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# Protecting Innovation in Computer Software, Biotechnology, and Nanotechnology:

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# ABSTRACT

In the 1970's, paying virtually no attention to the fundamental distinction between patent and copyright subject matter, Congress decided to protect computer programs as "literary works" under copyright law. As a result, a work of technology for the first time was consciously placed under the protective umbrella of a statute designed for art, music, and literature. More than thirty years later, courts still struggle to work out the appropriate rationale for copyright protection in computer programs. Now it appears that two newer technological areas—biotechnology and nanotechnology may raise similar ease-of-copying justifications for applying copyright, or something like copyright, to innovation within their domains. This article examines our thirty- to forty-year experience with copyright protection of computer software for lessons in better promoting innovation in the biotech and nanotech arenas. It concludes that we should resist calls for protection under copyright and devise a scheme that more aptly addresses the underlying problems.

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# TABLE OF CONTENTS

I.	Introduction	
II.	Software and Copyright	
III.	Lessons for Biotech and Nanotech Innovation	
IV.	Biotechnology	
V.	Nanotechnology	
VI.	Conclusion	

### I. INTRODUCTION

11 Under traditional intellectual property law, copyright law protected nonfunctional works of art, music, and literature, while patent law protected functional works of technology. For nearly two centuries in the United States, the differences between these two types of subject matter were so clear that they were essentially never articulated.<sup>1</sup> Computer software—an electronic technological work capable of representation in human-recognizable and mathematically manipulable symbols—raised the first serious challenge to this division of labor between the two major intellectual property regimes. The Commission appointed by Congress to provide advice on the treatment of computer software under intellectual property law (CONTU)<sup>2</sup> paid virtually no attention to the subject matter differences of the two statutes, noting only that patents would often be unavailable for complex software that was expensive to produce yet cheap and easy to copy.<sup>3</sup> Moreover, the first serious challenge to placing functional software under copyright did not appear until four years after Congress had accepted CONTU's recommendation<sup>4</sup> and judges had already begun deciding software cases under copyright law.<sup>5</sup>

¶2 After a very clumsy beginning, $^{6}$  courts eventually settled the doctrine in the three

<sup>&</sup>lt;sup>1</sup> Dennis S. Karjala, *Distinguishing Patent and Copyright Subject Matter*, 35 CONN. L. REV. 439, 440–41 (2003) [hereinafter *Subject Matter*].

<sup>&</sup>lt;sup>2</sup> LIBRARY OF CONGRESS, FINAL REPORT OF THE NAT'L COMM'N ON NEW TECHNOLOGICAL USES OF COPYRIGHTED WORKS (July 31, 1978) [hereinafter CONTU REPORT].

<sup>&</sup>lt;sup>3</sup> *Id*.

<sup>&</sup>lt;sup>4</sup> Pamela Samuelson, *CONTU Revisited: The Case Against Copyright Protection for Computer Programs in Machine-Readable Form*, 1984 DUKE L.J. 663 (1984).

<sup>&</sup>lt;sup>5</sup> See, e.g., Apple Computer, Inc. v. Franklin Computer Corp., 714 F.2d 1240 (3rd Cir. 1983); Midway Mfg. Co. v. Artic Int'l Inc., 704 F.2d 1009, 1012 (7th Cir. 1983); Midway Mfg. Co. v. Strohon, 564 F. Supp. 741 (N.D. Ill. 1983).

<sup>&</sup>lt;sup>6</sup> See, e.g., Whelan Assocs., Inc. v. Jaslow Dental Lab., Inc., 797 F.2d 1222 (3rd Cir. 1986) (holding that the program copyright extends beyond the literal code to so-called "structure, sequence, and organization" (SSO)); Digital Commc'ns Assocs. v. Softklone Distrib. Corp., 659 F. Supp. 449 (N.D. Ga. 1987) (protecting the method of choosing the first two letters of an English-language command to invoke the command in an interface protocol).

