**Nanotechnology: A Sui Generis Field Deserves a Sui Generis Bundle of Rights In the United State and Internationally**

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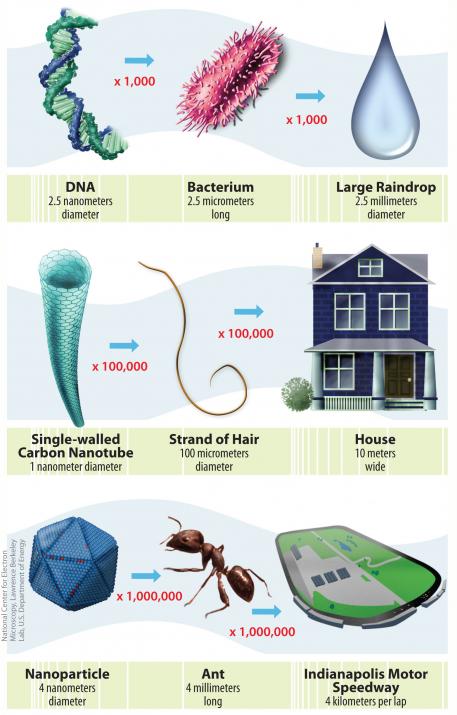
**Introduction**

What do you think of when you hear “nanotechnology?” For some, images of Star Trek like replicators[[1]](#footnote-1) come to mind or for those more sinister*,* self-replicating nanorobots from Michael Crichton’s novel, *Prey*.[[2]](#footnote-2) For others, its miniaturizing computers or molecular manufacturing.[[3]](#footnote-3) Then, there are those who think of buckministerfullerine (buckyballs) or carbon nanotubes.[[4]](#footnote-4) In truth, nanotechnology is an extremely broad field, and today it is often treated as a catchphrase because of all the hype around the potential it has.[[5]](#footnote-5) Emerging nanotechnology offers inventors intellectual property (IP) rights, however, it is important to consider what bundle of rights are best suited for nanotechnology inventors and society.

Nanotechnology (“nanotech”) controls and manipulates atoms.[[6]](#footnote-6) If we can manipulate atoms the possibility of creating whatever our imagination brings us is infinite.[[7]](#footnote-7) Until the 1980s, seeing atoms with the naked eye was impossible, but the Scanning Tunneling Microscope[[8]](#footnote-8) and Atomic Force Microscope[[9]](#footnote-9) changed the field entirely.[[10]](#footnote-10) In theory, the possibilities of nanotechnology are endless, as Richard Feynman said in his famous talk *There’s Plenty of Room at the Bottom,* “the principles of physics...do not speak against the possibility of maneuvering things atom by atom. It is not an attempt to violate any laws; it is something, in principle, that can be done; but, in practice, it has not been done because we are too big.”[[11]](#footnote-11)

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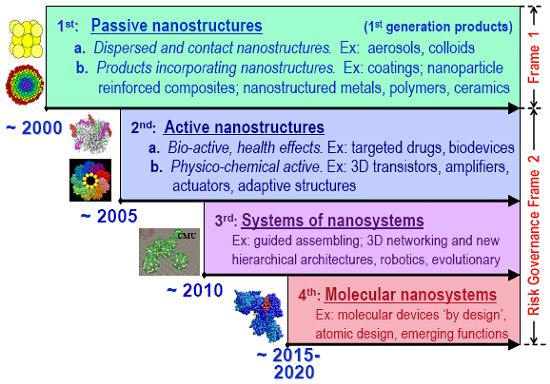
Because Nanotechnology is a field based on size it covers a very broad meaning. Many look to the United States National Nanotechnology Institute (NNI) for the adequate understanding of nanotechnology[[12]](#footnote-12), describing it as “the understanding and control of matter at the nanoscale, at dimension between approximately 1 and 100 nanometers, where unique phenomena enable novel applications.”[[13]](#footnote-13) See **Figure A**, for an illustration of how big a nanometer is and size comparisons.[[14]](#footnote-14) What is known about nanotech is that it is small, so small that it is one billionth of a meter.[[15]](#footnote-15) The trouble with understanding nanotechnology is that its’ broad understanding also encompasses many different fields, including, molecular physics, material science, chemistry, biology, computer science, electrical engineering, and mechanical engineering.[[16]](#footnote-16)



**Figure A**

The motivation to develop nanotechnology is a global effort.[[17]](#footnote-17) Nanotechnology has the potential of becoming a general-purpose technology.[[18]](#footnote-18) This includes four generations of products “with increasing structural and dynamic complexity.”[[19]](#footnote-19) See **Figure B.[[20]](#footnote-20)** The first generation includes passive nanostructures, such as, coatings, nanoparticles, nanostructured metals, polymers, and ceramics.[[21]](#footnote-21) The second generation includes active nanostructures, such as, amplifiers, targeted drugs, actuators, adaptive structures.[[22]](#footnote-22) The third generation consists of integrated nanosystems, such as, guided assembling, 3D networking, and new hierarchical

**Figure** **B**



architectures, robotics, and evolutionary.[[23]](#footnote-23) The fourth generation consists of molecular nanosystems, such as, molecular devices by design, atomic design, emerging functions. Currently, scientists have developed the first generation products and second-generation products. We have also entered a third generation for some technology. Accordingly, in the future we should see the fourth generation of nanosystem, which would be the kind Eric Drexler discusses.[[24]](#footnote-24)

After seeing the difficulty in understanding exactly what nanotechnology is, there is also the problem of determining what rights to give the ideas and designs of nanotech. The majority of nanotechnology rights are being done through patent protection. However, nanotechnology is difficult to pass patent review and even if it does receive a patent it may be hard to defend a patent that has been challenged.[[25]](#footnote-25) Some scholars and practitioners have suggested copyright would be a better form of protection for nanotech however copyright will not protect the idea of the design itself so some investors may not prefer this option. In the alternative, because of the importance of collaboration in nanotech some suggest open sourcing nanotechnology will provide many benefits to developing and researching the field of nanotechnology.[[26]](#footnote-26)

This discussion will be organized as follows: The first section explains problems nanotechnology inventions pose in today’s IP setting.[[27]](#footnote-27) The second section discusses what definition of nanotechnology should be applied for legal protection purposes.[[28]](#footnote-28) The third section discusses patent systems provided for nanotechnology in the United States, European Union, and Japan.[[29]](#footnote-29) Finally, this paper will propose the best intellectual property strategy for nanotechnology protection regardless of geographic location because nanotechnology is a global effort.[[30]](#footnote-30)

At the conclusion of this paper it should be understood that the focus of the nanotechnology field is to achieve molecular manufacturing which requires a development of top-down to bottom-up approach. This can only be done with less intellectual property protection for single firms and more public disclosure and collaboration along with a focus on prestige and knowledge expansion for the inventors and overall societal benefit with the development of greater technology. This can be done with a combination of copyright and open source strategy benefitting nanotechnology in the US and internationally.

1. **Issues in protecting nanotechnology**

Nanotech is an emerging market. It has been discussed as having the potential to becoming a general-purpose technology.[[31]](#footnote-31) This means nanotechnology will develop and evolve as a field and will “effect almost all areas of society.”[[32]](#footnote-32) As with many emerging fields, nanotechnology’s impact brings potential issues for the industry. It is also important to look at why protecting nanotech is important and how society is affected.

* 1. **Benefits the patent systems provide for nanotechnology do not out weigh its costs**

The biggest issue in patent protection for nanotech is the potential for litigation because of the broad claims in nanotech patents.[[33]](#footnote-33) Nanotechnology involves many different fields of study, as such, it requires patent offices to deal and understand cross-disciplinary technology, which many patent offices are not prepared for.[[34]](#footnote-34) One difficulty in nanotech is that often it may be based on already existing ideas but reformatted to be used on the nanoscale.[[35]](#footnote-35) When patentees do receive patents for their inventions they receive a limited monopoly in the market, preventing others from entering the market and represses competition, thereby reducing growth in the market.[[36]](#footnote-36)

* 1. **How nanotechnology Impacts Society**

When deciding what buddle of rights are to be given, it is important to give consideration on the impact of what exchange is given for those rights. When governments give these rights to an inventor, society must benefit in order to give these rights in the first place.[[37]](#footnote-37) This can be done by looking at the risks and benefits the technology or industry will give to society.

* + 1. **Risks: What does society give up in return for nanotechnology?**
       1. **Safety Issue**

Studies suggest a similarity between asbestos and carbon nanotubes because of their similarity in morphology and physicochemical characterizations and the application and use profile.[[38]](#footnote-38) Studies have found potential toxicity of nanotubes.[[39]](#footnote-39) This is especially dangerous for those working with nanotubes. However, not all nanotubes will be of equal hazard, suggesting regulation would be an appropriate regulation of potentially hazardous material.[[40]](#footnote-40) Nanotech substances “such as chemicals and nanomaterials can elude defense mechanisms and enter the body.”[[41]](#footnote-41) This can happen through inhalation, skin absorption, or ingestion.[[42]](#footnote-42)

* + - 1. **Environmental Issues**

Some studies suggest nanotechnology, particularly “nanoparticles might serve as environmental poisons that accumulate in organs.” [[43]](#footnote-43) There is concern that nanoscale particles “may enter and accumulate in vital organs, such as the lungs and brains, potentially causing harm or death or humans and animals, and that the diffusion of nanoscale particles in the environment might harm ecosystems.”[[44]](#footnote-44)

* + 1. **Benefits: What does society gain from nanotechnology?**

There are many benefits to nanotechnology. It is also important for society to understand these benefits to enable the right type of intellectual property protection. When society understands the benefits associated with nanotech applications they are more likely to accept nanotechnology when there are risks associated with them.[[45]](#footnote-45)

1. **Clean Water**

Advancement of technology gives society things that it needs and wants. In return, inventors have the incentive to create nanotech when they are given certain rights for their invention. For society, one important potential benefit is clean water. Through nanostructure materials technology is able to treat drinking water “using low-cost reusable, and sustainable biomembrane technologies.” [[46]](#footnote-46)

1. **Improving Clean Energy**

Another major advancement in technology is using nanotechnology in solar cells. Nanomaterials, such as, nano flakes and carbon nanotubes are used often in making solar cells.[[47]](#footnote-47) Benefits for manufacturing solar cells using nano flakes include creating cheap ways to produce solar cells, creation of solid-state heat engines to boost up to 60% energy, and a better way to focus on photons on the solar rays.[[48]](#footnote-48)

1. **Improving health and longevity**

One of the main health benefits by the utilization of nanotechnology is Robert Freitas’s (an expert in nanomedicine) respirocyte.[[49]](#footnote-49) He theorized respirocytes, which are hypothetical artificial red blood cells, could exist.[[50]](#footnote-50) Ideally they can supplement or replace the human body’s normal cellular respiratory system.[[51]](#footnote-51) However, respirocytes can store and transport 236 times more oxygen than regular human red blood cells.[[52]](#footnote-52) Applications include transfusable blood substitution, treatment for anemia, perinatal and neonatal disorders, lung diseases and condition, contribution to cardiovascular and neurovascular procedures, tumor therapies and diagnostic; prevention of asphyxia, maintenance of artificial breathing in adverse environments as well as other applications.[[53]](#footnote-53)

Other potential or in development nanotech currently being studied for the improvement of health and longevity of society include: advancements in cancer through nanotechnology-based cancer drugs,[[54]](#footnote-54) use of nanoparticles for chemotherapy and other drug delivery systems, nanosponges (technique that absorbs toxins and remove them from the bloodstream),[[55]](#footnote-55) ability to monitor the level of nitric oxide (monitoring inflammatory diseases),[[56]](#footnote-56) nanotech sensors that can detect low level cancer cells[[57]](#footnote-57), uses for antimicrobial agents (wound treatment)[[58]](#footnote-58), and many other advancements.

