inappropriate for patents by discussing the failings of peer review in other government agencies, such as the National Science Foundation, the Environmental Protection Agency, and the National Institutes of Health. *See* Noveck, *supra* note 216, at 138–43. However, peer review of technical papers seems the more relevant analogy because a patent, like a paper, summarizes a completed technical project, whereas federal grant agencies must decide which *un*completed research projects to fund. Still, some of the problems with peer review of federal grants that Noveck discusses may also apply to peer review of scientific papers.

220. In the United States, patentees have a one-year grace period between publishing their idea and submitting a patent application. *See* Leahy-Smith America Invents Act, Pub. L. No. 112-29, sec. 3(b), § 102(b)(1), 125 Stat. 284, 286 (2011). Other countries, however, require absolute novelty, where "novelty is judged as of the date of filing." 2 R. CARL MOY, MOY'S WALKER ON PATENTS § 8:208 n.1 (4th ed. 2011). Thus, many patent applicants would not want to wait until after an idea is published to submit their application. For example, one survey respondent wrote: "In my group, we tend to write a paper for a scientific journal and a patent simultaneously, and when we receive notice that the application has been received by the USPTO, we submit the paper to a journal." But applicants would still have time to alert the USPTO if they have their idea accepted by a peer-reviewed journal, as "it is generally more than a year, and sometimes more than two years, before the examiner even picks the application up off the pile." DAN L. BURK & MARK A. LEMLEY, THE PATENT CRISIS AND HOW THE COURTS CAN SOLVE IT 23 (2009).

Because scientists are accustomed to peer reviewing articles for free, at least some would probably willingly respond if the USPTO asked for their opinion about whether a patent is enabled.[221] For some inventions, enablement could be judged based on the patent document alone; in other cases, the USPTO might pay reviewers to try to reproduce the invention based on the disclosure, along with any source code or materials provided by the patentee.[222] Like the editors at *Science* and *Nature*, patent examiners should not be bound by the results of peer review,[223] and reviewers should be required to disclose conflicts of interest, which would mitigate problems with bad faith reviews by competitors. But the reviews would still be highly informative — if experts in the field give reasons why they cannot reproduce an invention without undue experimentation, then the patent is probably inadequately disclosed.

Implementing peer review for every patent might be administratively difficult for the USPTO, but it would certainly not be limited by the number of scientists who are willing to peer review articles.[224] For the past ten years, the USPTO has typically issued roughly 150,000 utility patents per year.[225] The ISI Science Citation Index, which covers 6650 major peer-reviewed scientific journals, averages nearly one million new articles per year.[226] In 2009, the USPTO issued 2675 patents with "nano" in one of their claims,[227] while the Science Citation Index contains 67,294 articles from 2009 with "nano" in the topic field.[228]

---

221. This may not be the case in non-technological fields, such as for business method patents.

222. Note that it is not currently required that every disclosed suggestion works. *See* Atlas Powder Co. v. E.I. du Pont De Nemours & Co., 750 F.2d 1569, 1576–77 (Fed. Cir. 1984) (stating that "[e]ven if some of the claimed combinations were inoperative, the claims are not necessarily invalid[,]" and that "[u]se of prophetic examples . . . does not automatically make a patent non-enabling").

223. *See Peer Review at* Science *Publications*, SCIENCE, http://www.sciencemag.org/site/feature/contribinfo/review.xhtml (last visited May 3, 2012); *Peer-Review Policy*, NATURE, http://www.nature.com/authors/editorial_policies/peer_review.html (last visited May 3, 2012).

224. It may be necessary, however, to overcome some researchers' biases against patents, such as the researcher who said he would only read a patent if he "was chained to a chair and water dripped on [his] head" because patents are "stifling to research." *See supra* Part III.E.

225. *See* U.S. PATENT & TRADEMARK OFFICE, ALL TECHNOLOGIES REPORT: JANUARY 1, 1986–DECEMBER 31, 2010, at 4 (2011), *available at* http://www.uspto.gov/web/offices/ac/ido/oeip/taf/all_tech.pdf.

226. *See Web of Science Databases*, ISI WEB OF KNOWLEDGE, http://images.isiknowledge.com/WOK46/help/WOS/h_database.html (last modified Feb. 17, 2009) (noting that the Science Citation Index averages 19,000 new records per week).

227. *See USPTO Patent Full-Text and Image Database*, *supra* note 126 (search for "ISD/$/$/2009 and ACLM/nano$").