major problem areas—the scope of program-copyright protection,<sup>7</sup> protection of user interfaces,<sup>8</sup> and reverse engineering of programs<sup>9</sup>—but to this day the rationales for limited protection in the first two of these areas remain poorly articulated by the courts.<sup>10</sup> Instead of trying to separate "idea" from "expression" in a computer program, courts long ago should have recognized that the *only* policy-based rationale for placing works of technology under copyright—not just works *about* technology but actual technological products that directly control the function of physical machines—is that these particular technological works were seen as vulnerable to misappropriation.<sup>11</sup> Computer programs containing no patentable invention could be expensive and time-consuming to create, but might be copied and further distributed cheaply and easily. Without some legal mechanism to protect the innovator's lead time,<sup>12</sup> there was a serious risk that valuable

<sup>9</sup> Sega Enters. Ltd. v. Accolade, Inc., 977 F.2d 1510 (9th Cir. 1992), *amended by* Order and Amended Opinion, D.C. No. CV-91-3871-BAC (Jan. 6, 1993) (holding that necessary copying of programs for the purpose of learning, extracting, and using unprotected program elements is a fair use).

<sup>10</sup> For example, Computer Assocs., 982 F.2d at 706–10, sets up a complex "Abstraction-Filtration-Comparison" methodology without realizing that an honest application of the methodology results in the protection only of literal program code and close paraphrases of code. See Dennis S. Karjala, A Coherent Theory for the Copyright Protection of Computer Software and Recent Judicial Interpretations, 66 U. CIN. L. REV. 53, 80–82 (1997) [hereinafter A Coherent Theory]. As a result, the Second Circuit itself misapplied its own theory in Softel, Inc. v. Dragon Med. & Sci. Commc'ns., Inc., 118 F.3d 955 (2nd Cir. 1997). See Dennis S. Karjala, Copyright Protection of Computer Program Structure, 64 BROOK. L. REV. 519 (1998). The First Circuit in Lotus v. Borland did better by looking to section 102(b) of the Copyright Act to deny copyright protection to an operational aspect of the user interface-the menu command hierarchy-but it neglected to analyze what kind of work the menu command hierarchy actually was. It thus failed to explain how the menu command hierarchy was deemed copyright subject matter at all, and it failed to deal with the objection that computer programs themselves are also "methods of operation." There is a reason that program code, although a method of operation, is not precluded from copyright protection by section 102(b) while the menu command hierarchy generated by the program code is excluded. Understanding that reason is critical for a sensible interpretation of the scope of copyright protection in a computer program. See Karjala, A Coherent Theory, supra, at 106–07.

<sup>11</sup> Karjala, *A Coherent Theory, supra* note 10, at 66–72. CONTU itself recognized that the ratio of development costs to duplication costs for programs was so great that a failure to protect programs would be a disincentive to program creation and distribution. CONTU REPORT, *supra* note 2, at 11. In concurrence, Professor Nimmer was worried that the failure to articulate a rationale for placing computer software under copyright and the broad interpretation of the term "literary work" could turn copyright into a general misappropriation law. *Id.* at 26. Thus, CONTU saw that misappropriation was the problem for computer programs. The Commission, however, was unable to specify that *machine-language code* was the point of vulnerability and failed to foresee how lawyers and judges would seek to apply traditional copyright law for novels and music to program structure and user interfaces. Neither program structure nor user interfaces are any more vulnerable to misappropriation than other technological works and are therefore more properly left to fend for themselves under the patent and trade secret regimes. Dennis S. Karjala, *The Relative Roles of Patent and Copyright in the Protection of Computer Programs*, 17 J. MARSHALL J. COMP. & INFO. L. 41, 51 (1998) [hereinafter *Relative Roles*].

<sup>12</sup> Professor Reichman was an early articulator of the need to overcome, for technologies that bear their technological know-how "on their face," the loss of lead time that had generally been available for

<sup>&</sup>lt;sup>7</sup> Computer Assocs. Int'l Inc. v. Altai, 982 F.2d 693, 706–10 (2nd Cir. 1992) (adopting the "Abstraction-Filtration-Comparison" (AFC) methodology for separating protected from unprotected elements of program SSO).

