Smith v. Van Gorkom and the Kobayashi Maru: The Place of the Trans Union Case in the Development of Delaware Corporate Law

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SMALL CAN BE INVENTIVE:
THE PATENTABILITY OF NANOSCALE
REPRODUCTIONS OF MACROSCALE MACHINES

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ABSTRACT

Nanotechnology is a thriving new field of research. If even a fraction of the excitement surrounding the field proves to be true, there will be profound benefits in many aspects of our lives. Crucial to its development, however, will be the treatment of nanotechnology with respect to patents. This field has the unique potential to replicate existing machines and devices at a billionth of their size. In light of rulings that “mere scaling” of prior inventions does not create a patentable invention, problems with patentability might arise. This Note tackles this issue, considering the patentability requirements of novelty and non-obviousness, the normative foundations of patent law, and the legal considerations unique to nanotechnology. There is something fundamentally different about machines at this scale that justifies a categorical finding of novelty and non-obviousness over macroscale predecessors.

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INTRODUCTION

In 1959, theoretical physicist Richard P. Feynman delivered a presentation outlining a new field of research—one he believed would unlock a realm of new possibilities.1 By manipulating and controlling matter on the atomic scale, we could achieve results never possible before, with an enormous range of technical applications.2 Feynman recognized that the idea of miniaturization was nothing new, but he envisioned something much more profound than electric motors the size of your fingernail or the Lord’s Prayer written on a grain of rice.3 He realized that we had hardly scratched the surface of the degree of miniaturization achievable: that there is “[p]lenty of [r]oom at the [b]ottom.”4 One day we might manipulate the very atoms that make up the objects around us, arranging them in any way we want.5 He predicted the wealth of new “properties that substances can have.”6 Feynman had introduced the world to the concept of nanotechnology.7

Indeed, Feynman was right. His now famous lecture marked the beginning of what would become a massive global research initiative.8 Today, more than sixty countries have launched national programs dedicated to nanotechnology research.9 And with the introduction of any new field technology, a host of new legal

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2 *Id.*
3 *Id.*
4 *Id.* at 24.
5 See *id.* at 25.
6 *Id.* at 34.
7 While Feynman introduced the concept, use of the term “nano-technology” did not come until later. Professor Norio Taniguchi was the first to coin the phrase. See Norio Taniguchi, *On the Basic Concept of ‘Nano-Technology,’* in PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON PRODUCTION ENGINEERING pt. II, at 18 (Tokyo 1974). The term was later introduced into the mainstream when used by Eric Drexler in 1986. K. ERIC DREXLER, *ENGINES OF CREATION: THE COMING ERA OF NANOTECHNOLOGY* 5 (1986).
9 *Id.* at 8.
implications is bound to follow.\textsuperscript{10} With all the promise of nanotechnology, one important issue moving forward will be how advancements in the field are granted intellectual property protection.\textsuperscript{11}

Unique to nanotechnology is the issue whether existing patents for “macroscale” devices—those we are accustomed to seeing, holding in our hands, etc.—can be said to anticipate similar devices created at the nanoscale.\textsuperscript{12} This is especially important when the original patent makes no reference at all to size.\textsuperscript{13} Is it enough that the only improvement over an existing invention is the ability to replicate it at the nanoscale?

Initially, one might expect it would be a major loophole if an inventor could simply scale down a previous invention to dodge an inventor’s patent protection.\textsuperscript{14} Surely a patent covers the same invention regardless of size.\textsuperscript{15} In fact, this is the stance that courts have taken when confronted with the issue broadly.\textsuperscript{16} But nanotechnology deals with miniaturization to the extreme, where researchers are manipulating individual atoms.\textsuperscript{17} The question is whether there is something fundamentally different about the nanoscale that should give patents a presumption of validity over their much larger predecessors.\textsuperscript{18}

This Note attempts to answer this in the affirmative: the world behaves much differently “at the bottom,”\textsuperscript{19} and there are unique challenges that make even reproductions of macroscale inventions fundamentally different.\textsuperscript{20} Part I explores recent


\textsuperscript{11} \textit{Id.}


\textsuperscript{13} \textit{Id.} at 28.

\textsuperscript{14} \textit{Id.} at 28–29.

\textsuperscript{15} \textit{Id.}

\textsuperscript{16} See \textit{infra} text accompanying notes 138–59.

\textsuperscript{17} Edward L. Wolf, \textit{Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience} 1 (2d ed. 2006).

\textsuperscript{18} See \textit{infra} Parts III, IV.

\textsuperscript{19} Feynman, supra note 1, at 24.

\textsuperscript{20} Nanotechnology deals with working machines at the smallest possible scale. Wolf, supra note 17, at 1. The smallest object that can be perceived by the typical human eye is roughly 88,646 nanometers. \textit{Visual Acuity of the
developments in nanotechnology and the range of industries where the technology can be beneficial. Part II provides a brief summary of the relevant patent law and identifies the most pertinent considerations to this analysis: novelty and obviousness. Equipped with these elements, Part III takes on the issue of patenting nanotechnology and shows that nanoscale devices do not in fact interfere with patents of macroscale devices, even as the patent system exists today. Finally, Part IV identifies policy reasons why this outcome is preferred in accordance with the normative object of patent law.

I. ADVANCEMENTS IN NANOTECHNOLOGY

In a sense, forms of nanotechnology have already existed in nature for perhaps billions of years. Living cells, the building blocks of biology, have many components in the nanometer range and utilize the unique properties at this scale. Understanding these components can inform our own engineering efforts in nanotechnology. Take for example the eye of an insect, which, for many species, consists of an array of thousands of tiny lenses and photoreceptor cells. Scientists have learned that this serves a number of important functions, including: reduced light reflection to aid vision; improved camouflage through reduced glare visible to predators; and even self-cleaning properties, like repelling pollen and other small particles that collect on the


21 See infra Part I.
22 See infra Part II.
23 See infra Part III.
24 See infra Part IV.
25 The first eukaryotic cells developed roughly 2.7 billion years ago. GEOFREY M. COOPER, THE CELL: A MOLECULAR APPROACH 10 (2d. ed. 2000).
26 WOLF, supra note 17, at 2.
27 Id.
Researchers are pursuing applications that will allow us to take advantage of properties at this scale, much in the way nature does. Perhaps we can create our own “self-cleaning” surfaces by mimicking the patterns found on the surface of the wing of a butterfly.

Unlike many other new frontiers in scientific discovery, there will not likely be a nanotechnology-specific market. There will not be a group of consumers standing in line to get their hands on the latest line of nanotech products. The greatest promise is in the ability to improve products and industries that already exist. Rather than creating a new discrete market for goods, it has the potential to expand and improve nearly all existing industries. This is not to say, however, that nanotechnology will not be lucrative. It is estimated that nanotechnology will soon top $1 trillion, making it, at least initially, the fastest growing industry in history. And applications with enormous potential continue to emerge.