228. *See Web of Science Advanced Search*, ISI WEB OF KNOWLEDGE, http://apps.isiknowledge.com/WOS_AdvancedSearch_input.do?product=WOS&SID=2DLF%40BLfiK1ChGfPApd&search_mode=AdvancedSearch (select timespan from 2009

I also propose that disclosure could be enforced in a novel way by establishing an obligation that patentees respond if a PHOSITA asks a good-faith question about reproducibility. In the scientific community, if a researcher has trouble replicating the result from a technical paper, she will often contact the paper's authors to explain her difficulty and ask for guidance, and the authors are generally willing to assist with reasonable requests. (Such requests do not necessarily mean that the papers were not "enabled" — for example, authors may have suggestions about troubleshooting or common mistakes.) As part of an effort to bring the patent system more in line with scientific norms, I argue below that the inventors listed on patents should be expected to respond to similar questions.

To implement this, a court could simply decide that evidence that an inventor did not respond to a question about enablement raises a presumption that the patent is not enabled. This presumption should be available to anyone who wishes to challenge the patent, whether in defense to an infringement suit or in another proceeding. The inventor could rebut this presumption by demonstrating that the question was vexatious or that the questioner was not a PHOSITA.[229] This idea would be further facilitated if the USPTO accepted unanswered questions for a patent's file, or if a third party created a public website to collect such questions. Congress could also amend the Patent Act to allow the patentee to request compensation from the questioner at a statutory rate. The gain from this approach would have to be weighed against the potentially significant burden on the patentee and the reduced incentive to innovate — although this burden might incentivize patentees to write patents very clearly in the first place.

One logistical difficulty with this proposal is dealing with language barriers between researchers in different countries. Many international scientists communicate in English, with scientists in non-English-speaking countries writing most of their papers for English-language scientific journals, which facilitates international communication and collaboration. But a rule that discriminated against non-English-speaking inventors would likely violate the "national treatment" provision of TRIPS, which requires foreigners to receive "treatment no less favourable" than a country's own nationals.[230] Inventors who are unable to respond because they are difficult to locate raise a similar concern. The easiest way to deal with this problem

---

to 2009, check the box only for "Science Citation Index Expanded," and search for "ts=nano*") (last visited May 3, 2012).

229. Although there is always the possibility of abuse, the United States has managed similar tradeoffs in favor of access to information, such as with the Freedom of Information Act. *See* 5 U.S.C. § 552 (2006 & Supp. IV 2010).

230. *See* TRIPS, *supra* note 21, art. 3, ¶ 1; *see also* Paris Convention for the Protection of Industrial Property, *supra* note 61, art. 2, ¶ 1 (containing a similar national treatment provision).

would be to put the burden on the researcher seeking help to prove that the inventor actually received the question and that the question was in a language the inventor understands.

A different problem arises when a patent is assigned (or exclusively licensed) to a third party, as the new owner might not want the inventor to say anything that might affect the legal status of the patent. This could be addressed by limiting the period of the presumption, such as for one year after the patent is granted, or again by putting the burden on the researcher seeking help to contact the current owner of the patent.

A third problem with an obligation to respond to questions about reproducibility is that other inventors might be hesitant to reveal that they are trying to reproduce a patented invention because of concerns about being sued for willful infringement. As discussed in the following Part, a more robust experimental use doctrine and scaled-back willful infringement rules would mitigate this problem. But even under current rules, some researchers do contact patentees about efforts to build on their inventions,[231] and the patent laws should help shape a norm that patentees should respond to these inquiries.

Both peer review and an obligation to respond to good faith questions will address the problem of obfuscating language as well as lack of technical information. If inventors know that other scientists will review their applications — not just patent agents who are used to legalese — they will have an incentive to write for their peers.[232] Similarly, obfuscating language will make it more likely that other scientists will need to ask questions about enablement, so applicants will have an incentive to write more clearly to avoid these questions in the first place, and their responses to questions will be available to help clarify remaining confusions.

In conclusion, whether the disclosure requirements of § 112 are enforced through an obligation to respond to questions about reproducibility, expanded peer review, or some of the suggestions from other commentators,[233] they should be enforced such that PHOSITAs *believe* that patented inventions are reproducible without undue experimentation. Courts may wish to adopt a more flexible view of what "new matter" is allowed in a disclosure without losing the priority

231. *See* Jaffe et al., *supra* note 105.