<sup>&</sup>lt;sup>8</sup> Lotus Dev. Corp. v. Borland Int'l, Inc., 49 F.3d 807, 815 (1st Cir. 1995), *aff'd by an equally divided Court*, 516 U.S. 233 (1996) (holding that a menu command hierarchy is an unprotected "method of operation" under 17 U.S.C. § 102(b)).

45

computer programs would be under-produced and, when produced, made available only pursuant to strict licensing.

¶3 For computer software, therefore, the vulnerability of program code to misappropriation was the problem, and copyright was the chosen solution. That choice was made without recognition of both the radical break that would result from the traditional distinction between patent and copyright subject matter and the complexities that had developed within copyright itself concerning the different scopes of protection afforded to different types of copyright-protected subject matter. This initial failure has generated confusion among the courts and commentators for over thirty years. Now it two other modern technological areas-biotechnology appears that and nanotechnology—may raise similar misappropriation problems. In the case of biotech, synthetic biology is already here, capable of supplying "off the shelf" biological black boxes that perform a specific biological function and can be combined with other similar boxes to achieve a desired biological result.<sup>13</sup> Synthesis platforms, roughly analogous to computer operating systems, are being developed,<sup>14</sup> and it may not be too long before the same situation arises in biotech as it has in computer software: namely, an expensive and complex product that is time-consuming to build and is easy to copy once released into the marketplace, but that lacks patentable invention.<sup>15</sup> Because DNA-sequence-related products, like computer programs, can be represented by sequences of humanunderstandable symbols (e.g., the letters A, G, C, T), it is not much of a stretch to call them "literary works" as is done for computer programs.<sup>16</sup> When and if that occurs, and

<sup>13</sup> Sapna Kumar & Arti Rai, *Synthetic Biology: The Intellectual Property Puzzle*, 85 TEX. L. REV. 1745 (2007). Professors Kumar and Rai describe the MIT Registry of Standard Biological Parts, the goal of which is development of a set of "well-specified, standard, and interchangeable biological parts" as a "critical step towards the design and construction of integrated biological systems." The Registry's web page is at http://partsregistry.org/wiki/index.php/Help:About\_the\_Registry. More recently, the New Yorker has published an article giving a layperson's overview of synthetic biology. Michael Specter, *A Life of Its Own*, THE NEW YORKER, Sept. 28, 2009, at 56, *available at* 

http://www.newyorker.com/reporting/2009/09/28/090928fa\_fact\_specter.

<sup>14</sup> Kumar & Rai, *supra* note 13, at 1761–62.

<sup>15</sup> There is also a potential problem that a single firm may come to dominate the synthesis platform market. *Id.* at 1767–68. Copyright protection for such platforms is likely to raise the same problems that it has for computer operating software, which has allowed Microsoft to dominate the market for PCs. See Dennis S. Karjala, *Copyright Protection of Operating Software, Copyright Misuse, and Antitrust, 9* CORNELL J.L. & PUB. POL'Y 161 (1999) [hereinafter *Copyright Protection of Operating Software*].

<sup>16</sup> This was precisely the approach taken by Professor Kayton in claiming flatly that genetically engineered works were copyright protected, noting the analogy to computer programs. Irving Kayton, *Copyright in Living Genetically Engineered Works*, 50 GEO. WASH. L. REV. 191, 199–200 (1982) (not discussing any potential limits on copyright based on functionality). A few years later Professor Burk looked at the software cases that had by then been decided and concluded that original DNA sequences might be copyright protected to the extent such protection was not barred by the functionality or merger doctrines. Dan L. Burk, *Copyrightability of Recombinant DNA Sequences*, 29 JURIMETRICS J. 469, 505 (1989). He concluded, however, that the difficulties the courts had squeezing software into copyright and basic differences in the software and biotechnology markets cautioned against expanding copyright to cover "a second information technology." *Id.* at 531. Nobel Prize winning chemist Walter Gilbert also argued in the 1980s that copyright might be appropriate for DNA sequences. Leslie Roberts, *Who Owns the Human Genome*, 237 SCIENCE 358, 359 (1987).

unpatented technological innovation under trade secret law. J.H. Reichman, *Legal Hybrids Between the Patent and Copyright Paradigms*, 94 COLUM. L. REV. 2432 (1994).

especially if it appears that investment in biotechnological innovation is deterred by the absence of sufficient intellectual property protection, we should expect further proposals for placing engineered genetic sequences under copyright.<sup>17</sup> Before those proposals arrive, we should be thinking of an approach that better encourages innovation without tying up crucial information in the lengthy exclusive rights that copyright would supply.