1. **Enabling space development**

Some experts discuss the possibility of expanding human needs into space. Possible contributions for nanotechnology through nanotech by making materials for travel increase payload, lower costs and increase safety.[[59]](#footnote-59)

* 1. **Why protect nanotech**

It is important to understand why an inventor would want to protect their invention in the first place to fully comprehend the issues the current IP system places on nanotechnology and how we can change the system for a better system anywhere in the world.

* + 1. **Patents**

We live in a “patent land grab”[[60]](#footnote-60) world, however, scientists often research based on their scientific curiosity.[[61]](#footnote-61) Why would scientists or inventors want to file a patent if they would invent the nanotech regardless of any incentive that stems from patent protection?[[62]](#footnote-62) There are four well-known positions to advocate for patent protection, they are: “natural-law, reward-by-monopoly, monopoly-profit-incentive and the exchange-for-secret.”[[63]](#footnote-63)

Under “natural-law”, people have “a natural property right in [their] own ideas.”[[64]](#footnote-64) With this in mind, natural law speaks about property as “exclusive,” therefore patent protection is a right for those who invent and is the “appropriate way for society to recognize this property right.”[[65]](#footnote-65)

In the “reward-by-monopoly” position, the argument believes that “justice requires a man receive reward for his services in proportion to their usefulness to society,” because society is required to give the inventor a “reward” for his usefulness it is “the most appropriate way…by means of temporary monopolies in the form of exclusive patent rights in their inventions.” [[66]](#footnote-66)

Under the “monopoly-profit-incentive” position the model is based on the assumption that “industrial progress is desirable, inventions and their industrial exploitation are necessary for such progress, but that inventions and/or their exploitation will not be obtained on sufficient measure if inventors and capitalists can hope only for such profits as the competitive exploitation of all technical knowledge will permit.”[[67]](#footnote-67) This means society must offer “temporary monopolies in the form of exclusive patent rights in inventions” to give capitalists and inventors the incentive to create technology for industrial progress.[[68]](#footnote-68)

Under exchange-for-secrets position, it follows the assumption that there is an exchange between inventor and society, where the inventor invents the technology and the society gives a “temporary exclusivity in knowledge in its industrial use.[[69]](#footnote-69) This is also based on the desire for progress and unless a patent is given to the inventor the secret might be kept with the inventor and never shared.[[70]](#footnote-70) Offering the possibility of future inventions that would be useful for society, but consequently not be invented.

* + 1. **Microscope Patents: The emergence of nanotechnology patents**

The Scanning Tunneling Microscope invented and later patent protected by two IBM researchers, Gerb Binnig and Heinrich Rohrer, allows scientists to see and position individual atoms using quantum tunneling, with higher resolution than the Atomic Force Microscope (AFM).[[71]](#footnote-71) [[72]](#footnote-72) The Atomic Force Microscope was invented by Binnig in 1986 and later patent protected.[[73]](#footnote-73) The Atomic Force Microscope obtains images by moving a nanometer sized probe across the surface of the image.[[74]](#footnote-74) The Scanning Tunneling Microscope (STM) is used for imaging surfaces at the atomic level and for conductance of single molecule.[[75]](#footnote-75) The Atomic Force Microscope is used for imaging, measuring and manipulating matter at the nanoscale i.e. DNA and proteins.[[76]](#footnote-76) Because of these two patents, the field of nanotechnology changed, the possibility of manipulating atoms at the atomic level was made easier and more realistic. IBM, the company whose employees invented these two microscopes, did not commercialize the inventions, but they did license the patents.[[77]](#footnote-77) The STM and AFM equipped scientist with the ability to “see an atomic-scale surface or object in detail both before and after the variable was manipulated.”[[78]](#footnote-78)

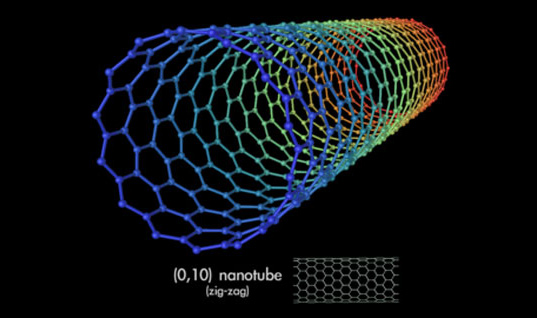
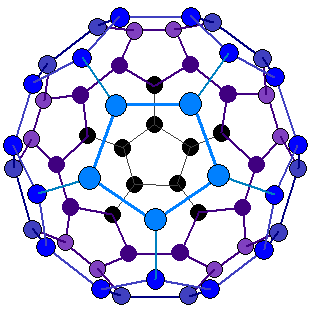
* + 1. **Copyright as the alternative to patents**

Copyright is a bundle of rights concerning authorship.[[79]](#footnote-79) Because copyright right law deals with the “ownership and use of works of literature, software, graphic designs, music an dart, copyright has its basic goal the enrichment of our society’s wealth of culture, knowledge, and information.”[[80]](#footnote-80) Copyright has the potential to be a great option for nanotech development because it applies to works made for hire, which is often the case in developing nanotech.[[81]](#footnote-81)

* + 1. **Carbon nanotubes and Buckyballs Patents**

In 1991, Sumio IiJima, a research fellow at NEC Corporation discovered carbon nanotubes.[[82]](#footnote-82) A carbon nanotube is a tube-shaped material made of carbon that has a diameter measuring on the nanometer scale.[[83]](#footnote-83) They are long chains of carbon atoms that are “extremely efficient at conducting and controlling electricity.”[[84]](#footnote-84) Solid-state carbon allotropes appear in four different forms, carbon nanotubes became the fifth.[[85]](#footnote-85) Another notable carbon allotrope first discovered in 1985 by Richard Smalley, Harold Kroto, and Robert Curl Jr., were fullerenes.[[86]](#footnote-86) The first fullerene known as, Buckministerfullerene, is a sixty-carbon atom form (C60) commonly known as “buckyballs” for their soccer ball-like shape.[[87]](#footnote-87) See Figure C.1 and C.2, for a visualization of fullerenes and nanotubes.[[88]](#footnote-88)

**Figure C.1**



**Figure C.2**

* 1. **Why an inventor would not want to protect nanotechnology**

Many countries have noted the importance of collaboration without the fear of stepping on patents. Since 2006 Japan and Canada have established a nanotechnology workshop.[[89]](#footnote-89) The EU and US have collaborated on some research proposals; many collaboration efforts have been established including, EU and Canada, EU and China, China and Japan, and many other countries.[[90]](#footnote-90) The Foresight Institute supported open source for nanotech as a way to prevent certain patents from patentability.[[91]](#footnote-91) An intellectual property software company, IP.com has set up a service offering open source disclosure.[[92]](#footnote-92) The US patent office also looks through their database for prior art.[[93]](#footnote-93)

* + 1. **Would an inventor want to protect Molecular nanotechnology**

Molecular nanotechnology here is considered under the Drexler approach, where true nanotechnology is considered molecular manufacturing.[[94]](#footnote-94) The ability to protect this type of technology is valuable through both natural law right and incentive rights.

John Locke’s theory on natural law rights argued people are entitled to individual property rights when they use their own labor to add something to nature.[[95]](#footnote-95) People may claim things as their property as long as “there is enough and as good left in common for others.”[[96]](#footnote-96) Individual rights (i.e. patents, copyrights, trademarks) given to individuals are appropriate where the rights the individual claims are “original only to him or her, leaving all the ideas and information that existed before.”[[97]](#footnote-97)

Incentive Rights in intellectual property rights refers to the economic incentives given to inventors who will receive a bundle of rights if their invention passes the requirements.[[98]](#footnote-98) Incentives usually come with a quid pro quo between society and the inventor(s). Inventors will be given a bundle of rights, which will benefit them in return for their contribution to society.[[99]](#footnote-99)

1. **Nanotechnology what does it mean?**

Discussing “nanotechnology” often gives off a perplexed look follow by the question: What exactly do you mean? There is a lot of hype in nanotechnology, mainly because when most people think of nanotechnology they think of the science fiction versions of nanotech. Another issue is in the fact nanotechnology bases its area of expertise on anything that can be classified on a nanoscale. The fundamental question when pondering the complexities of nanotechnology is: how to control the building blocks of matter from the bottom up.[[100]](#footnote-100)

* 1. **The Size of Nanotechnology**

Because nanotechnology is an industry based on the size of the technology many people have different interpretations of what it means. Nanotechnology is “by different people at different times…anything from 0.1nanometers (controlling the arrangement of individual atoms) to 100 nanometers or more (anything smaller than microtechnology).”[[101]](#footnote-101) Internationally, the International Organization or Standardization (ISO) defines the field of nanotechnology as the understanding and control of matter and processes at the nanoscale, typically, but not exclusively, below 100 nanomet[ers] in one or more dimensions where the onset of size-department phenomena usually enables novel applications.[[102]](#footnote-102) Although the world has for the most part come to an agreement on what the size of nanotechnology is, this also encompasses many fields of study. When a company or inventors has a desire to protect nanotech, it is important for others to understand nanotechnology and the specific field that the technology is intended for.

* 1. **Nanotechnology Background**

In Richard Feynman’s famous 1959 talk, *There’s Plenty of Room at the Bottom,* which looked at an important approach to nanotechnology, known as the top-down approach.[[103]](#footnote-103) Although the term “nanotechnology” was not coined until later, the idea Feynman meant to bring across to others is that there is “ a universe of space between the size of human-scale machines and the size of atoms.[[104]](#footnote-104) The “top-down” approach is “a process that starts form a large piece and subsequently uses finer and finer tools for creating correspondingly smaller structures.”[[105]](#footnote-105) Top-down nanotechnology like making a stone statute requires material waste. This process is used in silicon technology.[[106]](#footnote-106)

K. Erick Drexler, a graduate student at MIT studying matter at the molecular level and later encountered Feynman’s Paper.[[107]](#footnote-107) Because of the confusion concerning “nanotechnology” Drexler relabeled his goals of molecular assemblers “molecular manufacturing.”[[108]](#footnote-108) His vision of nanotechnology supports molecular manufacturing based on the bottom-up approach.[[109]](#footnote-109) The “bottom up” approach is a “self-assembling” approach to development, where “atomic or molecular dimensions self-assemble together…to give rise to larger and more organized systems.”[[110]](#footnote-110)

See Figure D, for a visual understanding of bottom-up and top-down approaches.[[111]](#footnote-111)

* 1. **Debate Against Molecular Nanotechnology: Smalley and Drexler Debate**

Cluster

Atoms

Powder

Nanoparticles

Bulk

Top-Down

Figure D

Bottom-Up

Drexler’s theory of nanotechnology largely consists of general assemblers, where these assemblers could manufacture anything “with atomic precision and no pollution.”[[112]](#footnote-112) General assemblers are mechanical devices capable of precisely positioning reactive molecules and therefore able to guide chemical reactions, based on bottom-up cellular assembly already common in nature.[[113]](#footnote-113) This theory shows that it could build on anything to specification like copies of itself with feedstocks (i.e. carbon).[[114]](#footnote-114) This process would transform industrial manufacturing into a process that uses cheaper goods and produces little to no waste.