232. As Federal Circuit Judge Jay Plager has noted, there are "no insurmountable doctrinal or statutory barriers" to writing clearer patents, which could be accomplished just as insurance policies recently shifted "from historically obscure documents written in legalese to documents written in working English." S. Jay Plager, *Challenges for Intellectual Property Law in the Twenty-First Century: Indeterminacy and Other Problems*, 2001 U. ILL. L. REV. 69, 72. And while the language and structure of patent claims are very specialized, the shift would be even easier in the patent specification. *See, e.g.*, ROBERT C. KAHRL, PATENT CLAIM CONSTRUCTION (2011) (a treatise of over 1000 pages dedicated to claim construction).

233. *See supra* notes 192–97 and accompanying text.

date to encourage amendments,[234] but even if they do not, the threat of losing their priority dates will encourage patent applicants to have better-disclosed patents in the first place.

B. Remove Legal Barriers to Using Patents as Technical Sources

In addition to strengthening the enforcement of existing disclosure requirements, the U.S. government should eliminate legal barriers to using patents as technical sources. In this Part, I argue that the government should (1) broaden the experimental use exemption; (2) limit the reach of the willful infringement doctrine; and (3) reduce the time before patent publication. Any of the three branches could take steps in this direction, as discussed below.

The first two problems — the lack of a robust experimental use exemption and the deterrent effect of willful infringement rules — are not actually deterring many innovators from reading patents. As described in Part III.E, less than two percent of the researchers I surveyed avoid reading patents because of concerns about adverse legal consequences (though the percentage is probably higher for industrial researchers in more applied scientific fields). And empirical evidence shows that the existence of patents rarely deters basic research.[235] I have previously argued that this evidence shows that "the need for an experimental use exemption is not as pressing as some have suggested,"[236] but it is an odd system in which inefficient laws are kept in place only because everyone ignores them. Patent laws help shape the norms and expectations of the scientific culture, and adjusting experimental use and willful infringement rules would help improve scientific trust in the patent system.

Experimental use exemptions — which prevent those who use patents only for basic research from being sued for infringement — exist in many other countries, including Canada, Japan, South Korea, Germany, the United Kingdom, and most other European countries.[237] The exemption was first suggested in the United States by a district court in 1813, but it has rarely succeeded in practice.[238] In the 2002 case *Madey v. Duke University*,[239] the Federal Circuit made it clear that university research is not exempt from patent infringement.[240]

234. *See supra* note 19 and accompanying text.

235. *See* Ouellette, *supra* note 24, ¶¶ 32–41 (summarizing survey evidence).

236. *Id.* ¶ 39.

237. John F. Duffy, *Rethinking the Prospect Theory of Patents*, 71 U. CHI. L. REV. 439, 457 n.68 (2004).

238. *See* Eisenberg, *supra* note 5, at 1023 (discussing *Whittemore v. Cutter*, 29 F. Cas. 1120, 1121 (C.C.D. Mass. 1813), where Justice Story first suggested an experimental use exemption).

239. 307 F.3d 1351 (Fed. Cir. 2002).

240. *Id*. at 1362 ("[S]o long as the act is in furtherance of the alleged infringer's legitimate business and is not solely for amusement, to satisfy idle curiosity, or for strictly philo-

This decision has been sharply criticized, including in the context of nanotechnology.[241] I join academics[242] who have argued for a broader experimental use exemption to help ensure that patent laws reflect traditional scientific norms.[243]

Willful infringement doctrine, which might subject parties who read patents to treble damages in infringement cases, was summarized in Part II.A.[244] As noted there, the Federal Circuit recently raised the standard for willful infringement to "objective recklessness," but the results of this change remain unclear.[245] The court should continue to limit the doctrine's perverse incentives.[246]

The third legal change that would help promote the use of patents as technical sources is shortening the time before publication of the patent application. A number of respondents indicated that the current eighteen-month delay limits their ability to use patents to learn about state-of-the-art technologies, which supports arguments that the publication delay undermines the disclosure function of patents.[247] The American Inventors Protection Act of 1999 changed the default from publication only of issued patents to publication of applications eighteen months after filing.[248] One survey of intellectual property owners found that only five percent thought they were negatively affected by this change, suggesting that it did not have a significant impact on innovation incentives.[249] But eighteen months is still a long time in many fields, including nanotechnology. For example, in 2006 the journal *Nano Letters* advertised five weeks to acceptance and eight

---

sophical inquiry, the act does not qualify for the very narrow and strictly limited experimental use defense.").