A. Consumer Product Applications

In astonishing amounts, nanotechnology has already found its way into products we use every day. As of March 2015, it was estimated that nanotechnology is used in over 1,800 consumer

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29 Id. at 3462.
33 See id.
34 See id. at 426.
35 Id. at 427.
36 Id.
37 Id.
38 See infra Section I.A–E.
products already on the market.\textsuperscript{40} Titanium dioxide, found in sunscreen, is being reduced to nano-sized particles, which can provide the same sun protection without that unsightly white appearance.\textsuperscript{41} Sunglass lenses have been coated with nanoscale coatings that do not affect optical performance but provide increased resistance to scratching.\textsuperscript{42} Wilson, the popular tennis brand, has even developed a premium line of longer-lasting tennis balls by applying an internal clay nanoparticle coating.\textsuperscript{43} While these consumer products are exciting, recent discoveries in other industries show potential for even more profound applications in the future.\textsuperscript{44}

\textbf{B. Computing Applications}

One very promising field for nanotechnology is computer science. Richard Feynman himself suggested this from the very beginning, in his 1959 speech.\textsuperscript{45} Despite living in a time where computers filled entire rooms, Feynman asked why we cannot “make them very small, make them of little wires, little elements.”\textsuperscript{46} Indeed, we have. Over the years, in a phenomenon described as Moore’s Law,\textsuperscript{47} key elements of computer chips have become increasingly smaller, allowing the number of transistors in a computer chip to double roughly every two years.\textsuperscript{48} This has led to

\begin{itemize}
\item \textsuperscript{40} See Marina E. Vance et. al., \textit{Nanotechnology in the Real World: Redeveloping the Nanomaterial Consumer Products Inventory}, 6 BEILSTEIN J. NANOTECH. 1769, 1771 (2015), http://www.beilstein-journals.org/bjnano/articles/6/181 [http://perma.cc/YT3C-8D6R].
\item \textsuperscript{41} A. P. Popov et. al, \textit{TiO$_2$ Nanoparticles as an Effective UV-B Radiation Skin-Protective Compound in Sunscreens}, 38 J. PHYSICS D: APPLIED PHYSICS 2564, 2569 (2005).
\item \textsuperscript{42} DOUGLAS MULHALL, \textit{OUR MOLECULAR FUTURE} 114 (2002).
\item \textsuperscript{44} See infra Section I.B–E.
\item \textsuperscript{45} Feynman, supra note 1, at 25.
\item \textsuperscript{46} Id.
\item \textsuperscript{47} The term is attributed to Gordon Moore, the co-founder of Intel, Inc. WOLF, supra note 17, at 7, Fig. 1.2.
\item \textsuperscript{48} Moore postulated that the number of components in an integrated circuit would double roughly every two years. See Gordon E. Moore, \textit{Cramming More Components onto Integrated Circuits}, 38 ELECTRONICS 114, 115 (1965), reprinted in IEEE SSCS NEWSLETTER 33, 34 (Sept. 2006).
\end{itemize}
increasingly smaller and faster processors as well, opening the door for modern devices such as the smartphone.\textsuperscript{49}

For Moore’s prediction to continue to hold true, computers must eventually take advantage of computing at the nanoscale.\textsuperscript{50} And the future looks promising.\textsuperscript{51} Rather than using transistor circuits, in which information is stored by “flipping” between one of two states (binary 1s or 0s), we could use a single atom or single photon to store the information.\textsuperscript{52} In this field, known as quantum computing, the biggest challenge lies in manipulating these individual atoms into a “flipped” state, in which they become extremely unstable.\textsuperscript{53} In a significant recent advancement in the field, researchers in Australia created a quantum bit that remains stable for ten times longer than any before.\textsuperscript{54} This could mark a major step towards the elusive quantum computer.\textsuperscript{55}

\textbf{C. Medical Applications}

Nanotechnology presents perhaps its most groundbreaking applications in the medical field.\textsuperscript{56} Recent research suggests that the use of nanoparticles may lead to a major shift in the way we


\textsuperscript{50} See supra text accompanying notes 45–49.

\textsuperscript{51} See infra text accompanying notes 52–54.

\textsuperscript{52} Feynman even imagined this in his initial 1959 speech! Feynman, supra note 1, at 26 (“[N]othing ... says the computer elements cannot be made enormously smaller than they are now.”).


\textsuperscript{54} Arne Laucht et al., \textit{A Dressed Spin Qubit in Silicon}, 12 \textit{Nature Nanotech.} 61, 66 (2017).

\textsuperscript{55} Development of quantum computers has been referred to as the “space race of the 21st century.” Quantum computers, supra note 53.

treat diseases.\textsuperscript{57} In the near future, we may use nanoparticles to deliver drugs in a way that specifically targets individual cells, such as cancer cells, by selectively maintaining therapeutic levels where desired while reducing toxicity in other areas of the body.\textsuperscript{58} To facilitate this approach, researchers have recently experimented with the creation of nanoparticles with unique shapes and sizes.\textsuperscript{59} Scientists are beginning to learn how different nanoparticle shapes affect navigation through biological systems, which can help in targeting difficult-to-reach cancer cells.\textsuperscript{60}

Other research shows that iron nanoparticles, when attached to tumor cells, prompt immune cells already present in the body to attack the tumor cells.\textsuperscript{61} This effect, when used in conjunction with surgery, could greatly increase the effectiveness of surgical tumor removal, targeting any residual cells missed during the procedure.\textsuperscript{62} Other promising research suggests that nanotechnology may even be able to spur new growth of nerve cells, such as in damaged spinal cords or brain cells.\textsuperscript{63} Eventually, doctors may even utilize small chip-based “nanolabs,” placed into the bloodstream, capable of monitoring and tracking individual cells.\textsuperscript{64}

D. Energy Applications

Recent advancements may indicate profound applications in energy production and storage as well.\textsuperscript{65} Modern silicon solar

\textsuperscript{57} Id. at 19.
\textsuperscript{58} Id. at 3.
\textsuperscript{59} Randall Toy et al., \textit{Shaping Cancer Nanomedicine: The Effect of Particle Shape on the In Vivo Journey of Nanoparticles}, 9 NANOMED. 121, 127 (2014).
\textsuperscript{60} Id. at 121.
\textsuperscript{61} Saeid Zanganeh et al., \textit{Iron Oxide Nanoparticles Inhibit Tumour Growth by Inducing Pro-Inflammatory Macrophage Polarization in Tumour Tissues}, 11 NATURE NANOTECH. 986, 986 (2016).
\textsuperscript{62} Id.
\textsuperscript{63} Lijie Zhang et al., \textit{Nanotechnology and Nanomaterials: Promises for Improved Tissue Regeneration}, 4 NANO TODAY 66, 75–76 (2009).
\textsuperscript{64} Holger Bartos et al., \textit{Microfluidics Meets Nano: Lab-on-a-Chip Devices and Their Potential for Nanobiotechnology}, in NANOBIOTECHNOLOGY: CONCEPTS, APPLICATIONS AND PERSPECTIVES 13, 26–27 (Christof M. Niemeyer & Chad A. Mirkin eds. 2005).
\textsuperscript{65} See infra text accompanying notes 66–71.
cells can achieve a maximum theoretical efficiency of 33.16 percent,\textsuperscript{66} which presents a significant barrier in the efficacy of solar energy.\textsuperscript{67}

Nanotechnology research in solar energy production shows promise to significantly increase solar cell efficiency.\textsuperscript{68} In 2008, a study at Stanford University showed a potential solar radiation absorption rate of approximately 93 percent utilizing silicon “nanowires” and “nanocones,” nearly twice that of traditional thin-film solar cells.\textsuperscript{69} More recently, silicon nanowire arrays have been produced up to 96 percent absorption.\textsuperscript{70} With such improved efficiencies, nanotechnology could potentially make solar power a prominent source of energy.\textsuperscript{71}

Promising applications for energy storage are emerging as well.\textsuperscript{72} A proliferation of consumer devices, medical devices, and even electric vehicles now rely on rechargeable lithium-ion batteries as a power source.\textsuperscript{73} Silicon has shown to be an attractive anode material for these devices but suffers problems with pulverization and capacity fading, leading to reduced battery life under repeated charging.\textsuperscript{74} New research suggests that using nanowire-based silicon electrodes may eliminate pulverization with little fading during cyclic loading, providing increased battery performance.\textsuperscript{75}

\textbf{E. Agricultural Applications}

Nanotechnology may also provide helpful advantages in the agriculture industry.\textsuperscript{76} Much like the targeted cancer drug


\textsuperscript{67} See id.