On the other side of the debate, Richard Smalley focuses mainly in carbon nanotubes, and nanotechnology in chemistry and physics (*See*, II. C.).[[115]](#footnote-115) He looks at what can be done in lab and relies on actual practices known today with knowledge of how to get tangible results. Smalley questions whether these general assemblers are even possible compared to what is actually possible in physical and chemical principles.[[116]](#footnote-116) While Drexler believes this is possible, Smalley believes the required control necessary for the nanomaterials does not exist.[[117]](#footnote-117)

Ultimately two different approaches to general assemblers seem to be theoretically possible: a mechanical approach and a chemical approach. A mechanical approach requires a great amount of control over atoms in order to handle them. On the other hand, a chemical approach to general assemblers, which questions the ability of controlling chemical reactions. Smalley argues that the mechanical approach is based on the chemical process, which will ultimately limit and again lack the control required to the make general assemblers.[[118]](#footnote-118)

Although Drexler’s general assemblers do not yet exist, through use of Scanning Tunneling Microscopes building structures atom-by-atom gives more control and precision in manipulating atoms.[[119]](#footnote-119)

* 1. **Ultimate conclusion**

The final question in this section is whether nanotechnology should be based on a top-down approach or a bottom up approach seeing nanotechnology with the goal of molecular manufacturing industry. Some high-precision machinery has been created in order to bring about this bottom up approach, including an electron-beam lithography that can cut within the 10-nanometer range.[[120]](#footnote-120) This issue brings to light that fact that the bottom-up approach is still theoretical and the true nanotech idea has not come into reality.

The Foresight Institute suggests these two theories should be used in unison to form a better more uniform approach to the true concept of nanotechnology. They suggest that the bottom-up approach will be the way parts are made and the Top-down will be the way they are put together. Meaning, in order to pursue nanotechnology in historical visions of both Feynman and Drexler these two theories must be used in order to get the outcome (general assemblers). Once we get general assemblers many nanotech benefits will be seen and more incentive for inventors to create and research different technology through nanotech. Now that we see what exactly nanotechnology is meant to be, it is important to understand what intellectual property rights will best fit inventors and society within this understanding of nanotechnology.

1. **Patents in Nanotechnology**

Nanotechnology is as discussed above involves many different fields of study, as such, it requires patent offices to deal and understand cross-disciplinary technology.[[121]](#footnote-121) Because of the Atomic Force Microscope, the ability to patent nanotechnology increased.[[122]](#footnote-122) The biggest issue in patent protection for nanotech is the potential for litigation because of the broad claims in nanotech patents.[[123]](#footnote-123) Since nanotechnology is still in early development, the fear is overlapping.[[124]](#footnote-124)

Discussed above, the patent bargain between the inventor and society, society promises the inventor that it will protect is invention for a limited time and in return the inventor discloses to the public the process used to create the innovation.[[125]](#footnote-125) Countries around the world have their own patent systems some of which are similar to the United States and some are different. Looking at different approaches will help to understand what approach is best overall for nanotechnology intellectual property rights. Patents in the United States, Europe and Japan will be discussed where an estimated 90 percent of the world’s patents are issued through these offices.[[126]](#footnote-126)

* 1. **How the United States Protects Nanotechnology through patents**

In the United States, the patent process requires the applicant must bee the first to file. This requires a filing fee, applicant’s oath, necessary drawings, and a written description.[[127]](#footnote-127) The USPTO classifies the application and sends it to an examining group that usually handles the type of invention in the application.[[128]](#footnote-128) The USPTO gives each examiner a specialization and requires the examiner to determine whether the application meets the standards for a patent.[[129]](#footnote-129) Despite this specialization, the complexity that comes with understanding nanotech patents may not what should be required of the examiner because their only educational requirements are a bachelor’s degree in science or engineering with a 3.0 grade point average or perform one year of work in the relevant field.[[130]](#footnote-130) Especially considering Drexler was the first person to receive a doctorate in molecular nanotechnology in 1991.[[131]](#footnote-131)

**1. Utility requirement issue**

Cross-disciplinary understanding of nanotechnology makes determination of usefulness more complex than many other patents because there can be many applications to nanotechnology.[[132]](#footnote-132) Patent examiners may lack the ability to understand what nanotechnology implications will be applied in the current field and other fields that the potential patent may impact.[[133]](#footnote-133) This is not patent examiners fault because there is quite a lot that is not yet understood about nanotechnology, especially when the field of molecular manufacturing has not yet been created.[[134]](#footnote-134)

Because of the need to produce a product for investors and the time and money it takes to develop nanotechnology for many by the time a patent application is reviewed it is still only partially in research and development.[[135]](#footnote-135)

2. **Novelty Requirement**

One difficulty in nanotech is that often it may be based on already existing ideas but reformatted to be used on the nanoscale.[[136]](#footnote-136) Prior art issues for patent examiners will be difficult unless they decide that all prior art unless on the nanoscale will not be applied to nanotech patents. Currently, the USPTO requires nanotech applications to establish the improved function of a nanocreation over its larger traditional counterpart believing mere diminution in size, absent new application, is insufficient grounds for patent approval.[[137]](#footnote-137)

This however is contrary to why nanoparticles in innovation work differently than all others. Based the laws of quantum mechanics the very effect of nanoparitcles may be different for all materials, which is why it is important to be able to have a great amount of control when experimenting with nanotechnology and being able to see the different reactions applied to material itself changes the invention itself.[[138]](#footnote-138) *In re Hoeksema,* the patent examiner rejected a claim of a chemical compound because prior art already suggested its claim. The court on appeal suggested that the chemical compound could be unobvious even though its structure is suggested, when no process existed at the time that would have enabled its production.[[139]](#footnote-139) The fact that nanotechnology may have various application and effect to materials that does not exist on the larger scale should mean the novelty and non-obviousness requirements of those larger patents should not apply when considering nanotech patents.

**3. Overbroad Patents**

As an emerging field and a field in rapid progress nanotech patents are prone to receive overbroad protection. It is clear why one would want to receive a broad patent protection, “the broader the scope the larger the number of competing products and processes that will infringe the patent.”[[140]](#footnote-140) In quid pro quo fashion, society wants to reward inventors for their inventions by giving them a limited monopoly. This is true especially when in emerging fields like nanotechnology the research and development costs will be high.

Receiving a patent is important for inventors in order to protect the patentee from free riders who have not spent money on R&D because the patentee has already expended money on trial and error and allowing the patentee to perfect their invention. Patents allows the original inventor to regain their expenditure from R&D, while preventing free riders the advantage of using the original patentee’s research and putting the invention on the market at a lower price for consumers. The original patentee will have to set the price of their invention to off set the costs from R&D, which is why this limited monopoly is an incentive for the patentee in the first place. For patentees looking to enter the nanotechnology market they will be given a first mover advantage over other inventors, however, when patent offices allow an overbroad description over their patent this has implications on the inventors who want to improve the original patent or are currently working on the same or similar idea. As mentioned above, Mihail Roco’s four generations of nanotechnology poses potential issues for next generation patents. Under an incentive right of patent law, post-invention conditions should be favorable to inventors “in order to make an extension of an initial patent to cover subsequently developed versions of the invention.”[[141]](#footnote-141) If overbroad patents in nanotechnology are being approved what effect will that have on the third and fourth generation of nanotechnology?

Edmund Kitch poses the question regarding how patent scope decisions influence the development of technology, arguing that granting a broad scope to an initial inventor induces more effective development and future invention. Kitch’s theory, the *prospect theory* of patent rights argues that a single patentee dominating a “technological prospect” allows development to be under the control of a single patentee and rivalry among competitors to avoided allowing the patentee to control their invention.[[142]](#footnote-142) Kitch ignores the past experience where when a patentee “develops and becomes competent in one part of a prospect it may be hard for it to give much attention to other parts, even though in the eyes of others, there may be great promise there.”[[143]](#footnote-143) As a result, more independent improvers will generate a broader range of ideas in development than a single patentee would with control over the invention.[[144]](#footnote-144)

This issue may be solved by determining whether society and the inventor will be better of by either allowing the improving inventor to improve the original patent or whether it is better off by allowing the original patentee the broad right to exclude others. While a limited monopoly allows the original patentee to recover costs it also stifles innovation during that time unless the original patentee allows others to use their patent through licensee, which would require the improver to pay an extra cost in R&D as well as increase the costs to the consumer for the invention. The problem with monopolies is that the market allows the monopolist (original patentee) to decide at what price to sell an invention and how much of to produce. A common effect results in deadweight loss, where the price the monopoly price may only be the desired price for a certain limited number of consumers resulting in a market of consumers who would like the product but will not buy it at the monopoly price. Another effect of monopoly is that the monopolist is less likely to produce the amount of product demanded, this result in a market of consumers who will not receive the product. Without competition and the fear that others will sell the product if they do not, society is worse off. In a scenario where overbroad patent rights are given to the original patentee it requires patent improvers or even those who are researching the area themselves are required to obtain a license or assignment from the patent holder who may limit the scope.[[145]](#footnote-145)

Robert Merges and Richard Nelson argue that “without extensively reducing [the original patentees] incentives, the law should attempt at the margin to favor a competitive environment for improvements, rather than an environment dominated by the [original patentee].”[[146]](#footnote-146) They find that the costs to society because of the loss of competitive for improvements to the original invention outweigh the benefits of the original patentee (see Kitch’s argument)[[147]](#footnote-147).[[148]](#footnote-148) If society is better off with more competition and improved inventions, then through the reverse doctrine of equivalents the improver of a patent should be free from infringement liability because the original patentee’s rights to exclude other inventors from improvement shows an inefficient use of their right.[[149]](#footnote-149) On the other hand, the doctrine of equivalents under patents allows a court to find a patent infringer liable even though the infringer does not fall within the literal scope of a patent claim but is the equivalent to the claimed invention.[[150]](#footnote-150) The reverse doctrine of equivalents, as discussed above, even if the invention technically infringes the patent a court may allow the original patent to be narrowed in scope so the new invention does not infringe even when it is substantially similar.[[151]](#footnote-151)

Although the reverse doctrine of equivalents is likely to result in the best outcome for society it may be difficult for the improver to establish. In Roche v. Apotex[[152]](#footnote-152), where Roche’s patent for the treatment of an eye inflammation drug and Apotex was sued for infringement of a of a prior suit, Apotex failed to establish non-infringement under the reverse doctrine of equivalents for failure of providing a prima facie case.[[153]](#footnote-153) The federal court stated reverse doctrine of equivalence applies when a device is so far changed in principle from a patented article that it performs the same or similar function in a *substantially different way*, but nevertheless falls within the literal words of the claim.[[154]](#footnote-154) The accused infringer has the burden of showing a prima facie case of non-infringement under the reverse doctrine of equivalents.