241. *See* Nicholas M. Zovko, Comment, *Nanotechnology and the Experimental Use Defense to Patent Infringement*, 37 MCGEORGE L. REV. 129 (2006).

242. *See* Ouellette, *supra* note 24, ¶ 31 & nn.87–89.

243. *See, e.g.*, Merges, *supra* note 1, at 164–65; Rai, *supra* note 1, at 139; Peter Lee, Note, *Patents, Paradigm Shifts, and Progress in Biomedical Science*, 114 YALE L.J. 659, 691–92 (2004); *cf.* Eisenberg, *supra* note 1, at 224–26 (noting that, though research may not merit a general exemption, patents often counteract the norm of dedicating an invention to the scientific community in an attempt to gain recognition).

244. *See supra* notes 71–74 and accompanying text.

245. *See supra* notes 76–78 and accompanying text.

246. *Cf.* Lemley & Tangri, *supra* note 71, at 1119–24 (suggesting narrowing the definition of willfulness and limiting the damages associated with willful infringement).

247. *See, e.g.*, Holbrook, *supra* note 5, at 143–45.

248. Pub. L. No. 106-113, § 4502(a), 113 Stat. 1501A-561 (1999) (codified as amended at 35 U.S.C. § 122 (2006)). Because of various exceptions, the publication time can be even longer. For example, the Peng patent application described in Part IV.A was based on a provisional application filed in October 2006, but it was not published until August 2010. *See supra* note 165. The corresponding research paper was published in August 2006, *see supra* note 166, so there is no reason to think any delay was necessary in that case.

249. *See supra* note 104 and accompanying text. Concerns were raised, however, about the Act's disproportionate impact on independent inventors. *See* Daniel K. N. Johnson & David Popp, *Forced out of the Closet: The Impact of the American Inventors Protection Act on the Timing of Patent Disclosure*, 34 RAND J. ECON. 96, 97 (2003).

weeks to publication,[250] and *Science* and *Nature* also manage rapid peer review.[251]

More rapid publication of patents is allowed under current law: "At the request of the applicant, an application may be published earlier than the end of such 18-month period."[252] Congress, however, should consider mandating more rapid publication, either for all patents or just for those in fast-moving fields. The benefits of faster disclosure would have to be weighed against the costs to innovation — inventors may be concerned about their inventions being published long before the patent right is granted. This problem would be ameliorated by efforts to "cut[] the average overall processing time of a patent application from 35 months to 20 months by 2015,"[253] but there is still no evidence of whether the most efficient publication time is eighteen months, twelve months, or immediately.

It would be a more straightforward reform for federal grant agencies like the NSF and NIH to change the rules for patents on federally funded research, which the Bayh-Dole Act permits.[254] As I have summarized previously, traditional innovation theories make little sense for Bayh-Dole patents — instead, the most plausible justification is commercialization (or prospect) theory, which argues that a property right is necessary to allow development of the invention into a commercial product.[255] Under this theory, early publication is actually beneficial, as it helps clearly demarcate the property right. Clearly written and quickly disclosed patents on federally funded research would be an important contribution to the technical literature.

C. Improve Access to the Patent Literature

The previous two Parts described governmental changes that would improve the disclosure function of patents, but private parties such as knowledge-promoting nonprofits, individual researchers, uni-

---

250. *See Faster Publication of Your High-Impact Research in* Nano Letters, 84 CHEMICAL & ENGINEERING NEWS 21 (2006).

251. *See General Information for Authors*, SCIENCE, http://www.sciencemag.org/site/feature/contribinfo/prep/gen_info.xhtml (last visited May 3, 2012) ("Reviewers are . . . asked to return comments within 1 to 2 weeks for most papers[,]" and "[m]ost papers are published . . . 4 to 8 weeks after acceptance."); *Getting Published in Nature: The Editorial Process*, NATURE, http://www.nature.com/nature/authors/get_published/#a6 (last visited May 3, 2012) ("Nature makes decisions about submitted papers as rapidly as possible . . . . [and m]ost referees . . . deliver a report within seven days . . . .").

252. 35 U.S.C. § 122(b)(1)(A) (2006).

253. Press Release, U.S. Patent & Trademark Office, Under Secretary of Commerce David Kappos Announces President Obama's FY 2012 Budget Request for the USPTO (Feb. 14, 2011), *available at* http://www.uspto.gov/news/pr/2011/11-12.jsp.