<sup>¶4</sup> Nanotechnology involves manipulation of matter at the nanoscale level.<sup>18</sup> At present, nanotech innovation does not appear anywhere near the stage at which off-theshelf nanoscale parts will be available to construct devices of nanoscale sizes, let alone macroscale sizes. Indeed, most nanotech products actually on the market may not even make use of the major factor that distinguishes nanotechnology from everything else: the dramatic changes in physical properties that often occur at the nanoscale.<sup>19</sup> Moreover, there is not yet a nanotech equivalent to the 1's and 0's of computer software or the AGCT molecules that sequentially make up strands of DNA. When nanotech matures, however, some believe that the production of anything—not just information—will become very inexpensive, once one has the "blueprint" for directing the nanotech builder.<sup>20</sup> Just as the ease of copying software led to the use of copying even *hardware*<sup>21</sup> will require a similar reconsideration of how to protect nanotech innovation under intellectual property law. Computer software under copyright is already being offered as a possible model for nanotech designs.<sup>22</sup> It is certain that when the possibilities

The oligonucleotide sequences are protected by copyright which is owned by Illumina. Illumina allows you to reproduce the oligonucleotide sequences for use with the Illumina Genome Analyzer and associated assays [including modifications necessary to such use]. Illumina grants you no other rights to use, reproduce or otherwise disclose the oligonucleotide sequences. Alteration or modification . . . for use with non-Illumina products is not allowed.

Undated letter from Customer Support, Illumina, Inc. to customers. (Dec. 2006) (on file with author). This letter suggests that the issue for biotechnology is much more immediate than might otherwise be apparent.

<sup>18</sup> See, e.g., Stephen Wood et al., Econ. & Soc. Research Council, NANOTECHNOLOGY: FROM THE SCIENCE TO THE SOCIAL 5 (2007); Georgios I. Zekos, *Nanotechnology and Biotechnology Patents*, 14 INT'L J.L. & INFO. TECH. 310, 314–15 (2006); R. Scott Roe, Note, *Nanotechnology: When Making Something Smaller Is Nonobvious*, 12 B.U. J. SCI. & TECH. L. 127, 128 (2006). One nanometer is 10<sup>-9</sup> meters, or one-billionth of a meter.

<sup>20</sup> K. Eric Drexler & Jason Wejnert, *Nanotechnology and Policy*, 45 JURIMETRICS J. 1, 11 (2004). <sup>21</sup> *Id*. at 12.

<sup>22</sup> See Cecilia R. Dickson, Creating and Protecting Intellectual Property Rights for Nanotechnology, BNA WORLD INTELL. PROP. REP. (2010), available at

http://news.bna.com/wiln/WILNWB/split\_display.adp?fedfid=18332322&vname=wiprunotallissues&wsn= 500086000&searchid=12932139&doctypeid=1&type=date&mode=doc&split=0&scm=WILNWB&pg=0. Ms. Dickson argues that copyright protection may be available for nanotech designs that incorporate elements analogous to software code or chip design. She found via online search "numerous" instances in which copyright protection was claimed for computer-readable text relating to nanotechnology, such as nanotech architecture for pattern making and design software for various nanotech-related applications.

<sup>&</sup>lt;sup>17</sup> Indeed, claims are already being made to engineered DNA sequences. A company named Illumina, Inc. has sent a letter to its customers offering them specific oligonucleotide sequences (specifically spelled out in sequences of the letters A, C, G, T) for use in the Illumina Genome Analyzer and claiming copyright in all of them:

<sup>&</sup>lt;sup>19</sup> Wood et al., *supra* note 18, at 8–9.

for nanotech misappropriation become a serious consideration, many in the legal system will seek to take advantage of the analogy to software under copyright.