This case establishes not only the difficulty in receiving a patent in the potential next generation invention of nanotechnology but also the difficulty in the creation of nanotech improvements.[[155]](#footnote-155) Current overbroad protection treats substitute technology through the doctrine of equivalents as already in existence.[[156]](#footnote-156) Because improvers have the ability to make better technology than the patent technology, the overbroad patents could discourage useful research.[[157]](#footnote-157) Unless patent reform allows a narrower look in the patent application then much progress in nanotechnology will be stifled.[[158]](#footnote-158) For example, the Edison Patent[[159]](#footnote-159), where the market share grew from 40 percent to 75 percent resulted in fewer firms in the market, the Edison General Electric Company’s “technological contributions were becoming relatively smaller than they had been during the early [1880s].”[[160]](#footnote-160) This broad patent slowed down progress in this field of patent technology.[[161]](#footnote-161)

Whether or not US Patent system is a good fit for nanotechnology cannot be determined under the current patenting system because of the tendency of examiners to give overbroad patent rights to original patentees. This not only limits competition but also limits research and development in the nanotechnology field. For society, the quid pro quo for nanotechnology would not be equivalent if the first inventors receive patent rights and do not develop the emerging field for the benefit of society.

* 1. **How nanotechnology is protected internationally through patents.**

Most international countries use the first to file system for patents, giving the first inventor who successfully completes all application requirements the patent rights. Each country has developed its own unique patent system.

**1. Europe Union**

As in the United States, nanotechnology inventions in Europe include “entities with a controlled geometrical size of at least one functional component below 100 nanometers in one or more dimensions susceptible of making physical, chemical.[[162]](#footnote-162) Also similar to US, all patent applications require: novelty, must involve an inventive step, it must be susceptible to *industrial application*, and the invention must be adequately disclosed and the claims must be clear, concise, and supported by the description.[[163]](#footnote-163) In January 2011, the European Patent Office began an international patent classification system for nanotechnology patent applications.[[164]](#footnote-164) The European Patent Office believes this new international classification “improves public access to information on these fields and creates a significant benefit for the whole patent systems.”[[165]](#footnote-165)

Under this system, the “industrial application”[[166]](#footnote-166) requirement limits the patent system compared to the United States system.[[167]](#footnote-167) Article 52 of the European Patent Convention provides subject not suitable for patentable inventions: (a) discoveries, scientific theories and mathematical methods; (b) aesthetic creations; (c) schemes, rules and methods for performing mental acts, playing games or doing business and programs for computers; (d) presentations of information,” expressly excluding computer software per se, however this does not include the application towards the resolution of technical problems.[[168]](#footnote-168) Article 57 provides for what can be considered industrial application: if it can be made or used in any kind of industry, including agriculture.”[[169]](#footnote-169)

**2. Japan**

In Japan, the Japan Patent Office examines all applications from around the world.[[170]](#footnote-170) The Japan Patent Office uses a first to file system.[[171]](#footnote-171) The patent examiner looks at whether the application meets the requirements include: whether the claimed invention is based on a technical idea which utilizes a law of nature; whether the technical idea existed before the filing of the current application; whether the claimed invention could have been easily invented by a person skilled in the art; whether the claimed invention is liable to contravene public order and morality; and whether the description in the specification conform exactly with the requirements for patentability.[[172]](#footnote-172)

Like the European office, the Japanese Patent Office has a requirement for industrial application. This requirement is “complementary” to the first requirement (the creation of technical ideas utilizing laws of nature). This requirement included in both the European and Japanese patent law upholds the integrity of their patent systems.[[173]](#footnote-173)

* 1. **Comparison** 
     1. **First to File, Novelty and Obviousness**

After the Leahy-Smith America Invents Act (AIA)[[174]](#footnote-174), the United States patent system was harmonized with Europe and Japan moving toward a first inventor to file system.[[175]](#footnote-175) This also changed the prior art component of the system. For patent applications after March 16, 2013, the first inventor to file system came into play changing to more of a race than before.[[176]](#footnote-176) The new system for United States prior art includes public disclosures of the claimed invention occurring anywhere in the world rather than the United States alone. Applications of prior art include patents and published applications domestic or foreign filing and foreign priority dates of prior art disclosures may be used in the United States to challenge later filed patent claims.

The European Patent Convention used in 38 States across Europe requires absolute novelty and includes a first to file system.[[177]](#footnote-177) However, it examines patents filed only under the European Patent Convention. While national patent systems exist in parallel with the European Patent Convention the patent application for a particular country is governed separately than the European Patent Convention.[[178]](#footnote-178) The novelty requirement is satisfied if “it does not form part of the state of the art”[[179]](#footnote-179), which comprises of “everything made available to the public y means of a written or oral description, by use, or in any other way, before the date of filing of the European patent application.”[[180]](#footnote-180)

Japanese Patent Law is also a first to file system and requires novelty throughout the world.[[181]](#footnote-181) Article 29(1) of Japanese Patent Law requires an invention be industrially applicable to be given patent rights unless the it was “publicly known, publicly worked, described in a distributed publication, or made publicly available in Japan or a foreign country prior to filing of the patent application.[[182]](#footnote-182) Article 29(2) of Japanese Patent Law denies patents if the invention “would have been easily made based on any of the prior art categories included in Article 29(1), however, earlier-filed later-published applications are not available prior art for obviousness considerations.[[183]](#footnote-183)

**2. Policies and Examination Procedures**

The USPTO policy for the Duty of Disclosure, Candor, and Good Faith rule requires a patent applicant to disclose and cite all prior related work they are aware.[[184]](#footnote-184) The Europe Patent Office does not have this requirement and a majority of the citations are added by the examiner. As a result of this process, a larger portion of USPTO patent applications are granted than EPO applications.[[185]](#footnote-185)

**3. Nanotechnology Patent Comparison**

Regardless where in the world the patent is filed there is a global impact for the patentee. Considering nanotechnology is also a global effort both in collaboration and competition with each other impacting those who want patent protection and giving those in a certain part of the world the potential monopoly in the market to develop nanotechnology inefficiently and stifle progress.

In a study from 2012, the USPTO issued 54 percent of the nanotech patent applications and grants reviewed.[[186]](#footnote-186) In comparison Japan only had 7.1 percent.[[187]](#footnote-187) In a 2013 study, the total volume of published nanotechnology patent literature increased 5 percent and tripled since 2003.[[188]](#footnote-188) United States nanotechnology patents issued in 2013 was more than 6,000, a 17 percent increase from 2012.[[189]](#footnote-189) 54% of the nanotechnology patent literature publish in 2013 was based in United States, with Japan at 8% in comparison.

While all three systems have similarities including: use of a first to file system, use of public disclosures made anywhere in the world, in any language to disqualify prior art for purposes of determining novelty and obviousness, also earlier-filed later-published applications can be used to determine novelty.[[190]](#footnote-190) There are still differences after AIA, for example, in the Japan and Europe require “absolute novelty” and “industrial requirement” The utility patent system in the three top patent systems results in overbroad patent rights in an emerging field where competition in the market is important and cooperation in the development of the field is necessary in order to develop nanotechnology and make the world better off. This section suggests nanotechnology field would be better off without utility patent protection.

* 1. **Design patents rather than utility patents**

Many other countries have an intellectual property doctrine that is completely separate from their patent systems and covers industrial designs similar to design patents in the United States.[[191]](#footnote-191) For the United States, an inventor can receive a design patent for “any new, original and ornamental design for an article of manufacture.”[[192]](#footnote-192) This patent protects only a design for a term of 14 years.[[193]](#footnote-193)

In Japan, an inventor can receive a “Design Right” through a registered design.[[194]](#footnote-194) The design right requires an application that contains: a design (shape, pattern, color or combination of these) in an article which arouses an aesthetic impression via the sense of sight; the design can be utilized industrially; design should be innovation and without precedent; and some other requirements.[[195]](#footnote-195) The design has a protection term of 20 years with an annual fee, however if the form of the design becomes famous it can receive protection under the Unfair Competition Prevention Law even after design rights lapse.[[196]](#footnote-196)

In Europe, one can receive a community design under European Community Design Regulation, which is applicable everywhere in the European Union.[[197]](#footnote-197) If the design is unregistered the term for protection is 3 years from publication in the EU with no renewal fees and no formalities required other than keeping documentary evidence of making the design in case of enforcement. If the design is registered the term for protection is up to 25 years with renewal fees every five years and an application filed with an appropriate office.[[198]](#footnote-198) This gives protection to designs of whole or part of a product, including any industrial or handcraft item, including parts of a more complex product, packaging, get-up, graphic symbols and typographic interfaces.[[199]](#footnote-199) The design is required to be novel and must have individual character.[[200]](#footnote-200)

Many inventors will believe utility patents are the better type of patent because it protects the functional aspects and has a broad protection. However, because of this broad protection, the future of the nanotechnology field will have a difficult time growing. Although design rights do not protect functional features of nanotechnology, the costs in obtaining a design patent or design right are much less than utility patents and general take less time than a utility patent. Between utility patents and design patents it seems for purposes of nanotechnology design patents is a better option.

1. **Copyright**

The artistic aspects of nanotechnology and its structures may allow copyright protection.[[201]](#footnote-201) While utility patents protect the functionality of an invention, copyright protests creative aspects of a work.[[202]](#footnote-202)

There are artistic aspects to nanotech structures that are amenable to copyright protection event where patents are not applicable.[[203]](#footnote-203) Even though to the naked eye nanotechnology may go unseen many artists have shown the aesthetic ability in nanotechnology.[[204]](#footnote-204) For example, on artist[[205]](#footnote-205) has created a 46-foot tall structure with iridescent polymer film, which reflects light with structural colors similar to butterfly wings.[[206]](#footnote-206) See Figure E. 1[[207]](#footnote-207), E.2[[208]](#footnote-208), and E. 3[[209]](#footnote-209), for examples of nanotech art. Figure E shows only a few examples of nanotech art. While the images protect the original author it also allows nanotechnologist to explore nanoscale materials without the limitations patents would place on scientists.[[210]](#footnote-210)



Figure E. 1



Figure E. 2

Figure E. 3

* 1. **How the United States protects Nanotechnology through copyright protection**

**1. “Nanoart”**

A process using electron-microscope scans of nanotech structures, using a computer painting process and printing the result with archival inks on canvas is termed “nanoart” by Cris Orfescu uses the term uses this as one of his processes in creating nanoart.[[211]](#footnote-211)

**2. Nano-sized sculpture**

Sculpture works qualify for copyright only if the design is of artistic craftsmanship that can be identified separately from utilitarian aspects.[[212]](#footnote-212) In 2001, researchers created a bull out of resin with a two-photon micropolymerization technique[[213]](#footnote-213) using a pair of laser beams to create a sculpture of a bull.[[214]](#footnote-214) Nanotechnology companies have recognized the potential for nanotech and art giving artists opportunities to work with scientists in order to include artistic features for nanotechnology.[[215]](#footnote-215)

**3. Literary Works**

Literary works include computer programs.[[216]](#footnote-216) For companies like Intel[[217]](#footnote-217), they can utilize copyrights when developing nanocomputers.[[218]](#footnote-218) Chemical sequences can be entitled to copyright protection as literary works since they use chemical instruction strings that can define how to build a variety of organisms.[[219]](#footnote-219) These are a few examples of what kinds of nanotechnology in the literary aspect of copyright would receive protection.

* 1. **How nanotechnology is protect through copyright internationally**

The World Intellectual Property Organization (WIPO) protects software through the WIPO Copyright Treaty (WCT).[[220]](#footnote-220) Article 4 of the WCT protects computer programs under the Berne Convention.[[221]](#footnote-221) The US adheres to UCC Geneva[[222]](#footnote-222), UCC Paris[[223]](#footnote-223), SAT[[224]](#footnote-224), WTO[[225]](#footnote-225), Berne Convention[[226]](#footnote-226), WCT, and WPPT[[227]](#footnote-227).

