Open-source nanotechnology: Solutions to a Modern Intellectual Property Tragedy

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Preprint of: J.M. Pearce, Open-Source Nanotechnology: Solutions to a Modern Intellectual Property Tragedy, *Nano Today* 8(4) (2013), pp. 339–341.
DOI: http://dx.doi.org/10.1016/j.nantod.2013.04.001

Open-Source Nanotechnology: Solutions to a Modern Intellectual Property Tragedy

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Introduction

A no less prestigious document than the U.S. Constitution authorizes the patent system, which provides the *right to exclude others* from making, using, or selling the patented invention for 20 years. The intention of our patent system is to encourage innovators to share their ideas with the public in exchange for a government enforced private monopoly. The potential for monopoly profits is an intuitive incentive for innovation and may even be responsible for economic growth witnessed in the industrial revolution[1]. The idea that intellectual property (IP) catalyzes innovation and economic growth is a baseline assumption seen in the expansion of contemporary IP-related legislation. For example, the 1980 Bayh-Dole Act allowed American universities to retain ownership of the IP of federally-funded research[2]. The *Economist* extolled the Bayh-Dole Act as "possibly the most inspired piece of legislation to be enacted in America over the past half-century"[3] as it provides financial incentives for academic researchers to exploit their ideas. On the face of it, this sounds great, particularly for nanotechnology researchers because nanotechnology offers the promise of enabling matter to be manipulated as easily as software so software characteristics of low-cost reproduction and dissemination would apply to material goods[4]. Nanotech researchers could all get rich while ushering in a technological utopia!

There is only one problem – the IP system is actually crippling innovation. A series of careful scientific studies have found weak or no evidence that IP increases innovation and, in fact, often retards it[5]. These conclusions are explained by the following inefficiencies: i) higher transaction costs for information exchange slows technical progress,[6] ii) patenting of building block technologies holds back downstream research and development[7], and iii) the flexible 'non-obvious' requirement of patents locks away common-sense approaches to solving problems, and basic, obvious algorithms for creating innovations[8]. Finally, many patents are not used, but only prevent others from following lines of inquiry[9]. These inefficiencies are a tragedy as society clearly faces many problems that would benefit from innovation. This "intellectual property tragedy" is acute in the field of nanotechnology[10,11].

While patent proponents cheer record numbers[12] of class 977 nanotechnology patent applications, a dense interlocking thicket of overly broad patents of nanotechnology 'building blocks' has been created. Building block patents on such nanotechnologies as quantum dots, nanowires, fullerenes and carbon nanotubes (CNTs) hamper innovators, who must acquire all the necessary licenses to avoid lawsuits[13,14]. These dense webs of overlapping rights are created as a result of the complex nature of the underlying science and incomplete information availability at the USPTO[15]. Hacking into this patent thicket is a challenge because of the extreme

interdisciplinary nature of the field and concomitant range of industries. In addition, patent lawyers use novel vocabulary to win claims and hide prior work from examiners. CNTs for example can be described as nanofibers, singlewall carbon molecules, shells, rolled graphene, nanocylinders, buckytubes, nanowires, etc. Finally, the difference between a process innovation and the fundamental properties resulting in a nanomaterial is difficult to define. This all results in a well-documented patent thicket, which strangles innovation.

Here is how: Imagine you have a new CNT product idea and you want to bring it to market. To start, you need to dig through >1,600 U.S. patents that mention them[16]. This would be a colossal waste of your time. Patents are legal documents with limited technical use whose purpose is to maximize legal scope, while remaining seemingly limited enough to obtain the monopoly rights. A technology transfer officer or lawyer might complete the paperwork for you, but resources spent on legal requirements are not being invested in your lab on actual innovation. Similarly, the costs of securing your own patent can be substantial and any time or money invested in doing so is lost to innovation. If granted a patent, you will then need to obtain a fistful of licenses just to use naturally-occurring carbon in this form – U.S. patent 6,683,783, for example covers "a composition of matter comprising at least about 99% by weight of singlewall carbon molecules" and dozens of other patents lay similarly broad claims. This is all clearly discouraging to you as an innovator. It is a windfall for your lawyers, but a loss for everyone else.