254. 35 U.S.C. §§ 200–212, *amended by* Leahy-Smith America Invents Act, Pub. L. No. 112-29, 125 Stat. 284 (2011).

255. *See* Lisa Larrimore Ouellette, Comment, *Addressing the Green Patent Global Deadlock Through Bayh-Dole Reform*, 119 YALE L.J. 1727, 1730–33 (2010).

versities, and scientific journals could also improve the accessibility of patents in several ways. First, search engines can continue to improve patent indexing and searching, making it easier for researchers to locate relevant patents. Second, peer production systems like WikiPatents[256] could encourage researchers to share enabling details about patents in addition to submitting relevant prior art. Third, universities and other recipients of public research funding could take the lead in setting the standards for robust patent disclosures. Finally, scientific journals could require authors to cite relevant patents. While any of these initiatives could occur without government intervention, the government could promote them through actions like providing seed money, funding conferences, or connecting the USPTO website to private sites.

As described in the survey results in Part III.B, some nanotechnology researchers indicated that they would use patents if they were easier to find. Patents are now readily accessible through online search engines, and many surveyed researchers are finding patents through these methods.[257] Patents would be even more accessible, however, if they appeared alongside the technical literature in the most commonly used search engines.[258] For example, Wolfgang Glänzel and Martin Meyer suggest that the relatively high number of patent citations in chemistry publications is related to "the fact that the database *Chemical Abstracts* is the only large traditional bibliographic database in which also patents are indexed."[259] The Derwent Innovations Index is now "[f]ully integrated in *Web of Knowledge*."[260] Google now provides patent results by default in Google Scholar searches (allowing one to see patent results in Google Scholar e-mail alerts),[261] which may open the patent literature to additional researchers. Google could also offer links to related patents based on patents that are commonly viewed together.

Another way to improve access to the patent literature is through peer production.[262] The Peer To Patent program, which encourages public suggestions of relevant prior art for pending applications, was described in Part V.A. Other platforms use peer production models to locate relevant prior art for granted patents, which can be used to raise novelty or obviousness challenges to those patents. As post-grant review of patent disclosures becomes possible under the America In-

256. WIKIPATENTS, http://www.wikipatents.com (last visited May 3, 2012).

257. *See supra* notes 135–43 and accompanying text.

258. *See* Fromer, *supra* note 7, at 586–87.

259. Wolfgang Glänzel & Martin Meyer, *Patents Cited in the Scientific Literature: An Exploratory Study of 'Reverse' Citation Relations*, 58 SCIENTOMETRICS 415, 426 (2003).

260. *Our Content*, ISI WEB OF KNOWLEDGE, http://wokinfo.com/benefits/whywok/ourcontent (last visited May 3, 2012).

261. *See supra* note 138 and accompanying text.

262. *See generally* Noveck, *supra* note 216, at 143–44 (providing examples of peer production in other contexts).

vents Act,[263] these platforms could focus on patent disclosures as well. WikiPatents functions like Wikipedia, enabling any registered user to add comments about published patents, with the goal "to become the crossroads at which inventors, engineers, scientists, . . . and other concerned members of the patent community openly share relevant and valuable information about specific patents . . . ."[264] The Electronic Frontier Foundation ("EFF") Patent-Busting Project seeks public contributions to help invalidate the "worst free-speech and innovation crushing software" patents, and they have invalidated or narrowed nearly half of the patents they have challenged.[265]

All of these platforms have focused on locating relevant prior art, but they could also be used as a tool to share information about patents. For example, if a nanotechnology patent does not include the specific details of a nanofabrication recipe needed to reproduce the invention, a researcher who develops a working recipe could post it on the wiki page for that patent. Patent owners might even post improved recipes themselves, in the hope that more follow-on inventors will want to build on (and license) the original patent.

Universities and other recipients of public research funds could also play a role in improving the content of patent disclosures and making them more accessible. As mentioned previously, the Bayh-Dole Act allows recipients of public funding to patent their results on the theory that a property right in the idea is needed to incentivize further development.[266] But university professors were innovating and disclosing their research in scientific publications long before Bayh-Dole out of a desire for prestige in being the first to publish a new result.[267] Because the details of university inventions will be disclosed anyway, university technology transfer offices should take the lead in writing patent specifications that are clear and technically useful; university patents should contain at least as much information as corresponding papers. Furthermore, universities could ask scientists who

263. *See supra* notes 188–90 and accompanying text.