**1. Europe**

The EU adheres to the WTO, WCT, and WPPT. Moral rights cannot be waived and the application of fair use differs in the EU than the US. Although the US, EU, and Japan all follow the WCT and WPPT there are still issues in protecting a copyright owners rights in other countries because the copyright laws are based on the country in which the copyright is given. Recently, the EU has been argued to have more protection in copyright law than the US based on Kirtsaeng v. Wiley[[228]](#footnote-228), which held that the first sale doctrine (allows the owner of a copyrighted work to sell or otherwise dispose of that copy as he wishes) applies to copies of a copyrighted work lawfully made abroad.[[229]](#footnote-229) Kirtsaeng, a Thai citizen, did not breach copyright laws when he resold imported copies of textbooks in the US.[[230]](#footnote-230)

**2. Japan**

Japan adheres to many acts for copyright protection including the Berne convention, UCC Geneva, UCC Paris, pheongrams, WCT, and WPPT. Japan’s national copyright law has considered changing their current copyright law to conform to US and EU copyright law.[[231]](#footnote-231) One proposal includes extending the period of protection to 70 years. A more uniform law will make trading IP rights easier.[[232]](#footnote-232)

What this means for nanotechnology is that it will be easier for the exchange of ideas to be presented to the commons. At the same time, it allows those who find the need to have proprietary advantage over the copyrights hold and exchange their rights.

**C. How Copyright laws would work better than patents**

As discussed above, copyrights can provide proprietary rights to individuals or companies where patents may not apply. It also allows for the convergence of science and art. It gives the author what many authors design most, recognition, while allowing the commons access to the information at a lower price and at lower transaction costs for the copyright holder. Having less proprietary protection over inventions in nanotechnology will enable inventors to develop the field in order to make the great leaps scientists desire to make.

1. **Open Source**

Open source is a term that is used to allow people to publish their work for the public to access.[[233]](#footnote-233) This strategy was originally used to develop computer software, where anyone could modify or enhance software code available of open source.[[234]](#footnote-234) This same application can be used in nanotechnology. For example, tomviz.org uses tomographic visualization for 3D materials at the nanoscale through open source software.[[235]](#footnote-235)

The importance of being the first to invent or discover a scientific break through is important for many scientists.[[236]](#footnote-236) It is a motivation for inventors to receive copyright for their artistic creations.[[237]](#footnote-237) However, it is also incredibly important for scientist to develop knowledge in their field based on the simple desire of curiosity that is natural in the field of science. Many physicists have input years of research to satisfy curiosity present in the field of nanotechnology.[[238]](#footnote-238) Open source provides not only a benefit for society, where less costs will be put on the consumer, as well as a wide availability of information and the opportunity to place a wider distribution of ideas and opinions together, it offers more of a benefit to society than patent rights and copyrights do. This is based on the idea with many independent inventors they will generate a wider and diverse set of explorations than when “one mind or organization” has control.[[239]](#footnote-239) Because open source avails itself to the commons there is no need to discuss the international implications because open source is equally available to all regardless of where they are.

* 1. **How open source benefits nanotechnology**

The costs associated with nanotechnology and open sourcing The foresight institute, a non-profit “think tan and public interest organization” focuses on future technology, has a mission to speed the development of nanotechnology, promote the beneficial uses of nanotech and reduce the misuse and accidents associated with it, among other fundamental tech.[[240]](#footnote-240) They have advocated for an opportunity to open source nanotechnology.

By using open source for nanotechnology society avoids the problem of anti-commons. Where the anti-commons preserves knowledge in unused intellectual property rights because transaction costs of various intellectual property owners are complicated with diverse interests and values.[[241]](#footnote-241) The anti-commons limits the growth of knowledge in the field.[[242]](#footnote-242) As is the case in nanotechnology, where large overbroad nanotech patents are handed out the potential is even higher that they will be underused. Underused patents result in higher prices and restricted use unless innovation can be encouraged through the disclosure of ideas.[[243]](#footnote-243) In the alternative, when the commons are given information and cooperation is encouraged results in less transaction costs and offers more opportunities to develop ideas.[[244]](#footnote-244)

* + 1. **Open Source Nanotechnology**

Open Source Nano is a site that allows others to share with the commons knowledge and techniques available to everyone.[[245]](#footnote-245) Open Source Nano believes open sourcing for nanotechnology is not only important, but also beneficial.[[246]](#footnote-246) It gives the ideas directly to those who may need it the most without having to go through the usual routes.[[247]](#footnote-247) The societal importance of nanotechnology that improves areas of social justice, environmental heath and safety and intellectual property balance without having to impose high costs on the use of these ideas.[[248]](#footnote-248) Finally, open sourcing allows scientists to approach nanotechnology without limitation of creating ideas and collaboration, while at the same time allowing for competition in the market when they can utilize nanotechnology in a product and take it to market. As seen in patent, when monopoly pricing and producing takes over a market it limits competition in the market in order for the monopolist to regain its costs and benefit from monopoly profits.

Currently, Open Source Nano is working on three ideas for nanotechnology. The first project uses magnetite nanocrystals for arsenic removal.[[249]](#footnote-249) Second, a universal water filter, a project that uses magnetite with an anti-microbial treatment where if two or more components are combined a universal filter can be achieved.[[250]](#footnote-250) The third project is making a home made scanning tunneling microscope, which can be “easy and cheap.”[[251]](#footnote-251)

* + 1. **Foresight institute and IP.com**

One of the Foresight Institute’s projects is the Open Source Disclosure Project.[[252]](#footnote-252) As mentioned above, the institute was able to work with IP.com to accomplish a more informed nanotech community. This project focuses on getting information out about prior art for potential patent applicants.[[253]](#footnote-253) The Foresight Institute finds the open source method feasible under the current intellectual property systems.[[254]](#footnote-254) Between licensing for software and the ability to explore other areas companies can have a mixed strategy if they wanted.[[255]](#footnote-255) The Institute posits the “most promising pathway for open source”[[256]](#footnote-256) to be through software for molecular design. Because Drexler’s theory of nanotechnology through molecular manufacturing has not come into fruition yet, the need to collaborate and explore it would be benefitted by open source where everyone can utilize all available knowledge in order to achieve molecular manufacturing, the true essence of nanotechnology.

* 1. **Conclusion**

In order to avoid anti-commons issues and large transactions costs imposed on intellectual property open source for nanotechnology would pose on society the best possible benefit.[[257]](#footnote-257) Where molecular nanotechnology is the focus of the field an open source path would be beneficial in order the advance the field of nanotechnology.[[258]](#footnote-258) Through open source Drexler’s molecular manufacturing can be accomplished with lower transactions costs, at a quicker pace, and beneficial to all countries in its initial development.

1. **Proposals**
   1. **Sui Generis Nanotechnology Strategy**

For the development of molecular nanotechnology, the utilization of copyrights and open source together in order to equip scientist with everything they need to develop the field. On the one side, for scientists who find it compelling enough to research the nanotechnology field to without the proprietary rights afforded by copyright, they can collaborate with the commons in the best interest of science and society. On the other hand, nanotechnology can utilize the copyright system when an individual (or investors) finds it more beneficial to have proprietary rights over the authorship of the innovation. The inventor will have incentive where he believes he needs it whether it includes proprietary rights or whether it includes open source. If innovation was stifled by lack of incentive society could provide rewards for innovation, ones that do not include a monopoly right over the invention itself. Assuming society believes nanotechnology from the bottom up will be a benefit for everyone involved, the incentive for inventors will be the inherent scientific curiosity, as well as the prestige in being recognized, regardless of their monopoly position everyone will be better off under this strategy.

1. **Conclusion**

In summation, the focus of the nanotechnology field is to achieve molecular manufacturing which requires a development of top-down to bottom-up approach. This can only be done with less intellectual property protection for single firms and more public disclosure and collaboration along with a focus on prestige and knowledge expansion for the inventors and overall societal benefit with the development of greater technology. This can be done with a combination of copyright and open source strategy benefitting nanotechnology in the US and internationally.