\textsuperscript{68} Jia Zhu et al., \textit{Optical Absorption Enhancement in Amorphous Silicon Nanowire and Nanocone Arrays}, 9 NANO LETTERS 279, 281–82 (2009).

\textsuperscript{69} Id. at 281.

\textsuperscript{70} Michael D. Kelzenberg et al., \textit{Enhanced Absorption and Carrier Collection in Si Wire Arrays for Photovoltaic Applications}, 9 NATURE MATERIALS 239, 240 (2010).

\textsuperscript{71} Id. at 239.

\textsuperscript{72} Candace K. Chan et al., \textit{High-Performance Lithium Battery Anodes Using Silicon Nanowires}, 3 NATURE NANOTECH. 31, 31 (2008).

\textsuperscript{73} Id.

\textsuperscript{74} Id.

\textsuperscript{75} Id.

\textsuperscript{76} Prem Lal Kashyap et al., \textit{Chitosan Nanoparticle Based Delivery Systems for Sustainable Agriculture}, 77 INT'L J. BIOLOGICAL MACROMOLECULES 36, 37 (2015).
delivery discussed above, nanoparticles could provide targeted delivery of fertilizers or pest control products. This would reduce the amount of sprayed chemicals, not only improving cost efficiency, but providing environmental benefits as well. Silica nanoparticles may be used to transport DNA and chemicals through plant cellular walls, which may lead to advances in plant breeding and genetic engineering. Even the way we store and package food could see great benefits from nanotechnology.

F. Legal Implications

With such abundant research continually ongoing, the future applications of nanotechnology are promising to say the least. Nanotechnology may very well represent a new frontier of possibility across many industries. As the science community plugs along in its research and makes continued breakthroughs, the legal community will have to keep up.

As nanotechnologies are introduced into agriculture and food production, it may create challenges for the Food and Drug Administration. Nanoparticles may also have an unforeseen impact on the environment, which the Environmental Protection

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77 Id. at 48.
78 One foreseeable benefit would be bringing back the honey bee. Researchers have found alarming declines in bee populations worldwide. See, e.g., Jay D. Evans & Ryan S. Schwarz, Bees Brought to Their Knees: Microbes Affecting Honey Bee Health, 19 TRENDS MICROBIOLOGY 614, 614 (2011). Fertilizers and pesticides likely contribute to this problem. See Cleiton G. Rodrigues et al., Leaf Fertilizers Affect Survival and Behavior of the Neotropical Stingless Bee Friesella Schröttkyi, 109 J. ECON. ENTOMOLOGY 1001, 1005–07 (2016). By targeting plants more precisely, perhaps nanotechnology will reduce the impact on nontarget organisms such as bees.
80 Anu Keshwani et al., Advancements of Nanotechnology in Food Packaging, 4 WORLD J. PHARMACY & PHARMACEUTICAL SCI. 1054, 1056 (2015).
81 See, e.g., Linda MacDonald Glenn & Jeanann S. Boyce, Nanotechnology: Considering the Complex Ethical, Legal, and Societal Issues with the Parameters of Human Performance, 2 NANOÉTHICS 265, 268 (2008).
82 Id.
83 For an overview of issues surrounding nanotechnology, see id. at 265.
Agency will likely look to regulate. Though not quite nano-sized, the microbeads found in cosmetic products provide a recent example of unforeseen environmental impacts of particles on rivers, lakes, and oceans that prompted regulation.

Concerns may arise in the regulation of nanotechnologies as imports and exports as well. And, as more products are placed in the market, cases of products liability with nanotechnology will almost certainly be brought. Perhaps nanoscience will even open up new avenues for criminal activity as well—something not too far-fetched given the anthrax attacks of 2001.

More central to the focus of this Note, however, courts will have to determine how intellectual property law will treat developments and inventions in nanotechnology. Specifically, courts must determine how the well-established patent system will apply to this unique field of technology. The examples considered so far set the stage for this analysis.

II. REQUIREMENTS FOR PATENTABILITY

To understand the issues surrounding potential interference with larger-scale patents, a brief overview of the requirements for patentability is helpful. This Part reviews these requirements, with a particular focus on their application to nanotechnology.

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85 Id. at 110–11.
87 BOUCHER, supra note 84, at 129.
88 For an extreme example of potential liability, see MICHAEL CRITCHON, PREY 83 (2002) (depicting the inadvertent creation of a rapidly reproducing “nanoswarm” exhibiting predatory behavior).
89 BOUCHER, supra note 84, at 217.
92 See supra Part I.
93 See infra Section II.A–E.
94 Id.
A. General Requirements

The patent law system essentially operates as a *quid pro quo* between an inventor and the general public. In exchange for a form of limited monopoly over the use, sale, and production of an invention, the inventor fully discloses the invention, and how it is made, to the public. This enriches society with the knowledge of the invention and, once the patent expires, the ability to make and use the invention freely. In the meantime, the patent might inspire other inventors to “invent around” the patent, potentially leading to new discoveries that would not otherwise have been made. The patent law system incentivizes inventors to bring ideas into the public realm, rather than tuck them away in secrecy.

To protect the public’s interest in this *quid pro quo*, the inventor must meet certain requirements dictated by the patent system. There are a number of disclosure requirements to ensure the patent properly provides the public with the benefit of their bargain. In filing a patent, an inventor must include a “written description of the invention, and the manner and process of making and using it.” The patent must describe the invention clearly enough that someone skilled in the art would be able to make and use the invention with minimal experimentation. It must also clearly define the limits of what is being claimed so that others are aware of the boundaries of the legal right.

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95 Ariad Pharm., Inc. v. Eli Lilly & Co., 598 F.3d 1336, 1345 (Fed. Cir. 2010) (“[O]ne describes an invention, and, if the law’s other requirements are met, one obtains a patent.”).
97 See id.
98 Slimfold Mfg. Co. v. Kinkead Indus., 932 F.2d 1453, 1457 (Fed. Cir. 1991) (“Designing around patents is, in fact, one of the ways in which the patent system works to the advantage of the public in promoting progress in the useful arts....”).
100 Ariad Pharm., 598 F.3d at 1345.
102 Id.
103 In re ’318 Patent Infringement Litig., 583 F.3d 1317, 1323 (Fed. Cir. 2009).
Additionally, only certain types of inventions are eligible for protection. The patent must fall into one of four eligible patent categories: process, machine, manufacture, or composition of matter. Abstract ideas, such as mathematical equations or naturally occurring phenomena, are not patentable. This subject matter requirement is traditionally treated as a distinct issue in patent law, separate from the other major requirements of utility, novelty, and non-obviousness.

B. Utility

An invention must satisfy a utility requirement for patentability. This is based on statutory language requiring that an invention be “new and useful” and that the application disclose the “manner and process of making and using the invention.” Since the utility requirement arises from two single words in the statute, the bulk of the inquiry has developed through case law.

This utility requirement is generally not a difficult standard to meet as a browse through the patent database might reveal. The vast majority of patents are granted with minimal inquiry into utility. Many of the nanotechnology applications identified in Part I would almost certainly pass this low bar: a nanotechnology patent could conceivably be filed under any of these four categories. An inventor could patent a process for creating a nanotechnology component (such as nanotubes or buckyballs) or a process for achieving a specific result such as those listed in Part I. A nanoscale machine or device could be invented, such as the chip-based “nanolab” with medical applications. Patents in manufacture might arise when a basic building block, such as nanotubes, are reformed to produce a desirable product. A composition of matter patent might involve the manipulation of individual atoms to create materials in a way that was previously unachievable.