264. *Frequently Asked Questions for WikiPatents*, WIKIPATENTS, http://www.wikipatents.com/faq (last visited May 3, 2012). Jeanne Fromer has also described the possibility of a "publicly available annotated patent document." Fromer, *supra* note 7, at 592.

265. *See* Rebecca Jeschke, *EFF Tackles Bogus Podcasting Patent — And We Need Your Help*, ELEC. FRONTIER FOUND. DEEPLINKS BLOG (Nov. 19, 2009, 10:40 AM), https://www.eff.org/deeplinks/2009/11/eff-tackles-bogus-podcasting-patent-and-we-need-yo (stating that, of ten challenged patents, "two [were] busted entirely, one [was] narrowed, four rexams [were] granted by the Patent office, and another one [was] invalidated by the courts").

266. *See supra* notes 255–57 and accompanying text.

267. *See* Rai, *supra* note 1, at 92 ("[P]erhaps the strongest [motivator] is that of invention itself . . . . [T]he highest levels of recognition and prestige are bestowed upon those who make original contributions to the common stock of knowledge.").

publish their work to list patents along with papers on their websites.[268]

A final way to make patents more accessible to researchers is by increasing the number of citations to patents in scientific journal articles. Although relatively few scientific articles currently cite patents,[269] some scientific publishers are working to increase scientific engagement with patents. For example, there is now a series of twenty-seven journals focused on describing interesting patents in specific fields, with titles like *Recent Patents on Nanotechnology* and *Recent Patents on Anti-Cancer Drug Discovery*.[270] But scientific journals could do more to increase the accessibility of patents to researchers. A letter to the editor in *Nature* in 2009 noted the absence of patent citations in the top scientific journals:

> Why are patent citations so conspicuously absent across academic journals, with most even omitting formatting instructions for these in their author guidelines? Patents present novel, rigorously reviewed unpublished work, as well as providing an unmatched resource for detail.
>
> We randomly selected one month (December 2008) and reviewed all citations in the reviews, articles and letters/reports in *Nature* (1,773 citations) and *Science* (1,367). These citations included textbooks, arXiv.org preprints and abstracts — but no patents.[271]

A response noted that "from a US perspective, this is unsound advice" because of willful infringement,[272] which is why this Article argues for scaling back that doctrine.[273] I agree with the original writers that "there should now be a more comprehensive citation of the patent literature in scientific publications."[274]

---

268. *See supra* note 12 and accompanying text.

269. *See* Glänzel & Meyer, *supra* note 259, at 418 ("On an average, about 13500 publications yearly are citing patents [from 1996 to 2000]. This is about 1.7% of all publications indexed in the SCI database.").

270. *See Titles A-Z*, BENTHAM SCI. PUBLISHERS, http://www.benthamscience.com/a-z.htm (last visited May 3, 2012). For an example article related to nanotechnology, see Rachel M. Frazier et al., *Recent Progress in Graphene-Related Nanotechnologies*, 3 RECENT PATS. ON NANOTECHNOLOGY 164 (2009).

271. Donald F. Weaver & Christopher Barden, Letter to the Editor, *Don't Overlook the Rigorously Reviewed Novel Work in Patents*, 461 NATURE 340, 340 (2009).

272. David Piehler, Letter to the Editor, *Legal and Practical Pitfalls in Making Use of Patents*, 462 NATURE 276, 276 (2009).

273. *See supra* Part V.B.

274. Weaver & Barden, *supra* note 271.

Scientific journals have played a key role in improving access to the data and code that researchers use for their publications.[275] They could play a similar role in improving access to patents by requiring researchers to cite relevant patents as well as publications, or by requiring a separate patent section in the citation list. Journals could also recommend that referees suggest patents that should be added to the citation list, just as referees currently frequently suggest technical publications that should be cited. Increased mixing of the scientific and patent literature would go a long way toward increasing scientists' engagement with patents.

VI. CONCLUSION

This Article has sought to reevaluate and add to the empirical literature on patent disclosure. These results show not only that the technical value of patent disclosures is greater than many legal scholars have appreciated, but also that many patents probably fail to meet the existing disclosure requirements. This seems particularly true for patents based on the legal fiction of constructive reduction to practice — many experiments do not work the way one might expect, so it would require undue experimentation for a PHOSITA to create many speculative inventions. And disclosure problems may worsen as we switch to a first-to-file system,[276] in which racing to the USPTO (perhaps with an incomplete disclosure) becomes more important.