1. *Star Trek, The Next Generation*: *TNG 165 – Sins of the Father* (CBS Studios, Mar. 19, 1990). [↑](#footnote-ref-1)
2. Michael J. Remington, *How copyright laws may apply to nanotechnology*, The Nat’l L. J. 1, 3 (May 9, 2005), <http://www.drinkerbiddle.com/Templates/media/files/publications/2005/how-copyright-laws-may-apply-to-nanotechnology.pdf> [↑](#footnote-ref-2)
3. Eric Drexler, Engines of Creation 4 (Marvin Minsky ed., 1986). [↑](#footnote-ref-3)
4. Nanotechnology Now, <http://www.nanotech-now.com/nanotube-buckyball-sites.htm> (last visited Oct. 20, 2014). [↑](#footnote-ref-4)
5. Cecillia R. Dickson, *Creating and Protecting Intellectual Property Rights for Nanotechnology,* <http://www.jonesday.com/practiceperspectives/nanotechnology/protecting_rights.html> (last visited Oct. 20, 2014). [↑](#footnote-ref-5)
6. National Nanotechnology Initiative (NNI), <http://www.nano.gov/nanotech-101/what> (last visited Oct. 20, 2014). NNI was the first US national initiative for the need for basic research. *Id.* [↑](#footnote-ref-6)
7. Richard P. Feynman, *There’s Plenty of Room at the Bottom,* 1 J. of Microelectromechanical Sys 60, 62 (1992). [↑](#footnote-ref-7)
8. *Infra* part I.C.2 [↑](#footnote-ref-8)
9. *Infra* part I.C.2 [↑](#footnote-ref-9)
10. NNI, *supra* note 6. [↑](#footnote-ref-10)
11. Feynman, *supra* note 7. [↑](#footnote-ref-11)
12. NNI, <http://www.nano.gov/node/599> (last visited Oct. 20, 2014). The USPTO used the NNI definition for nanotechnology in the development of patent-related nanotechnology classification. *Id.*  [↑](#footnote-ref-12)
13. NNI, *Supra note 6. See also,* Mike Roco, *NNI Vision and Outcomes 1, 5* (2006), https://nanohub.org/resources/1232/download/2006.02.06-roco-dls.pdf [↑](#footnote-ref-13)
14. NNI, <http://www.nano.gov/nanotech-101/what/nano-size> (last visited Oct. 20, 2014). [↑](#footnote-ref-14)
15. NNI, <http://www.nano.gov/nanotech-101/what/definition> (last visited Oct. 20, 2014). [↑](#footnote-ref-15)
16. Foresight Institute, <http://www.foresight.org/nano/whatisnano.html> (last visited Oct. 20, 2014). [↑](#footnote-ref-16)
17. See Mihail C. Roco, *The long view of nanotechnology development: the National Nanotechnology Initiative at 10 years,* 13 *J. Nanopart. Res.* 427 (2011). [↑](#footnote-ref-17)
18. *Id*. General purpose technology is “a new method of producing and inventing that is important enough tot have a protracted aggregate impact.” Boyan Jovanovic & Peter L. Fousseau, *General Purpose Technologies, in* Handbook of Economic Growth 1181, 1182 (Philippe Aghion & Steven N. Durlauf eds., 2005). [↑](#footnote-ref-18)
19. Roco, *supra* note 17. [↑](#footnote-ref-19)
20. Mihail Roco, *Four Generations,* <http://www.crnano.org/whatis.htm> (last visited Oct. 20, 2014). [↑](#footnote-ref-20)
21. Roco, *supra* note 17, at 427. [↑](#footnote-ref-21)
22. *Id.*  [↑](#footnote-ref-22)
23. *Id.*  [↑](#footnote-ref-23)
24. *Infra* See III.B. [↑](#footnote-ref-24)
25. Dickson *, supra* note 5. [↑](#footnote-ref-25)
26. Bryan Bruns, *Open Sourcing Nanotechnology Research and Development: Issues and Opportunities,* <http://www.foresight.org/Conference/MNT8/Papers/Bruns/index.html> (last visited Oct. 20, 2014). See also, *supra note 2, at 2.* [↑](#footnote-ref-26)
27. *Infra* part I. [↑](#footnote-ref-27)
28. *Infra* part II. [↑](#footnote-ref-28)
29. *Infra* part III. [↑](#footnote-ref-29)
30. *Infra* part IV. [↑](#footnote-ref-30)
31. Roco. *supra* note 7, at 432. [↑](#footnote-ref-31)
32. Roco, *supra note 13, at 6*. [↑](#footnote-ref-32)
33. *Infra* part IV. [↑](#footnote-ref-33)
34. Vivek Koppikar, Stephen B. & Maebius, J. Steven Rutt, *Current Trends in Nanotechnology Patents: A view from inside the patent office,* 116 Nanotechnology L. & Bus 24 (2004). See *Infra* Section III. [↑](#footnote-ref-34)
35. *Infra* part II.A.2. [↑](#footnote-ref-35)
36. *Infra* part II.A.3. [↑](#footnote-ref-36)
37. World Trade Organization, *Intellectual property: protection and enforcement,* <http://www.wto.org/english/thewto_e/whatis_e/tif_e/agrm7_e.htm> (last visited Oct. 20, 2014). [↑](#footnote-ref-37)
38. Robert J. Aitken, Sheona A.K. Peters, Alan D. Jones & Vicki Stone, *Regulation of carbon nanotubes and other high aspect ratio nanoparticles: approaching this challenge from the perspective of asbestos,* International Handbook on Regulating Nanotechnologies 205, 229**.** (Graeme A. Hodge, Diana M. Bowman, & Andrew D. Maynard eds., 2005). [↑](#footnote-ref-38)
39. *Id.* at 232. [↑](#footnote-ref-39)
40. *Id.* at 231. [↑](#footnote-ref-40)
41. Leo Stander and Louis Theodore. *Environmental Implications of Nanotechnology—An Update*. 8 Int. J. Environ. Pub. Health 470, 471 (Feb. 10, 2011), http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3084472/ [↑](#footnote-ref-41)
42. *Id.*  [↑](#footnote-ref-42)
43. *Id.* at 471. [↑](#footnote-ref-43)
44. John F. Sargent Jr, *Nanotechnology and Environmental, heath, and Safety: Issues for Considerations* summary(Jan. 20, 2011), <http://fas.org/sgp/crs/misc/RL34614.pdf>. [↑](#footnote-ref-44)
45. See Michael Siegrist, *Predicting the Future: Review of Public-Perception Studies of Nanotechnology,* Nanotechnology: Ethical and Social Implications 321, 325 (Ahmed S. Khan ed., 2012). [↑](#footnote-ref-45)
46. [↑](#footnote-ref-46)
47. Dharmender Kumar, *Nano Flake Technology – A cheaper way to produce Solar Cells* (Feb. 5, 2014), <http://www.renewableenergyworld.com/rea/blog/post/2014/02/nano-flake-technology-a-cheaper-way-to-produce-solar-cells>. *See also,* Interview with Richard P. Barber, Director, Center for Nanostructures, in Santa Clara, Cal. (Sep. 25, 2014). [↑](#footnote-ref-47)
48. Kumar, *supra note 47.*  [↑](#footnote-ref-48)
49. Shailesh Yadav et al., *Nanomedicine: Current Status and Future Implications,* 22Indian J. of Clinical Prac. 6 (2012). [↑](#footnote-ref-49)
50. Rob Burgess, Understanding Nanomedicine: An Introductory Textbook 405 (Pan Stanford Publishing Pte. Ltd. ed., 2012) [↑](#footnote-ref-50)
51. *See* *Id.* [↑](#footnote-ref-51)
52. The Nano Age, *Respirocytes –Imporving upon Nature’s Desgin: Breathe Easy With Respirocytes,* <http://www.thenanoage.com/respirocytes.htm> (last visited Oct. 20, 2014). [↑](#footnote-ref-52)
53. Robert A. Freitas Jr., *A mechanical artificial red cell: Exploratory Design in medical Nanotechnology* (1999) http://www.foresight.org/Nanomedicine/Respirocytes4.html#Sec6 [↑](#footnote-ref-53)
54. National cancer institute, *NCI Alliance for Nanotechnology in Cancer,* <http://nano.cancer.gov/learn/now/> (last visited Oct. 20, 2014). Nanotechnology in medicine precisely engineered materials to develop novel therapies and devices hat may reduce toxicity, as well as, enhance the efficacy and delivery of treatments. *Id.*  [↑](#footnote-ref-54)
55. Earl Boysen, *Nanotechnology in Medicine,* <http://www.understandingnano.com/medicine.html> (last visited Oct. 20, 2014). [↑](#footnote-ref-55)
56. *Id.*  [↑](#footnote-ref-56)
57. *Id.*  [↑](#footnote-ref-57)
58. *Id.*  [↑](#footnote-ref-58)
59. Foresight Institute, *Enabling Space Development,* <http://www.foresight.org/challenges/space001.html> (last visited Oct. 20, 2014). [↑](#footnote-ref-59)
60. Sean O'Neill et. al., *Broad Claiming in Nanotechnology Patents: Is Litigation Inevitable?,* 4 Nanotechnology L. & Bus. 29, 31(2007). [↑](#footnote-ref-60)
61. Barber, *supra* note 47. [↑](#footnote-ref-61)
62. *Id.*  [↑](#footnote-ref-62)
63. Fritz Machlup, *An economic Review of the Patent System, in* Foundations of Intellectual property 53(Robert P. Merges & Jane C. Ginsberg eds., 2012). [↑](#footnote-ref-63)
64. *Id.* at *54.* [↑](#footnote-ref-64)
65. *Id.* at 53 [↑](#footnote-ref-65)
66. *Id.* [↑](#footnote-ref-66)
67. *Id.* at *54*. [↑](#footnote-ref-67)
68. *Id.* at 53 [↑](#footnote-ref-68)
69. *Id.* [↑](#footnote-ref-69)
70. See *Id.* [↑](#footnote-ref-70)
71. ibm, *Scanning Tunneling Microscope,* <http://www-03.ibm.com/ibm/history/ibm100/us/en/icons/microscope/> (last visited Oct. 20, 2014). [↑](#footnote-ref-71)
72. Education for the information age,  *Scanning Tunneling Microscope* <http://www.edinformatics.com/nanotechnology/scanning_tunneling_microscope.htm> (last visited Oct. 20, 2014). [↑](#footnote-ref-72)
73. google, *Atomic force microscope and method for imaging surfaces with atomic resolution* (Nov. 26, 1985), https://www.google.com/patents/US4724318?dq=4724318&hl=en&sa=X&ei=RByQU8KZFe\_Q7AbK\_4Fg&ved=0CCoQ6AEwAA [↑](#footnote-ref-73)
74. Muniba Safdar, *Difference Between Scanning Tunneling and Stomic Force Microscope (Oct. 24, 2010),* http://www.biotecharticles.com/Biotech-Research-Article/Difference-Between-Scanning-Tunneling-and-Atomic-Force-Microscopes-429.html [↑](#footnote-ref-74)
75. *Id.* [↑](#footnote-ref-75)
76. *Id.* [↑](#footnote-ref-76)
77. Steven A. Edwards**,** *The Nanotech Pioneers: Where Are They Taking Us* 58(2006). [↑](#footnote-ref-77)
78. Chris Toumey, *Tracing and disputing the story of nanotechnology,* International Handbook on Regulating Nanotechnologies 46, 53 (Graeme A. Hodge, Diana M. Bowman, & Andrew D. Maynard eds., 2010). [↑](#footnote-ref-78)
79. Paul Goldstein, *Copyright , in* Foundations of Intellectual Property 302 (Robert P. Merges & Jane C. Ginsberg eds., 2012). [↑](#footnote-ref-79)
80. Remington, *supra* note 2, at 2. [↑](#footnote-ref-80)
81. Behfar Bastani & Dennis Fernandez, *Intellectual Property Rights in Nanotechnology,* <http://ip.ibiocat.eu/admin/files/Nanotech1.pdf>(last visited Oct. 20, 2014). [↑](#footnote-ref-81)
82. Nec, *Innovative Engine:* *Carbon Nanotube,* <http://www.nec.com/en/global/rd/innovative/cnt/top.html> (last visited Oct. 20, 2014). [↑](#footnote-ref-82)
83. Nec, *Carbon Nanotube: What are carbon nanotubes,* <http://www.nec.com/en/global/rd/innovative/cnt/02.html> (last visited Oct. 20, 2014). [↑](#footnote-ref-83)
84. Stanford University, *Stanford Engineers Build First Computer Based on Carbon Nanotube Technology (Sep. 25, 2013),* http://engineering.stanford.edu/news/stanford-engineers-build-first-computer-using-carbon-nanotube-technology [↑](#footnote-ref-84)
85. *Nec, supra* note 83. [↑](#footnote-ref-85)
86. *See* American Chemical Society, *Discovery of Fullerenes National Historic Chemical Landmark* (Oct. 11, 2010), *http://www.acs.org/content/acs/en/education/whatischemistry/landmarks/fullerenes.html* [↑](#footnote-ref-86)
87. Nec, *supra* note 83. [↑](#footnote-ref-87)
88. Colin France, Atomic Structure: Nanoscience and Nanoparticles, <http://www.gcsescience.com/a38-buckminsterfullerene.htm> (last visited Oct. 20, 2014). [↑](#footnote-ref-88)
89. University of Waterloo,  *Waterloo Institute for Nanotechnology,* <https://uwaterloo.ca/institute-nanotechnology/research-waterloo-institute-nanotechnology/partnership-program/japan/nanotechnology-workshop/collaboration> (last visited Oct. 20, 2014). [↑](#footnote-ref-89)
90. *See generally* Nanoforum.org, *European Nanotechnology Gateway* (Dec. 2005), http://www.eurosfaire.prd.fr/7pc/doc/1155904567\_internationalnanotechnology.pdf [↑](#footnote-ref-90)
91. Foresight Institute, *Foresight Open Source Disclosure Project,* <http://www.foresight.org/priorart/> (last visited Oct. 20, 2014). [↑](#footnote-ref-91)
92. *Id.* [↑](#footnote-ref-92)
93. *Id.* [↑](#footnote-ref-93)
94. *Infra* III.B,C. [↑](#footnote-ref-94)
95. John Locke, *Second Treatise on Government (1690),* Foundations of Intellectual Property 1, 2-3 (Robert P. Merges & Jane C. Ginsberg eds., 2012). [↑](#footnote-ref-95)
96. *Id.*  [↑](#footnote-ref-96)
97. *Id.*  [↑](#footnote-ref-97)
98. Jeanne C. Fromer, *Expressive Incentives in Intellectual Proeprty,* 98 Va L. Rev. 1745 (2012). [↑](#footnote-ref-98)
99. Raj Bawa, *Patenting Inventions in Bionanotechnology: A Guide for Scientists and Lawyers,* Bionanotechnology: Global Prospects 309, 318 (David E. Reisner ed., 2009). [↑](#footnote-ref-99)
100. Bloomberg Businessweek, *Nanotech: Beyond the Hype –and Fear* (May 5, 2004). http://www.businessweek.com/stories/2004-05-05/nanotech-beyond-the-hype-and-fear [↑](#footnote-ref-100)
101. Foresight Institute, *An Overview of Nanotechnology,* <http://www.foresight.org/nano/overview.html> (last visited Oct. 20, 2014). [↑](#footnote-ref-101)
102. International Organization for Standardization, *ISO/TC 229 Nanotechnologies (2005),* http://www.iso.org/iso/iso\_technical\_committee?commid=381983 [↑](#footnote-ref-102)
103. *See supra* note 7. [↑](#footnote-ref-103)
104. Lawrence M. Krauss , Quantum Man: Richard Feynman's Life in Science (Great Discoveries) 264 (W. W. Norton & Company, eds., 2012). [↑](#footnote-ref-104)