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106 Id. A nanotechnology patent could conceivably be filed under any of these four categories. An inventor could patent a process for creating a nanotechnology component (such as nanotubes or buckyballs) or a process for achieving a specific result such as those listed in Part I. See supra Part I. A nanoscale machine or device could be invented, such as the chip-based “nanolab” with medical applications. See supra text accompanying note 64. Patents in manufacture might arise when a basic building block, such as nanotubes, are reformed to produce a desirable product. A composition of matter patent might involve the manipulation of individual atoms to create materials in a way that was previously unachievable.
108 MERGES & DUFFY, supra note 104, at 69.
109 See § 101.
110 Id. (emphasis added).
111 Id. § 112 (emphasis added).
112 MERGES & DUFFY, supra note 104, at 209.
113 See, e.g., U.S. Patent No. 6,368,227 (filed Nov. 17, 2000) (describing a “method of swing[ing] on a swing ... in which a user ... induces side to side motion by pulling alternately on one chain and then the other.”).
114 MERGES & DUFFY, supra note 104, at 209.
nanotechnology device that delivers drugs to selectively target cancer cells is at least as useful as a “beerbrella”\textsuperscript{115} that keeps your favorite brewed beverage protected from the sun.\textsuperscript{116}

One issue, however, known as practical or specific utility, may present problems for certain nanotechnology patents in the way it prevented a number of biotechnology patents.\textsuperscript{117} This requires that the invention be refined and developed to the point that the inventor can identify a specific benefit.\textsuperscript{118} Inventors must take care not to file for a patent too early in development, or they may fail this requirement.

C. Novelty

More important to the issue here, however, are the requirements of novelty and non-obviousness. In order for a patent to be granted, the invention must not already be publicly available.\textsuperscript{119} That is to say, that the invention must be new or novel.\textsuperscript{120} This is one of the most basic requirements of a patent system: to receive the benefit of a patent, the inventor must disclose to the public an invention not already within the public sphere.\textsuperscript{121}

Novelty is determined through a search of what is referred to as “prior art,” including previously granted patents as well as other sufficient public uses or publications.\textsuperscript{122} The idea of novelty is interpreted to mean something distinct from inventiveness—\textsuperscript{123}—a


\textsuperscript{116} This of course depends on how the application is drafted. Utility is analyzed based on the claims and description and whether they identify and enable a use. See § 112.

\textsuperscript{117} Many early biotechnology patents were invalidated for failing to establish a specific utility. See, e.g., In re Fisher, 421 F.3d 1365, 1379 (Fed. Cir. 2005) (invalidating patent for purified nucleic acid sequences); Brenner v. Manson, 383 U.S. 519, 540 (1966) (Harlan, J., concurring) (invalidating patent for creating steroid).

\textsuperscript{118} See Brenner, 383 U.S. at 534–35 (“Until the process claim has been reduced to production of a product shown to be useful, the metes and bounds of that monopoly are not capable of precise delineation.”).


\textsuperscript{120} Id.

\textsuperscript{121} See MERGES & DUFFY, supra note 104, at 337.

\textsuperscript{122} See § 102(a)(1).

\textsuperscript{123} See Allied Wheel Prods., Inc. v. Rude, 206 F.2d 752, 760 (6th Cir. 1953); 69 C.J.S. Patents § 34 (2017).
patent will not fail to meet the novelty requirement just because it was discovered purely by accident.

D. Non-Obviousness

In a sense, the doctrine of non-obviousness picks up where novelty leaves off. While an invention might be novel in that it is not explicitly described in prior art, the non-obvious requirement asks whether the idea is sufficiently inventive. An inventor would receive an unfair benefit in a patent that is just an obvious application of a known technology. This requirement can be thought of as the “nontriviality” requirement of patent law, and it is the most stringent of the basic patent law requirements.

As with novelty, the starting point for this inquiry is an examination of the prior art. The court analyzes obviousness with regard to a “person having ordinary skill in the art” related to the subject matter. The test is to determine whether such a person would have found the technology to be obvious based on a combination of prior art references.

This concept originally arose in *Hotchkiss v. Greenwood* in 1851. The patent at issue was for a new and useful improvement over existing doorknobs by instead using clay and porcelain. The Supreme Court affirmed the decision of the lower court in invalidating the patent because nothing inventive was brought to the table. There was nothing new about the knob; it was simply made from a different material than had previously been used. After *Hotchkiss*, the 1952 Patent Act codified this requirement stating that “[a] patent may not be obtained ... [if the
differences over prior art] would have been obvious at the time
the invention was made to a person having ordinary skill in the
art.”\textsuperscript{136} The Supreme Court later expanded upon this definition
of non-obviousness in \textit{Graham v. John Deere Co.}, providing fur-
ther framework for the analysis.\textsuperscript{137}

The issue addressed in this Note lies firmly within the
bounds of novelty and non-obviousness: when an inventor creates
something described in prior art—just at a scale not contemplated
by the original invention—is it in fact new? And, if so, is it suffi-
ciently inventive?

\textbf{E. Issues of Scale}

Though novelty and non-obviousness are separate and
distinct requirements, courts have addressed the two together
with regard to issues of scale.\textsuperscript{138} Specifically, courts have exam-
ined whether mere changes in size meet the requirements for
novelty or non-obviousness.\textsuperscript{139} Because nanotechnology essen-
tially just describes scientific advancements made at an extreme
scale, it is worth reviewing the courts’ decisions on this matter
separately. And the case law is not very supportive at first glance.
The United States Patent and Trademark Office (USPTO)\textsuperscript{140}
points to three cases in particular that highlight this notion.\textsuperscript{141}

The first case, \textit{In re Rose}, dealt with a patent application
for a “Package of, Apparatus for Packaging and Method of Han-
dling and Storing Lumber.”\textsuperscript{142} The claims at issue describe how
individually banded bundles of lumber are stacked in a specific
way to form a “lumber package.”\textsuperscript{143} In response to a challenge of

\textsuperscript{137} See 383 U.S. 1, 17 (1966).
\textsuperscript{138} See infra text accompanying notes 140–59.
\textsuperscript{139} Id.
\textsuperscript{140} U.S. PATENT AND TRADEMARK OFFICE, MPEP § 2144.04(IV)(A) (9th ed.
/LCE3-482H].
\textsuperscript{141} Id.
\textsuperscript{142} 220 F.2d 459, 459 (C.C.P.A. 1955).
\textsuperscript{143} The Board of Appeals of the Patent Court found “[t]he number of strips
in a bundle, the number of bundles in a layer, the number of layers of bundles
and the relative dimensions of the strips, the bundles and the package
his patent, the applicant argued that his lumber package was significantly larger and had to be lifted by truck whereas the prior lumber packages could be lifted by hand. The United States Court of Customs and Patent Appeals found that this size limitation was not “patently significant since it at most relates to the size of the article under consideration which is not ordinarily a matter of invention.” Effectively, the only difference was that the patent described heavier, larger bundles of lumber.

Similarly, in Gardner v. TEC Systems, the United States Court of Appeals for the Federal Circuit addressed the issue of whether size limitations were a non-obvious improvement for the purposes of patentability. Thomas Gardner was awarded a patent for a device used in drying ink on high-gloss paper for printing periodicals. Gardner brought an unsuccessful infringement claim against TEC Systems, which he then appealed. The court affirmed the dismissal, holding that his patent was invalid for obviousness. In comparison to prior art, the only distinction in Gardner’s claims were dimension restrictions, calling for certain spacing between the device and the paper relative to other dimensions of the machine. The court held that mere recitation of dimensions does not distinguish it in any meaningful way over the prior art.