The results of this Article suggest that disclosure requirements should be enforced and even strengthened, and I argue that the best way to accomplish this is to encourage scientists to increasingly engage with the patent literature. For example, the USPTO could send patents to scientists for peer review, or patentees could be obligated to respond to enablement questions from other scientists. The patent literature should also become more accessible to scientists (including by removing legal barriers to its use). Bringing patents more in line with scientific norms will benefit both patent law and the scientific community.

---

275. *See supra* notes 44–47 and accompanying text.

276. *See* Leahy-Smith America Invents Act, Pub. L. No. 112-29, sec. 3, 125 Stat. 284, 285–293 (2011) (to be codified in scattered sections of 35 U.S.C.).

APPENDIX

Table 1: Survey Questions and Answers from All 211 Respondents

Question	**Summary of Responses**
Which of the following best describes your current research environment?	Academic: 161 (76%) Government: 27 (13%) Industry: 16 (8%) Nonprofit: 4 (2%)
Is your research primarily experimental or theoretical?	Experimental: 189 (90%) Theoretical: 21 (10%)
Would you characterize the bulk of your research as basic or applied?	Primarily applied: 30 (14%) Equal mix of basic and applied: 76 (36%) Primarily basic: 104 (49%)
What is your highest degree?	Bachelor's: 2 (1%) Master's: 3 (1%) PhD or other doctoral: 203 (96%)
From what department did you receive this degree?	Biomedical Engineering: 6 (3%) Chemical Engineering: 10 (5%) Chemistry or Biochemistry: 46 (22%) Electrical Engineering: 19 (9%) Materials Science: 12 (6%) Mechanical Engineering: 7 (3%) Physics or Applied Physics: 98 (46%)

In what decade did you receive this degree?	1960s: 8 (4%) 1970s: 10 (5%) 1980s: 25 (12%) 1990s: 75 (36%) 2000s: 84 (40%) 2010s: 7 (3%)
Gender:	Female: 22 (10%) Male: 181 (86%)
Do you currently work in the United States?	Yes: 158 (75%) No: 51 (24%)
In the past two years, how many peer-reviewed papers have you published (including co-authored papers)? (If none, please enter "0")	Mean: 13.6 Min: 1 (N = 6) Max: 100 (N = 1)
In the past two years, how many U.S. patent applications have been submitted on your inventions? (If none, please enter "0")	Mean: 2.1 Min: 0 (N = 86) Max: 45 (N = 1)
If you discover a patentable invention in the future, would you like to have a patent on it?	Yes: 195 (92%) No: 16 (8%)
Have you ever read any part of an actual patent (other than your own) for any purpose related to your research?	Yes: 135 (64%) No: 76 (36%)

Notes: For details about the survey and how respondents were chosen, see *supra* notes 120–22 and accompanying text.

Table 2: Comparing Respondents with Random Sample of All Researchers Contacted

Measure	Respondents	Sample of Researchers
Number	211	100 (9% of 1078)
Papers (mean)	13.6	20.2
Patents (mean)	2.1	2.3
Academic	76%	76%
Government	13%	15%
Industry	8%	9%
Female	10%	10%
Outside U.S.	24%	28%

Notes: For details about how the random sample was measured, see *supra* note 126 and accompanying text. The only statistically significant difference between the respondents and the random sample is the number of papers published in the past two years: the survey respondents do not include the scientists who get their names on the highest number of papers. There is no significant correlation, however, between number of papers and whether a researcher reads patents, wants patents, thinks they are useful, or thinks they are enabled.

Table 3: Responses from Researchers Who Have NOT Read a Patent

Question	**Responses**
Why haven't you read any patents for research purposes?	*(% out of 76)*
Please check all that apply:	
I do not think patents contain information that would be useful to me.	65 (86%)
I do not know how to find relevant patents.	22 (29%)
I am worried about negative legal effects of looking at patents.	2 (3%)
I am not interested in patenting the results of my research.	5 (7%)
Other: _______	17 (22%)
Do you anticipate that reading a patent later in your career might be useful?	Yes: 36 (47%) No: 40 (53%)