105. Andres La Rosa et al., *Top-Down and Bottom Up Approaches to Nanotechnology: An overview in the context of developing Proton-fountain Electric-field-assisted Nanolithography (PEN): Fabrication of polymer nanostructures that respond to chemical and electrical stimuli* 1 (2013), http://www.pdx.edu/pnna/sites/www.pdx.edu.pnna/files/(2013)\_Top-down\_Bottom-up\_Approaches\_to\_Nanotechnology\_\_An\_overviwe\_in%20\_the\_contect\_of\_PEN%20Lithography.pdf [↑](#footnote-ref-105)
106. Graz University of Technology, *Top- Down Nanotechnology,* <http://lamp.tu-graz.ac.at/~hadley/nanoscience/week3/3.html> (last visited Oct. 20, 2014). [↑](#footnote-ref-106)
107. Tomey, *supra* note 78, at 50 [↑](#footnote-ref-107)
108. Foresight Institute, *Drexler open letter to Smalley,* <http://www.foresight.org/nano/Letter.html> (last visited Oct. 20, 2014). [↑](#footnote-ref-108)
109. Feynman/drexler [↑](#footnote-ref-109)
110. Rosa, *supra* note 105 [↑](#footnote-ref-110)
111. Gitam University, Schematic representation of building up of nanostructures, [http://www.gitam.edu/resource/nano/nanotechnology/role\_of\_bottomup\_and\_topdown\_a.htm](http://www.gitam.edu/eresource/nano/nanotechnology/role_of_bottomup_and_topdown_a.htm) (last visited Oct. 12, 2014). [↑](#footnote-ref-111)
112. See Octavio Bueno, *The Drexler-Smalley Debate on Nanotechnology: Incommensurability at Work?.* 10 Int’l J. for Phil. of Chem. 83-98 (2004). [↑](#footnote-ref-112)
113. See Encyclopedia of Nanoscience and Society (David H. Guston ed., 2010). [↑](#footnote-ref-113)
114. *Id.*  [↑](#footnote-ref-114)
115. Bueno. *Supra note 112.* [↑](#footnote-ref-115)
116. *Id*. [↑](#footnote-ref-116)
117. *Id.* [↑](#footnote-ref-117)
118. See *Id.*  [↑](#footnote-ref-118)
119. See Graz University of Technology, *Universal Assemblers,* <http://lamp.tu-graz.ac.at/~hadley/nanoscience/assemblers/assemblers.php> (last visited Oct.12, 2014). This requires low temperatures because scanning tunneling microscopes are based on low temperature uses. *Id.*  [↑](#footnote-ref-119)
120. Foresight Institute, *Feynman’s Path to Nanotech,* <http://www.foresight.org/nanodot/?p=3165> (last visited Oct. 12, 2014). [↑](#footnote-ref-120)
121. Vivek Koppikar, Stephen B. Maebius, & J. Steven Rutt, *Current Trends in Nanotechnology Patents: A view from inside the patent office,* Nanotechnology L. & Bus (April, 15, 2004). [↑](#footnote-ref-121)
122. *See Id.*  [↑](#footnote-ref-122)
123. Sean O'Neill et. al., *Broad Claiming in Nanotechnology Patents: Is Litigation Inevitable?,* 4 Nanotechnology L. & Bus. 29, 30 (2007) [↑](#footnote-ref-123)
124. *Id.*  [↑](#footnote-ref-124)
125. Patrick M. Boucher, Nanotechnology: Legal Aspects 1 (2008); Anastasia D. Carter, *Overly Broad Patents on Nanostructures: How Patent Policy Obstructs the Development of cancer diagnostic and treatments on a Macro*, 46 Tex. Tech L. Rev 561 (2014). [↑](#footnote-ref-125)
126. Raj Bawa, *Nanotechnology Patent Proliferation and the Crisis at the U.S. Patent Office.* 17 Alb. L. J. Sci. & tech. 699, 722(2007) [↑](#footnote-ref-126)
127. Carter, *supra note 125,* at 566. [↑](#footnote-ref-127)
128. *Id.* at 567 [↑](#footnote-ref-128)
129. Id.at 567 [↑](#footnote-ref-129)
130. United States Patent and Trademark Office, *Should I become a Patent Examiner?* <http://careers.uspto.gov/Pages/PEPositions/fitcheck.aspx> (last visited Oct. 20, 2014). [↑](#footnote-ref-130)
131. Eric Drexler, Metamodern Blog (Nov. 2, 2013), <http://metamodern.com/about-the-author/> *See* *also* Eric Drexler, *Molecular Machinery and Manufacturing with Applications to Computation* (Sep. 1991), http://e-drexler.com/d/09/00/Drexler\_MIT\_dissertation.pdf [↑](#footnote-ref-131)
132. Carter, *supra note 125,* at 572 [↑](#footnote-ref-132)
133. *Id.* at 572. [↑](#footnote-ref-133)
134. *Id.* at 572. [↑](#footnote-ref-134)
135. Barber, *supra* note 47; Carter, *supra note 125*, at 572. [↑](#footnote-ref-135)
136. See Carter, *supra* note125. [↑](#footnote-ref-136)
137. *Id*. at 573. [↑](#footnote-ref-137)
138. Barber, *supra* note 47; Overly Carter, *supra note 125, at* 573 [↑](#footnote-ref-138)
139. See, Koppikar, *supra* note 121, at 29 (2004). [↑](#footnote-ref-139)
140. Richard p. Nelson, *On the Complex Economics of Patent Scope*, *In* Foundations of Intellectual Property151 (Merges & Ginsberg eds., 2012). [↑](#footnote-ref-140)
141. Nelson, *supra* note 140, at 153. [↑](#footnote-ref-141)
142. *Id. at* 154-155. [↑](#footnote-ref-142)
143. *Id.* at 155. [↑](#footnote-ref-143)
144. *Id.* at 155. [↑](#footnote-ref-144)
145. Carter, *supra* note 125, at 576 [↑](#footnote-ref-145)
146. Nelson, *supra* note 140 at152. [↑](#footnote-ref-146)
147. Koppikar, *supra* Note 121 [↑](#footnote-ref-147)
148. Nelson, *supra* note 140, at 153. [↑](#footnote-ref-148)
149. Nelson, *supra* note 140, at 153. [↑](#footnote-ref-149)
150. USPTO, 2186 Relationship to the Doctrine of Equivalents, <http://www.uspto.gov/web/offices/pac/mpep/s2186.html> (last visited Oct. 20, 2014). [↑](#footnote-ref-150)
151. Alan l. Durham, Patent Law Essentails: A Concise Guide 6 (Praeger Publishers eds., 2nd ed. 1963) [↑](#footnote-ref-151)
152. *Roche Palo Alto LLC v. Apotex, Inc.,* 531 F. 3d 1372 (Fed. Cir. 2008). [↑](#footnote-ref-152)
153. Roche (Fed. Cir. 2008) at 1379 [↑](#footnote-ref-153)
154. *Id* at 1377. [↑](#footnote-ref-154)
155. Nelson, *supra* note 140, at 154 [↑](#footnote-ref-155)
156. *Id.* at 154. [↑](#footnote-ref-156)
157. *id.* at 154. [↑](#footnote-ref-157)
158. Nelson, *supra* note 140, at 155. When the technology is in its early stages the overbroad patent may preclude other inventors form making use of their inventions without infringing the original patent. Merges explains that a broad “pioneer” patent can give a patentee legal control over a large area and in “multicomponent products” broad patents on different components held by several inventors may lead to a sitaiton in which no one can or will advance the technology int eh absence of a license from someone else. *Id.* at 157. [↑](#footnote-ref-158)
159. US Patent 223,898 (1890) Broad patent for incandescent-lamp industry covering the use of a carbon filament as the source of light. [↑](#footnote-ref-159)
160. Nelson, *supra* note 140, at 159. [↑](#footnote-ref-160)
161. *Id.* [↑](#footnote-ref-161)
162. <http://documents.epo.org/projects/babylon/eponet.nsf/0/623ECBB1A0FC13E1C12575AD0035EFE6/$File/nanotech_brochure_en.pdf> See also, http://www.nanowerk.com/nanotechnology-news/newsid=34168.php [↑](#footnote-ref-162)
163. <http://www.nanowerk.com/nanotechnology-news/newsid=34168.php>. These requirements are contained in the European Patent Convention. http://documents.epo.org/projects/babylon/eponet.nsf/0/623ECBB1A0FC13E1C12575AD0035EFE6/$File/nanotech\_brochure\_en.pdf [↑](#footnote-ref-163)
164. European Patent Office. EPO classification work leads to new international standard 28 January 2011. Patent offices worldwide will classify nanotechnology under the B82Y symbol building on the EPO’s Y01N coding system. [↑](#footnote-ref-164)
165. *Id*. [↑](#footnote-ref-165)
166. John R. Thomas, *The Patenting of the Liberal Professions*, *in* Foundations of Intellectual Property 88 ( Merges & Ginsberg eds., 2012). This application derives from German patent law. Patentable technologies were limited to those which involved the treatment or processing of raw materials through mechanical or chemical means. *Id*. Today, this requirement is “a technical rule for the control of natural forces, or a teaching for systematic activity using controllable natural forces for that attainment of a causally predictable result.” *Id*. [↑](#footnote-ref-166)
167. Thomas, *supra* note 166, at 88 [↑](#footnote-ref-167)
168. *Id.* at 89 [↑](#footnote-ref-168)
169. *Id.* at 89 [↑](#footnote-ref-169)
170. Japan Patent Office, *Procedures for Obtaining a Patent Right,*  <http://www.jpo.go.jp/cgi/linke.cgi?url=/tetuzuki_e/t_gaiyo_e/pa_right.htm> (last visited Oct. 20, 2014). [↑](#footnote-ref-170)
171. *Id*. [↑](#footnote-ref-171)
172. Japan Patent Office, *Section 6 Substantive Examination*, <http://www.jpo.go.jp/cgi/linke.cgi?url=/tetuzuki_e/t_gaiyo_e/pa_right.htm> (last visited Oct 17, 2014). [↑](#footnote-ref-172)
173. Thomas, *supra* note 166, at 89. [↑](#footnote-ref-173)
174. Public Law 112-29. Enacted September 16, 2011. Amends title 35 to provide for patent reform. http://www.gpo.gov/fdsys/pkg/PLAW-112publ29/content-detail.html [↑](#footnote-ref-174)
175. http://www.kenyon.com/NewsEvents/Publications/2014/2-21-The-American-Invents-Act-and-its-Foreign-Counterparts.aspx [↑](#footnote-ref-175)
176. *Id*. [↑](#footnote-ref-176)
177. *Id.*  [↑](#footnote-ref-177)
178. http://www.kenyon.com/NewsEvents/Publications/2014/2-21-The-American-Invents-Act-and-its-Foreign-Counterparts.aspx . Some exceptions to this rule. http://www.epo.org/law-practice/legal-texts/epc.html [↑](#footnote-ref-178)
179. EPC Art. 54(1) (2007) [↑](#footnote-ref-179)
180. EPC Art. 54(2) (2007). [↑](#footnote-ref-180)
181. http://www.kenyon.com/NewsEvents/Publications/2014/2-21-The-American-Invents-Act-and-its-Foreign-Counterparts.aspx . Some exceptions to this rule. http://www.epo.org/law-practice/legal-texts/epc.html [↑](#footnote-ref-181)
182. http://www.kenyon.com/NewsEvents/Publications/2014/2-21-The-American-Invents-Act-and-its-Foreign-Counterparts.aspx . Some exceptions to this rule. http://www.epo.org/law-practice/legal-texts/epc.html [↑](#footnote-ref-182)
183. Id. [↑](#footnote-ref-183)
184. Xin LI, Yiling Lin, Hsinchun Chen, Mihail C. Roco. *World nanotechnology development: a comparative study of USPTO, EPO, and JPO patents (1976-2004). J Nanopart Res (2007) 9:977, 978.* [↑](#footnote-ref-184)
185. *Id.* *See* *also* Quillen CD, Webster OH, Eichmann R (2002) Continuing patent applications and performance of the US patent and trademark Office—extended. Federal Circuit Bar J 12(1): 35-55. (http://www.researchoninnovation.org/quillen/quillenfcbj02.pdf) [↑](#footnote-ref-185)
186. http://www.reuters.com/article/2013/02/14/us-patents-nanotechnology-idUSBRE91D0YL20130214 [↑](#footnote-ref-186)
187. Erin Geiger Smith, *US based inventors lead world in nanotechnology Patents: Study* (Feb. 14, 2013)*,* http://www.reuters.com/article/2013/02/14/us-patents-nanotechnology-idUSBRE91D0YL20130214 [↑](#footnote-ref-187)
188. Paul Dvorak, *2013 nanotechnology patent trends: Energy applications on the rise* (Feb. 13, 2014), http://www.windpowerengineering.com/design/materials/2013-nanotechnology-patent-trends-energy-applications-rise/ [↑](#footnote-ref-188)
189. *Id.*  [↑](#footnote-ref-189)
190. http://www.kenyon.com/NewsEvents/Publications/2014/2-21-The-American-Invents-Act-and-its-Foreign-Counterparts.aspx . Some exceptions to this rule. http://www.epo.org/law-practice/legal-texts/epc.html [↑](#footnote-ref-190)
191. *See* Patrick M. Boucher, Nanotechnology: Legal Aspects (CRC Press Eds., 2008) [↑](#footnote-ref-191)
192. Remington, *supra* note 2, at 3; 35 U.S.C. 171. [↑](#footnote-ref-192)
193. *Id*. Design patents cover aesthetic features of articles. *Id.*  [↑](#footnote-ref-193)
194. Japan Patent Office, *Procedures for Obtaining a Desgin Right,* <http://www.jpo.go.jp/cgi/linke.cgi?url=/tetuzuki_e/t_gaiyo_e/de_right.htm> (last visited Oct. 20, 2014). [↑](#footnote-ref-194)
195. <http://www.faipatents.com/Europe_-_Patent___Design_Pr.html>. The design must not conflict with public order or morality. *Id.*  [↑](#footnote-ref-195)
196. http://www.jetro.go.jp/en/invest/setting\_up/laws/section5/page7.html [↑](#footnote-ref-196)
197. http://www.faipatents.com/Europe\_-\_Patent\_\_\_Design\_Pr.html [↑](#footnote-ref-197)
198. *Id.*  [↑](#footnote-ref-198)
199. *Id.* [↑](#footnote-ref-199)
200. http://www.faipatents.com/Europe\_-\_Patent\_\_\_Design\_Pr.html Novelty requires being different “by more than immaterial details from known designs.” *Id.* Having Individual Character requires production of a “different overall impression on the informed user” (i.e. end user). *Id.*  [↑](#footnote-ref-200)
201. Boucher, *supra* 191 at 52 [↑](#footnote-ref-201)
202. *Id*. at 51 [↑](#footnote-ref-202)
203. *Id. at* 52. [↑](#footnote-ref-203)
204. Art and nanotech coverage in campus biennial. Cornell Chronicle. Sept 11, 2014. [↑](#footnote-ref-204)
205. Kimsooja [↑](#footnote-ref-205)
206. *supra* at Note 184. See also, Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers and Architects.