Finally, in In re Rinehart, the United States Court of Customs and Patent Appeals addressed the issue of scaling in regards to obviousness. The patent application in question described a method for producing polymeric ethylene terephthalate (PET) resin by heating acid in the presence of glycol under high

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144 Id.
145 Id. (citing In re Yount, 171 F.2d 317, 318 (C.C.P.A. 1948)).
146 See id.
148 Id. at 1340.
149 Id. at 1339.
150 Id. at 1350.
151 See id. at 1345–46.
152 Id. at 1346.
153 531 F.2d 1048, 1051 (C.C.P.A. 1976).
154 See id.
pressures at a specific glycol-to-acid ratio. The only substantive difference between the applicant’s claims and the prior art was the recitation that the process was for “commercial scale production” using “commercial scale quantities.” The court found that one skilled in the art could easily determine the proper ratio and successfully solve the problem of scaling up the prior art process to a commercial scale. The language used by the court, that “mere scaling up of a prior art process capable of being scaled up ... would not establish patentability in a claim to an old process so scaled,” is particularly troubling for nanotechnology devices. The question remains whether these devices are a “mere scaling” down of larger, very similar devices or whether they are in fact new and inventive.

III. PATENTS FOR NANOTECHNOLOGY DEVICES

As a threshold matter, there is no question that nanotechnology devices, categorically, are patentable. There is nothing inherent about devices at this scale that precludes them from meeting the patentability requirements described above. In fact, thousands of nanotechnology patents have already been granted, and patent filings continue to increase at an almost alarming rate. And other nanotechnology patents can and

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155 Id. at 1049.
156 Id.
157 See id. at 1054.
158 Id. at 1053.
159 Id.
161 See supra Part II.
should prevent patents filed at that scale, subject to the patentability considerations already defined.\textsuperscript{164}

The more difficult question arises when prior art for a much larger device challenges a nanotechnology patent.\textsuperscript{165} While this is a unique and potentially rare situation, it could have a profound effect on patents at the nanoscale level.\textsuperscript{166} Take for example the invention of a “nanodrill.”\textsuperscript{167} Perhaps one day researchers will develop a device, similar to the drill you would find in your DIY tool kit, with a rotating shaft capable of grinding away small holes just a few nanometers wide.\textsuperscript{168} This would not be much of a stretch based on the progress of current developments.\textsuperscript{169}

It is easy to imagine potential uses for such a device too. In drug delivery applications, this could be used to target the interior of cells or penetrate certain barriers such as the blood-brain barrier.\textsuperscript{170} In fact, a similar concept can already be found in nature. Scientists discovered that certain bacteria use a nano-sized “drill” to cut away holes in the exterior of our cellular walls to attack our cells.\textsuperscript{171} A man-made version of this could have exciting implications for medical treatment.\textsuperscript{172}

This illustration, though admittedly simplistic, shows how a claim might be brought from patent holders of larger-scale drills.\textsuperscript{173} There likely is not any single owner of a patent on a drill as a whole and, if someone ever did, it would be long expired

\textsuperscript{164} Supra text accompanying notes 100–08.


\textsuperscript{166} See id. at 129–30.

\textsuperscript{167} For a similar product, see, e.g., HONEYBEE ROBOTICS: NANO DRILL, https://www.honeybeerobotics.com/portfolio/nano-drill/ [https://perma.cc/KYS3-XZR8].

\textsuperscript{168} See, e.g., id.

\textsuperscript{169} Researchers have already created nanoscale motors powered by light. See Nagatoshi Koumura et al., Light-Driven Monodirectional Molecular Rotor, 401 NATURE 152, 152 (1999); Ming Liu et al., Light-Driven Nanoscale Plasmonic Motors, 5 NATURE NANOTECH. 570, 570 (2010).

\textsuperscript{170} See supra text accompanying notes 56–64.

\textsuperscript{171} See Henri-Francois Renard et al., Endophilin-A2 Functions in Membrane Scission in Clathrin-Independent Endocytosis, 517 NATURE 493, 496 (2014).

\textsuperscript{172} See Michael E. Gertner, Nanotechnology and its Impact on Clinical Medicine, 1 NANOTECH. L. & BUS. 147, 147 (2004).

by now.\textsuperscript{174} Any patents relating to drills today are likely based on small features and improvements.\textsuperscript{175} For the purposes of this Note, assume a patent exists for a powered drill that covers all of the basic ways in which it functions.\textsuperscript{176} Based on the courts’ rulings on issues of scale,\textsuperscript{177} the outcome of an infringement suit will likely depend on the extent to which the device is merely a scaled-down version of the existing patent.\textsuperscript{178}

\textbf{A. Patents for Nanoscale Devices Are Inherently Novel}

As noted previously, a claim must be novel in relation to applicable prior art.\textsuperscript{179} The prior art we are concerned with might describe generally the same functions as a new “nanodevice,” just with no mention of scale.\textsuperscript{180} The only real difference may be that the new device is composed of individual atoms or the method of construction might be through self-assembly of molecules.\textsuperscript{181} Although the original patent may describe the same device in broad terms, it should not preclude the new application on the nanoscale.\textsuperscript{182}

To fully appreciate the novelty of the nanodevice, it is important to consider just how small we are talking.\textsuperscript{183} What does our world look like “at the bottom?”\textsuperscript{184} Nanotechnology consists of the study and manipulation of materials ranging from 1 to 100 nanometers.

\begin{itemize}
\item\textsuperscript{174} Patents last for twenty years. 35 U.S.C. § 154(a)(2) (2012).
\item\textsuperscript{175} See, e.g., U.S. Patent No. 9,573,264 (filed December 17, 2010) (claiming handheld power tool with a “gear unit” and “switch device for switching the gear unit”).
\item\textsuperscript{176} Cf. Koppikar et al., supra note 173, at 28 (discussing how the growing number of patents has severely limited the advancements in a field and how those in commercial development must always be aware of the patents in their field).
\item\textsuperscript{177} See cases cited supra notes 132–59.
\item\textsuperscript{178} Roe, supra note 165, at 133.
\item\textsuperscript{179} See supra note 95 and accompanying text.
\item\textsuperscript{180} See Robert A. Freitas, What is Nanomedicine, 1 NANOED. 2, 2 (2004) (discussing the characteristics and capabilities of nanotechnology other than size).
\item\textsuperscript{181} See, e.g., id. at 7 (referencing the materials of construction being made up of atoms).
\item\textsuperscript{182} See Roe, supra note 165, at 133–34.
\item\textsuperscript{183} See Gregory Mandel, Nanotechnology Governance, 59 ALA. L. REV. 1323, 1328 (2008) (discussing the possibilities technology can bring when operating at the nanoscale).
\item\textsuperscript{184} Feynman, supra note 1, at 22.
\end{itemize}
nanometers. The prefix “nano” means one billionth, and thus, one nanometer is just one-billionth of a meter.

Even with that description, it is difficult to conceptualize this scale. Some more illustrative comparisons might help. A sheet of newspaper is about 100,000 nanometers thick. The human hair is typically about 80,000 nanometers in diameter. Yet carbon nanotubes, small cylindrical tubes of carbon used in numerous nanotechnology applications, are a mere 1 nanometer in diameter. Until recently, microscopes capable of resolving images at this scale did not exist. Devices at this scale approach the fundamental limitations of size.