Table 4: Responses from Researchers Who HAVE Read a Patent

Question	**Responses**
In the past two years, approximately how many patents have you read?	*Mean: 11.1* *Min: 0 (N = 5)* *Max: 100 (N = 1)*
Please check ALL of the ways in which you have found a patent:	*(% out of 135)*
A lawyer or someone from a legal department gave it to me.	52 (39%)
Another scientific researcher gave it to me.	45 (33%)
I found a citation to it in a paper or publication.	37 (27%)
I searched on the US Patent and Trademark Office website.	81 (60%)
I searched using Google Patents.	61 (45%)
I found one by chance in another search.	39 (29%)
Other: _______	11 (8%)
Please check ALL of the reasons for which you have read a patent:	*(% out of 135)*
Looking for legal information (either of the following two):	95 (70%)
To determine whether my research might be infringing a patent.	43 (32%)
To determine whether my research might be patentable.	84 (62%)
Looking for technical information (any of the following three):	94 (70%)
To learn how other researchers solved a particular technical problem I was facing.	54 (40%)
To research a general scientific topic.	60 (44%)
To browse information about cutting-edge technologies.	22 (16%)
To cite the patent in one of my publications.	17 (13%)
Other: _______	4 (3%)

If you have read a patent to gain scientific knowledge (either applied to a particular problem or regarding a general research topic), did you find useful information there?	Yes: 64 (60%) No: 43 (40%)
Were the patents you read worded in such a way that you or another nanotech researcher could recreate the invention without additional information?	Yes: 48 (38%) No: 79 (62%)
Do you worry that reading patents could have negative legal effects?	Yes: 6 (4%) No: 128 (96%)

Table 5: Regression Coefficients for Survey Responses

	Papers	**Patents**	**Want Patent**	**Read Patent**	**Useful**	**Enabled**
Industry	-0.34* (0.19)	1.64*** (0.24)	—	2.00* (1.04)	0.66 (0.71)	1.30** (0.63)
Experi-mental	-0.10 (0.17)	1.08*** (0.40)	-0.24 (0.78)	1.24** (0.51)	1.37 (0.97)	—
Basic Research	-0.03 (0.11)	-0.79*** (0.18)	-1.54** (0.68)	-0.71** (0.35)	-0.61 (0.46)	0.22 (0.44)
Chemistry	0.09 (0.15)	0.02 (0.22)	-0.50 (1.20)	1.28*** (0.48)	-0.72 (0.62)	-0.88* (0.53)
Physics	-0.16 (0.13)	-0.25 (0.25)	-1.81* (1.09)	0.39 (0.39)	0.05 (0.57)	-0.18 (0.50)
Time Since PhD	0.31*** (0.06)	0.31*** (0.08)	0.47** (0.24)	0.21 (0.17)	0.60*** (0.21)	-0.14 (0.19)
Female	-0.29** (0.14)	-0.17 (0.27)	-0.81 (0.66)	0.15 (0.50)	-0.05 (0.72)	-0.21 (0.61)
Outside U.S.	0.31** (0.15)	-0.50* (0.28)	-0.43 (0.52)	-0.42 (0.36)	0.60 (0.59)	0.27 (0.49)
N	208	209	209	209	106	126

Notes: The dependent variables for the quasi-maximum likelihood Poisson regressions in the first two columns are (1) the number of peer-reviewed papers published in the past two years; and (2) the number of U.S. patent applications submitted in the past two years. The dependent variables for the logistic regressions in the last four columns are dummy variables for (3) whether respondents want patents if they discover a patentable invention in the future; (4) whether they have ever read part of a patent (other than their own) for a research purpose; (5) whether respondents who have read patents to gain scientific knowledge found useful information; and (6) whether respondents who have read patents thought they were worded in such a way that the invention could be recreated by the respondent or another nanotech researcher without additional information (which is related to, but not identical to, the legal enablement requirement).

Independent variables (listed in separate rows) are (1) whether respondents work in industry; (2) whether their research is primarily experimental; (3) whether they primarily do basic research; (4) whether they received their PhDs in Chemistry, Biochemistry, or Chemical Engineering; (5) whether they received their PhDs in Physics or Applied Physics; (6) decades since they earned their PhDs (or other highest degree), where 0 = 2010s and 5 = 1960s; (7) whether respondents are female; and (8) whether respondents work outside the United States. The final row gives the number of responses used in each regression, which varies due to non-responses (N).

The "Industry" variable was omitted from the "Want Patent" regression because there were no industrial researchers who do not want a patent. Similarly, the "Experimental" variable was omitted from the "Enabled" regression because there are no non-experimentalists who believe patents are enabled.

Robust standard errors are in parentheses. Asterisks indicate statistical significance at the 1% (***), 5% (**), and 10% (*) levels.