      By Daniel L. Schodek, Paulo Ferreira, Michael F. Ashby page 437. (2009). [↑](#footnote-ref-206)
207. A high resolution SEM image of zinc oxide “nanoflowers” synthesized by a physical vapor deposition technique. Self-illuminating flowers of Pandora. Image Jian Shi, University of Wicconsin. Website: <http://www.nanowerk.com/news/newsid=16903.php>. One of this zinc oxide flowers are two micrometers long. Luminescing technology is suggested use in biomarkers for the study of cells or aid in delivering drugs to specific targets within the body. [↑](#footnote-ref-207)
208. Nano PacMan (copper oxide) Scanning electron microscope image of copper oxide cluster, 3.5 microns in diameter, prepared by evaporation and condensation over a alumina substrate. <http://www.pbs.org/wgbh/nova/tech/art-nanotech.html>. Everything in the image is presented in original SEM image with white color-enhancement. Image: Elisabetta Comini, University of Brescia, Itality. Website: http://www.nanowerk.com/news/newsid=16903.php [↑](#footnote-ref-208)
209. ZnO Nanowire Array SEM image of vertically aligned ZnO nanowire with a standing human-lke form. Color added. Image: Surawut Chuangchote, Kyoto University. Website: Id. [↑](#footnote-ref-209)
210. See, http://www.pbs.org/wgbh/nova/tech/art-nanotech.html [↑](#footnote-ref-210)
211. Boucher, *supra* note 191, at 54. [↑](#footnote-ref-211)
212. *Id.* at 54. [↑](#footnote-ref-212)
213. See *Two-photon polymerization technique for microfabrication of CAD-designed 3D scaffolds from commercially available photosensitive materials* http://www.ncbi.nlm.nih.gov/pubmed/18265416 [↑](#footnote-ref-213)
214. Boucher, *supra* note 191, at 54. [↑](#footnote-ref-214)
215. *Id.* at 54. This is done especially when there can be purely utilitarian aspects for the structures. *Id* at 55. Companies include IBM who’s researchers inscribed “NANO USA” on a sheet of copper using 112 carbon monoxide molecules. *Id.*  [↑](#footnote-ref-215)
216. 17 U.S.C. 102(a) [↑](#footnote-ref-216)
217. Moore’s Law, Single atom transistors. [↑](#footnote-ref-217)
218. Boucher, *supra* note 191, at 57. [↑](#footnote-ref-218)
219. *Id.*  [↑](#footnote-ref-219)
220. World Intellectual Proeprty Organization Coprygiht Treaty, Geneva, 1996. [↑](#footnote-ref-220)
221. <http://www.wipo.int/edocs/mdocs/copyright/en/wipo_ip_cm_07/wipo_ip_cm_07_www_82573.doc>. See Also, Article 2 of the Berne Convention. [↑](#footnote-ref-221)
222. Universal Copyright Convention, Geneva 1952. [↑](#footnote-ref-222)
223. Universal Copyright Convention as revised at Paris, 1971. [↑](#footnote-ref-223)
224. Convention Relating to the Distribution of Programme-Carrying Signals Transmitted by Satellite, Brusels, 1974. [↑](#footnote-ref-224)
225. World Trade Organization, established pursuant to the Marrakesh Agreement of April 15, 1994, to implement the Uruguay Round Agreements. The Agreements on Trade-Related Aspects of Intellectual Proeprty Rights (TRIPS) is one of the WTO agreements. [↑](#footnote-ref-225)
226. Berne Convention for the Protection of Literary and Artistic Works, 1971. [↑](#footnote-ref-226)
227. WIPO Performances and Phonograms Treaty, Geneva, 1996. [↑](#footnote-ref-227)
228. 133 S. Ct. 1351 (2013) [↑](#footnote-ref-228)
229. *Id.* [↑](#footnote-ref-229)
230. http://www.out-law.com/articles/2013/march/eu-law-gives-more-copyright-protection-than-us-after-first-sale-us-court-ruling-says-expert/ [↑](#footnote-ref-230)
231. http://www.worldipreview.com/news/japan-considers-copyright-law-extension [↑](#footnote-ref-231)
232. *Id.*  [↑](#footnote-ref-232)
233. http://opensource.com/resources/what-open-source [↑](#footnote-ref-233)
234. *Id.*  [↑](#footnote-ref-234)
235. Robert Hovden, Visualizing nanotechnology in 3D with open source software, 22 Sep 2014. Website: <http://opensource.com/life/14/9/visualize-nanotechnology-3D-open-source-software>. Computers today are built with nanotechnology, with processors containing billions of transistors (each 14 nanometers). Tomviz allows 3D reconstructios and visualization accessible to everyone. *Id.* See also, http://www.tomviz.org [↑](#footnote-ref-235)
236. Barber, *supra* note 47. [↑](#footnote-ref-236)
237. *Id*. [↑](#footnote-ref-237)
238. *See* *Id.*  [↑](#footnote-ref-238)
239. *Id*. [↑](#footnote-ref-239)
240. Foresight Institute, *Promoting Transformative Technologies*, <http://www.foresight.org> (last visited Oct. 20, 2014). [↑](#footnote-ref-240)
241. Bryan Bruns. Open Sourcing Nanotechnology Research and Devleoplement: Issues and Opportunities.(2000) Website: http://www.foresight.org/Conference/MNT8/Papers/Bruns/index.html [↑](#footnote-ref-241)
242. *Id.*  [↑](#footnote-ref-242)
243. *Id.*  [↑](#footnote-ref-243)
244. *See* *Id.*  [↑](#footnote-ref-244)
245. http://opensource.com/resources/what-open-source [↑](#footnote-ref-245)
246. http://opensourcenano.net/about/ [↑](#footnote-ref-246)
247. *Id.* [↑](#footnote-ref-247)
248. *Id.* [↑](#footnote-ref-248)
249. http://opensourcenano.net/projects/ [↑](#footnote-ref-249)
250. *Id.*  [↑](#footnote-ref-250)
251. *Id.*  [↑](#footnote-ref-251)
252. Foresight Institute, <http://www.foresight.org/priorart/> (last visited Oct. 20, 2014). [↑](#footnote-ref-252)
253. *Id.* See also, ip.com [↑](#footnote-ref-253)
254. http://www.foresight.org/Conference/MNT8/Papers/Bruns/index.html [↑](#footnote-ref-254)
255. *Id.*  [↑](#footnote-ref-255)
256. *Id.*  [↑](#footnote-ref-256)
257. Boucher, *supra* at note 218. [↑](#footnote-ref-257)
258. Foresight Institute, *Foresight Open Source Disclosure Project,* <http://www.foresight.org/nanodot/?p=6156> (last visited Oct. 20, 2014). [↑](#footnote-ref-258)