Even physics behave differently at this scale. Of course, there is only one set of laws of physics that apply universally, but the classical physical laws we are accustomed to are minimized at this scale. Engineering constraints based on viscosity, friction, gravitational load, and wind resistance do not apply to the degree that it would make any meaningful difference. In their place, are intermolecular forces such as Van der Waals attraction, capillary action, and ionic repulsion that are negligible at a larger scale. In fact, these unique properties are what makes nanotechnology so promising. Scientists and engineers can take advantage of new forces and behaviors in ways that

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186 Id.
188 What is Nanotechnology?, supra note 185.
189 Size of the Nanoscale, supra note 187.
190 Id.
191 Inventors Gerd Binnig and Heinrich Rohrer were awarded the Nobel Prize in Physics in 1986 for the invention of the scanning tunneling microscope, capable of resolving images on the scale of 0.1 nanometers. C. BAI, SCANNING TUNNELING MICROSCOPY AND ITS APPLICATIONS 1 (2d. ed. 1992).
192 Anything we create must be composed of atoms and a mere 10 atoms side-by-side would measure about 1 nanometer. WOLF, supra note 17, at 1.
193 WOLF, supra note 17, at 2.
194 Id.
195 Id. at 26.
197 See WOLF, supra note 17, at 2.
have previously been unavailable. This becomes important in the consideration of novelty.

In the pre-nanotechnology era, the laws of physics were not a factor in determining novelty. Patent examiners could at the very least assume that basic concepts such as friction and gravity were uniform between two inventions. When comparing a nanotechnology patent with a patent for a much larger-scale invention, these assumptions are no longer valid. And this should make a difference when considering novelty. The two inventions are inherently different because they are premised on a different set of physical properties.

Our nanodrill might look and act similar to the ones we are accustomed to, or even achieve the same result, but it will utilize different forces to do so. Rather than magnetism, the motor may use light photons to create torque. The “bearings” might spin completely frictionless, something of which engineers at Black & Decker only dream. In essence, even if the claims are written with identical language with the only apparent difference being a recitation of dimensions, they cannot simply describe the same device. So when a patent for a device at this scale comes across an examiner’s desk, there should be, at the very least, a strong presumption that the claims are novel in comparison to all non-nanotechnology devices in the prior art.

198 See, e.g., WOLF, supra note 17, at 24.
199 See supra text accompanying notes 195–96.
200 Id. Initially, very few patent examiners were even familiar with nanotechnology. Bawa, Patent Proliferation, supra note 163, at 725.
201 See, e.g., WOLF, supra note 17, at 24.
202 MERGES & DUFFY, supra note 104, at 337.
203 See infra text accompanying notes 204–09.
204 See infra text accompanying notes 215–17.
205 Nanoscale technologies can take advantage of some of these fundamental differences as with the motor that is propelled by light photons. See supra note 169.
206 WOLF, supra note 17, at 25.
208 See supra text accompanying notes 204–07.
209 See supra Section III.B.
B. Patents for Nanoscale Devices Are Non-Obvious

Perhaps more concerning may be the treatment of nanotechnology patents with regard to obviousness. This requirement, called “inventive step” in some patent law systems, requires that the device be sufficiently inventive over combinations of prior art. There are very good reason why nanotechnology devices are, broadly speaking, inventive.

First, there is nothing obvious about the process researchers undertake in pioneering this new field of science. It would be naïve to claim otherwise. Billions of dollars have poured into nanotechnology research, and scientists are still tackling major preliminary hurdles. We do not quite yet have quantum computers because researchers can only keep atoms in their altered state for 2.4 milliseconds, which is still a whopping ten times longer than previous attempts. Scientists imagine ways to target drug delivery to cancer cells, but we are at the early stages of learning how different-shaped nanoparticles navigate through the body. It would seem that if there were anything obvious about the science, we would at the very least have nanoscale versions of all existing technology figured out.

It was only until fairly recently that researchers were able to create a nanoscale version of a car, complete with four wheels, independently rotating alkyne axels, and a photon-propelled motor. This nanocar could have important applications in

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210 See, e.g., MERGES & DUFFY, supra note 104, at 606.
211 “An invention shall be considered as involving an inventive step if, having regard to the state of the art, it is not obvious to a person skilled in the art.” Convention on the Grant of Eur. Patents art. 56, Oct. 5, 1973, 13 I.L.M. 270, 286.
212 Id.
213 See infra text accompanying notes 224–27.
215 See Quantum computers, supra note 53.
216 Bertrand et al., supra note 56, at 19.
217 See infra text accompanying notes 218–29.
218 BOUCHER, supra note 84, at 7–8.
transporting materials around, allowing precise placement of nanostructures.\textsuperscript{219}

Scientists had to overcome significant challenges in creating this car however. In the original nanocar, the wheels bonded with the surface below, locking the car in place.\textsuperscript{220} It was not until researchers increased the temperature to 200 degrees Celsius before the wheels were freed and the car could traverse the surface.\textsuperscript{221} As one author points out, it was far from a matter of taking the blueprints of a Ferrari and producing it at this scale.\textsuperscript{222} The same would be true for a nanodrill, or for that matter, any nanoscale reproductions.\textsuperscript{223} Significant challenges would prevent anyone from simply pulling the specifications for a Black & Decker power tool and reducing the dimensions by a factor of one billion.\textsuperscript{224}

The strongest arguments for invalidating nanotechnology patents based on obviousness might draw from various courts’ rulings regarding size—that mere scaling down of prior art is not an inventive step.\textsuperscript{225} These cases are easily distinguishable when applied to nanotechnology, however.\textsuperscript{226} One of the main rulings related to issues of scale is \textit{In re Rose}, discussed at length in Part II.\textsuperscript{227} The Court emphasized that the lumber package invention “at most relates to the size of the article under consideration which is not \textit{ordinarily} a matter of invention.”\textsuperscript{228} While it may

\textsuperscript{219} Id.

\textsuperscript{220} Boucher, \textit{supra} note 84, at 7 (stating that Shirai created the world’s first nanocar); Yasuhiro Shirai et al., \textit{Directional Control in Thermally Driven Single-Molecule Nanocars}, 5 Nano Letters 2330, 2331 (2005) (explaining that the wheels bonded to the surface).

\textsuperscript{221} Shirai et al., \textit{supra} note 220, at 2333.

\textsuperscript{222} Boucher, \textit{supra} note 84, at 16.

\textsuperscript{223} Id. at 17.

\textsuperscript{224} Such a design would require an electrical system. See, \textit{e.g.}, \textit{20V MAX Lithium Drill/Driver}, Black & Decker, http://www.blackanddecker.com/en-us/products/power-tools/portable-power-tools/drills/20v-max-lithium-drilldriver/bdcdd120c [https://perma.cc/GL32-YBLA]. However, nanoscale electrical systems have not been invented yet. See Boucher, \textit{supra} note 84, at 17.


\textsuperscript{226} See, \textit{e.g.}, \textit{infra} text accompanying notes 227–29.

\textsuperscript{227} See \textit{supra} text accompanying notes 142–46.

\textsuperscript{228} Rose, 220 F.2d at 463 (emphasis added).
not ordinarily be a matter of invention, in the case of nanotechnology, that is the very heart of the invention.  

In the example of the nanodrill, the only difference may be the use of single atoms as the material of construction. One could argue this is effectively a mere recitation of dimensions. But at some point this line of reasoning breaks down. Perhaps it is obvious to scale down an invention by factors of two, ten, one hundred, or even thousands. But when the object is scaled down by a factor of one billion times, to the point where the same fundamental forces do not even apply, and where a highly specialized microscope is required to even visualize the new scale, it is no longer merely scaled down.