In historical contrast to other emerging fields at their times, nanotechnology is in a unique situation[17]. Universities in the U.S., which tend towards more fundamental research than industry, have mounted aggressive patenting campaigns because of Bayh-Dole. Now a large swath of nanotechnology patents cover basic science in the quantum field, which raises serious questions about the ownership of science[18]. While technologies in other fields had time to develop without patents, nanotechnologies are being locked away, limiting sharing and use of critical knowledge in the field[19,20]. This restricts downstream innovation, preventing development of more complex technologies due to exorbitant transaction costs. Thus, patenting of nanotechnologies actually reduces commercial competition by making the use of some nanotechnologies prohibitively expensive.

Decades of free and open-source software (FOSS) innovation have proven there is another way. You benefit from FOSS every day as major internet-based companies like Google are dependent on FOSS. Due to this tremendous success of FOSS, open-source technological development has spread to areas such as appropriate technology for sustainable development [21], science [22] and medicine [23]. Why not apply what we have learned from the information technology revolution to nanotechnology as well?

Open-Source Nanotechnology

An open-source model of nanotechnology design would help to overcome the limitations of the IP system by i) reducing the potential for monopolies, ii) increasing the speed of innovation through collaborative production, and iii) by making knowledge open and accessible to a larger community [11]. Thus, open-source approaches could greatly expand access to future benefits from nanotechnology [11,24]. This is because open-source philosophy encourages access and sharing of knowledge by encouraging contribution, recognizing good work through peer approval, and propagating improvements[25-27]. If knowledge is freely

and openly available to all there would be fewer roadblocks and lower transaction costs to nanotechnology innovation as knowledge would not be held hostage for 20 years. An open-source model would provide nanotechnology innovators with the freedom to use the best tools, materials, and devices available. Without the shelter of an IP monopoly, innovation would be a necessity for a firm to survive and nanotechnologies would move faster from science to application.

Since companies would no longer have to recoup the losses associated with transaction costs or pay as much into R&D per unit of output, research into nanotechnologies that do not maximize profit margins could be undertaken for explicitly social benefits. Open-source nanotechnology would especially be helpful for marginalized communities as nanotechnology has the potential to solve problems in the developing world[28]. This would help create nanotechnology solutions in areas that are not commercially-feasible but socially just, such as providing inexpensive medicine for developing communities[29]. In addition, the cost of entry for businesses into the nanotechnology market would be lowered, encouraging the rapid innovation brought by competition.

Due to its interdisciplinary nature, the field of nanotechnology is a combination of information, software, and hardware, all of which can be improved by the adoption of open-source development. NanoHub.org already exist for members of the nanotechnology community to share information. FOSS in the field of nanotechnology is proliferating rapidly and ranges from microscope control software to molecular modeling tools. Finally, free and open-source hardware as a whole is in its infancy, but quickly maturing and offering potential applications for scientific equipment[30,31], which could be useful for nanoscience.

If nanotechnology is left open for competition, we will get far more innovation than we do now. Three steps are needed. First, the U.S. government has recently announced that all federally-funded research should be open-access[32]. This line of reasoning, summarized as the “public pays once”, should be extended to all publicly-funded innovations in the nanotechnology sector. Instead of being patented, innovations should be placed in the public domain. Second, Congress should alter Bayh-Dole to exclude private intellectual lockdown of publicly-funded innovations. Third, the USPTO should issue a moratorium on patenting nanotechnology-related fundamental science, processes, materials, and concepts. Simply identifying a new behavior of a material at the nanoscale should not be enough to claim a patent, and in doing so, prevent others from working with that material.

Conclusions

In conclusion, if nanotechnology is to meet its full potential as rapidly as possible in driving the next industrial revolution, it must be set free and open sourced. There is an urgent need for opening up nanotechnology before too much of the basic scientific knowledge gets locked into proprietary systems retarding technological development for decades. Nanotechnology researchers should encourage open-source nanotechnology to maximize the social return from investment in nanotechnology research.

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