Finally, it is unclear who a “person having ordinary skill in the art” would be. The brilliant engineers developing the most impressive automobiles on the road today would not be the same engineers able to finally create the nanocar. Nanotechnology is a highly technical and scientific field, and any advancements come from a very specialized subdivision of scientists and engineers. At the time of this Note, there are at least seventy specialized degree programs in nanotechnology in the US, and many schools offer doctorate programs in the field. Although a “person having ordinary skill in the art” is afforded some creativity

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229 See What is Nanotechnology?, supra note 185.
230 See, e.g., 20V MAX Lithium Drill/Driver, infra note 224; What is Nanotechnology?, supra note 185.
232 See infra text accompanying notes 233–34.
235 See BOUCHER, supra note 84, at 16.
238 Id.
when courts determine obviousness, nanotechnology is too unique of a field to be considered obvious to experts of any macroscale technologies.239

For these reasons, anything produced in the field of nanotechnology is inherently non-obvious with regard to macroscale devices.240 The examples used in this Part of course may be oversimplified, and the biggest area of concern will not likely come from the consumer power tools market.241 But any time the two patents are at such different scales that different forces are used and one invention consists of individual atoms, at the very least, a strong presumption should exist that anything produced at that scale is non-obvious.242

IV. POLICY REASONS WHY MACROSCALE PATENTS SHOULD NOT ANTICIPATE NANOSCALE REPRODUCTIONS

The previous Part of this Note attempted to show, through a technical application of the law, that nanotechnology patents should not be deemed invalid solely due to larger scale prior art.243 It is important to keep in mind the normative objectives of patent law when making this consideration.244 Broadly interpreting prior art claims to cover nanoscale counterparts would frustrate rather than serve these normative goals.245

The Constitution grants Congress the power to “promote the progress of science and useful arts, by securing ... to authors and inventors the exclusive right to their respective [w]ritings and [d]iscoveries.”246 Pursuant to this “intellectual property clause,” Congress has expressly authorized the USPTO to grant and issue

240 See supra Section III.C.
242 For another argument for heightened standard of obviousness in nanotechnology, see Roe, supra note 165.
243 See supra Part III.
244 See infra text accompanying note 248.
245 Id.
246 U.S. CONST. art. I, § 8, cl. 8.
patents and “establish regulations, not inconsistent with the law.” It is this promotion of “science and useful arts” upon which all of the patent system is based.

Federal patent laws must strike a delicate balance between promoting innovation and recognizing the need for imitation within the competitive economy. Patents essentially grant inventors with a monopoly of limited duration to exclude others from making, using, selling, or importing the invention. This incentivizes inventors, and investors, to put time, money, and effort towards developing an idea because they know they will have an opportunity to recoup these costs. The public also benefits from the rich market of technologies that are made available as a result. So, although the inventor holds a temporary monopoly, which is generally frowned upon, the result is a publicly available description of the invention that can either be invented around or used as a platform for refinement.

Although critics debate whether patent law truly serves this purpose, the ultimate goal is to promote the progress of science and innovation. Thus any application of patent laws that fails to serve this function would be inappropriate, perhaps even Constitutionally so.

A. Overprotection Concerns

Patent law promotes innovation by providing economic incentives for inventors to devote the resources necessary for innovation. It does so by limiting competition on the back end (after

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249 Id.
250 Id. at 150.
251 Id.
252 Id. at 151.
253 See id.
255 U.S. CONST. art. I, § 8, cl. 8.
256 See id.
257 See supra text accompanying note 95.
the patent is granted) but by promoting competition on the front end (racing to be the first to file).258 Thus, the success of our patent law system depends largely on economic incentives generated by the patent.259

To strike the balance in a way that promotes innovation rather than restricts it, the monopoly created by the patent must be finely tuned.260 To the extent that a patent holder can assert his right to exclude over other inventors, in markets not reasonably related to his invention, the economic rationale for patents begins to break down.261 The inventor may gain too much from his patent in ways that exceed the incentive required to justify his investment and that restrict other inventors from realizing their incentives.262

The issue in this Note considers a limited situation, where prior art is on the scale of one billion times larger.263 In this case, it is highly unlikely that the two inventors here would see any competition from their respective inventions. In the case of the nanodrill, it is hard to imagine any market in which the two inventors would be in competition. The Black & Decker drill would have applications in consumer products, construction and a number of related industries, whereas the nanodrill will likely have applications in the medical and pharmaceutical industries.264 The two could operate in conjunction seeing little interference within their respective markets.265 The same would be true for many of the promising applications presented in Part I.

To be fair to the macroscale inventor, he likely never considered any nanoscale applications of his invention.266 And nobody

260 Id. at 167 (noting the “careful balance” of the patent statute).
261 In re BRCA1- and BRCA2-Based Hereditary Cancer Test Patent Litig., 774 F.3d 755, 763 (Fed. Cir. 2014).
262 See Bonito Boats, 489 U.S. at 152.
263 See supra Part III.
264 Id.
266 Id. at 621.
would expect him to; it is outside of his expertise.\textsuperscript{267} But to grant him rights, and then restrict later entrepreneurial experts in nanotechnology, would give him too much.\textsuperscript{268} He only needs the incentives required to put forth his investment, which he has already received.\textsuperscript{269} Anything else would surpass the normative goals of patent law and give him too broad of a monopoly.\textsuperscript{270}

\textbf{B. Chilling Effect on Innovation}

While providing too much protection for previous inventors would disrupt the balance intended by the patent system, so too would the restraint placed on new inventors.\textsuperscript{271} Nanotechnology development is highly research-intensive and requires a significant upfront investment.\textsuperscript{272} Therefore, patents become even more important in bringing nanotechnology products to market.\textsuperscript{273} Researchers and investors will be less likely to put forth the initial investment if there is uncertainty surrounding the protection they can receive.\textsuperscript{274} This creates a sort of “chilling effect” on nanotechnology, which is the very thing patents are designed to avoid.\textsuperscript{275} To the extent that patents are hindering, rather than promoting, the progress of science, the protection they provide begins to frustrate the normative objectives of patent law.\textsuperscript{276}

\textbf{C. Reducing the Nanotechnology Patent Thicket}

The unique way in which nanotechnology has developed creates an exceptional need to avoid a further chilling effect.\textsuperscript{277} From early on, the United States has supported the excitement

\textsuperscript{267} See id.
\textsuperscript{268} See id. at 620.
\textsuperscript{270} Lemley, supra note 265, at 618.
\textsuperscript{272} See Bawa, Patent Proliferation, supra note 163, at 719.
\textsuperscript{273} Id. at 719–23.
\textsuperscript{274} Bawa, Nanotechnology Patenting, supra note 269, at 32.
\textsuperscript{275} See Makker, supra note 271, at 1176.
\textsuperscript{276} See, e.g., id.
\textsuperscript{277} See Lemley, supra note 265, at 613–14.
surrounding nanotechnology and has become a key player in the new “nano-race.” By 1991, the United States National Science Foundation had launched an entire program dedicated to nanoscience research. In the year 2000, at the same school where Feynman first gave his influential speech, President Bill Clinton announced that his 2001 budget request would include $500 million dedicated to a new National Nanotechnology Initiative (NNI).

This Initiative has continued to grow through today. President Obama’s 2017 budget, submitted in February 2016, provides over $1.4 billion dedicated towards the NNI. This will bring the cumulative total funding for the NNI to nearly $24 billion since Clinton’s announcement. As shown by this dedication in funding, there is little doubt that nanotechnology will continue to be an important focus of research for quite some time.

Following the wave of lucrative funding that the NNI has provided, researchers are swarming to develop the technology. Patents are crucially important in the commercialization of the technologies and serve as useful business tools for securing investments. Because nanotechnology is highly research-intensive, getting products into the marketplace will be greatly hindered without patent protection. Recognizing this, startups, corporations, and universities have aggressively sought to carve out broad and far-reaching patent protection. And the USPTO has

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278 By 2015, an estimated combined total of over $250 billion had been invested in nanotechnology research by US government and private sectors making the US a global leader in the field. See Dong et al., supra note 8, at 8.


280 Corie Lok, Small Wonders, 467 NATURE 18, 19 (2010).


282 Id.

283 See id.


285 Bawa, Patent Proliferation, supra note 163, at 713, 719.

286 Id. at 719.

287 Bawa et al., supra note 32, at 428.
been generous in granting them.\textsuperscript{288} This has been referred to as the “gold rush” of nanotechnology patents.\textsuperscript{289}

This “gold rush” has created many concerns among commentators.\textsuperscript{290} At least as early as 2004, commentators pointed out that nanotechnology advancements will be impeded by the “patent thicket” that has developed.\textsuperscript{291} During this key developmental stage, the USPTO granted hundreds of overly broad and far-reaching patents that clearly overlap.\textsuperscript{292} As Professor Mark Lemley points out, nanotechnology is unique in that the very building blocks of the industry have been patented up front.\textsuperscript{293} During the proliferation of patents being granted through 2004, relatively few actual products were being produced.\textsuperscript{294} This means that the majority of patents are on the building blocks of the technology, rather than the final product.\textsuperscript{295} Many of these “building block” patents come from universities trying to gather protection for their researchers.\textsuperscript{296} This is different than many other fields of invention in history, such as computers, software, and the Internet, where the basic building blocks went unpatented.\textsuperscript{297}

Not only have the building blocks been patented up front, but due to the patent “gold rush,” many of these building blocks have been granted overlapping patents.\textsuperscript{298} Take the carbon nanotube for example, which is a basic building block with promising properties.\textsuperscript{299} John Miller points out that the USPTO granted patents for carbon nanotubes very generously early

\textsuperscript{289} Bawa et al., supra note 32, at 428.
\textsuperscript{291} See, e.g., Lemley, supra note 265, at 618.
\textsuperscript{292} Sean O’Neill et al., \textit{Broad Claiming In Nanotechnology Patents: Is Litigation Inevitable?}, 4 NANO\textsc{tech}. L. \& BUS. 29, 30 (2007).
\textsuperscript{293} Lemley, supra note 265, at 613–14.
\textsuperscript{294} Id. at 604.
\textsuperscript{295} Id. at 606.
\textsuperscript{296} See id. at 615.
\textsuperscript{297} Id. at 606.
\textsuperscript{298} Id. at 618 (citing JOHN C. MILLER ET AL., THE HANDBOOK OF NANO\textsc{TECHNOLOGY}: BUSINESS, POLICY, AND INTELLECTUAL PROPERTY LAW 69–71 (2005)).
\textsuperscript{299} See Miller & Harris, supra note 288, at 428–32.
By 2006, there were already 446 patents for carbon nanotubes issued in the US. Miller suggests this is likely due to a number of challenges the patent office faced in dealing with such a new industry.

First, nanotube research has applications in a wide range of disciplines, including chemical and materials engineering, semiconductors, and biotechnology. Prior to 2004, the USPTO did not have a dedicated nanotechnology examination group or a prior art classification for nanotechnology. As a result, very similar patent applications were directed to different technology centers where they were reviewed in reference to case law and prior art unique to that technology center.

Second, Miller notes, applications have used different terminology to describe the same ideas. The terms “single shell nanocylinders,” “buckytubes,” “nanowires,” and “nanotubes” have all been used to describe the same thing. This resulted in increased difficulty for patent examiners in dealing with nanotechnology at such an early stage.

While patents are important for promoting commercial development, they can also impede this development. With the unique way in which nanotechnology patenting has unfolded, there are already significant obstacles for anyone new to the market. Imagine if the new nanodrill required nanotubes as part of its construction. There would potentially be hundreds of infringement claims with regard to the drill’s use of nanotubes alone. While licensing agreements with patent holders is often an option for navigating patents, when the volume of
potential infringement claims is so large, licensing with every patent owner can be cost-prohibitive.\textsuperscript{313} If the hypothetical macroscale drill patent owner could then bring his own patent infringement claims, it would only further complicate the matter.\textsuperscript{314}

Allowing the entire body of patents issued prior to the nanotechnology “gold rush” to further limit development in the field would be devastating.\textsuperscript{315} As patent filings become more focused on commercially viable products, rather than building blocks, there is already enough of a patent thicket that is a cause for significant concern.\textsuperscript{316} With all of the promise that nanotechnology brings, any additional unnecessary restriction should be avoided.\textsuperscript{317}

CONCLUSION

Nanotechnology is in a crucial stage of development and presents enormous possibilities for technical innovation.\textsuperscript{318} If even a small fraction of the benefits promised by recent research pan out, nanotechnology will likely revolutionize medicine, computing, agriculture, and potentially many other industries.\textsuperscript{319} It also presents unique challenges both for researchers but also for the law.\textsuperscript{320} In any new field of technology, the protection offered by patents is crucial to development, and the law is often faced with new challenges in interpreting the technology.\textsuperscript{321} But nanotechnology is unique. The entire field is based on manipulating matter at an extremely small scale, and much of the benefits might come simply from reproducing existing devices at this scale.\textsuperscript{322}

The law should not restrict development by extending broad protection from patents that are outside of the realm of nanotechnology.\textsuperscript{323} Protection for the macroscale devices should

\begin{itemize}
\item \textsuperscript{313} Bawa, Patent Proliferation, supra note 163, at 731.
\item \textsuperscript{314} See id.
\item \textsuperscript{315} Lemley, supra note 265, at 618–20.
\item \textsuperscript{316} Bawa, Nanotechnology Patenting, supra note 269, at 43; see Lemley, supra note 265, at 620–21.
\item \textsuperscript{317} Makker, supra note 271, at 1164.
\item \textsuperscript{318} Id.
\item \textsuperscript{319} Bawa et al., supra note 32, at 429.
\item \textsuperscript{320} See Makker, supra note 271, at 1196.
\item \textsuperscript{321} See id.
\item \textsuperscript{322} Chen et al., supra note 279, at 1; Lemley, supra note 265, at 621.
\item \textsuperscript{323} Lemley, supra note 265, at 621.
\end{itemize}
not preclude these nanoscale applications, and based on the patentability requirements of novelty and obviousness, there is no reason to do so.\textsuperscript{324} There is something inherently innovative and unique about development at this scale that is presumptively novel from macroscale prior art.\textsuperscript{325} Further, it would disrupt the normative objectives of patent law by providing too much protection for the previous patents and overly restricting new ones.\textsuperscript{326}

Researchers are on the brink of immensely promising and exciting applications in a new field of science.\textsuperscript{327} By avoiding the conclusion that this work is a mere matter of scale, we can eliminate at least one of the challenges researchers are faced with in bringing the benefits of this new technology into fruition.\textsuperscript{328}

\begin{footnotes}
\footnote{\textsuperscript{324} Id.}
\footnote{\textsuperscript{325} Id.}
\footnote{\textsuperscript{326} Makker, supra note 271, at 1176.}
\footnote{\textsuperscript{327} Id. at 1164.}
\footnote{\textsuperscript{328} See supra Part IV.}
\end{footnotes}