The question is what relevance the thirty- or forty-year debate over the legal protection of computer software has for the encouragement of innovation in the biotech and nanotech arenas. The thesis of this article is that applying copyright directly to solve the software misappropriation problem was a mistake. Copyright does protect against "piracy" by prohibiting direct copying of source and object code,<sup>23</sup> but the long history of copyright protection of nonliteral elements (such as detailed plots and delineated characters) of literary works like novels and plays encouraged courts to protect functional aspects of software technological work. Moreover, copyright endures for much too long a term, especially for functional products.<sup>24</sup> In retrospect, a sui generis statute that protected only literal or near-literal copying of code, for a much shorter term, would have been preferable.<sup>25</sup>

 $\P_6$  Patent today continues to serve the biotech and nanotech industries reasonably well, notwithstanding the ongoing debate over several aspects, especially the patenting of human genes.<sup>26</sup> These industries are likely to reach the stage, however, at which new

<sup>25</sup> Professor Samuelson was arguing for sui generis protection of software at an early stage. Pamela Samuelson, *Creating a New Kind of Intellectual Property: Applying the Lessons of the Chip Law to Computer Programs*, 70 MINN. L. REV. 471 (1985). A serious proposal for sui generis protection of software was made in Japan but was abandoned under heavy pressure from the United States to apply copyright law to computer programs. Betsy E. Bayha, Am. L. Inst., *Reverse Engineering of Computer Software in the United States, the European Union, and Japan*, in ANTI/INTELLECTUAL PROPERTY CLAIMS IN HIGH TECHNOLOGY MARKETS, C137 ALI-ABA 175, 190–91 (1995); Dennis S. Karjala, *Copyright Protection of Computer Software in the United States and Japan: Part II*, 13 EUR. INTELL. PROP. REV. 231 (1991). The Japanese proposal recommended a much shorter term of protection (application programs versus operating software, for example). *See* Dennis S. Karjala, *Lessons from the Computer Software Protection Debate in Japan*, 1984 ARIZ. ST. L.J. 53, 55; *see also* Jonathan Zittrain, *The Un-Microsoft Un-Remedy: Law can Prevent the Problem that it can't Patch Later*, 31 CONN. L. REV. 1361, 1373 (1999) (recommending a term of software protection of five to ten years).

<sup>26</sup> See, e.g., Ass'n for Molecular Pathology v. U.S. Patent & Trademark Office, 702 F. Supp. 2d 181 (S.D.N.Y. 2010) (holding that a naturally occurring DNA sequence, even one that has been isolated and purified, does not qualify as patent subject matter); John M. Conley, *Gene Patents and the Product of Nature Doctrine*, 84 CHI.-KENT L. REV. 109, 132 (2009) (urging caution in granting exclusivity to genes); Linda J. Demaine & Aaron Xavier Fellmeth, *Reinventing the Double Helix: A Novel and Nonobvious Reconceptualization of the Biotechnology Patent*, 55 STAN. L. REV. 303 (2002); Dennis S. Karjala, *Biotech Patents and Indigenous Peoples*, MINN. J. L. SCI. & TECH. 483, 499–505 (2006). This is not to say that there are no problems in applying traditional patent law to biology or nanotech. Professors Kumar and Rai fear, for example, that the growing number of patents on basic biological parts could create a patent thicket that might impede progress. Kumar & Rai, *supra* note 14, at 1747. Some commentators have noted the possibility of inhibiting innovation in the nanotech area as well by patents covering building-block components. Antonio G. Spagnolo & Viviana Daloiso, *Outlining Ethical Issues in Nanotechnologies*, 23 BIOETHICS 394, 401 (2008).

<sup>&</sup>lt;sup>23</sup> See 17 U.S.C. § 106 (2006).

<sup>&</sup>lt;sup>24</sup> For many programs this has not been a problem because their lifetimes are short. However, as the Microsoft example shows, some programs can convey a very long technological monopoly under copyright, especially when network effects come into play, as they do for operating software. Karjala, *supra* note 15.

functional products will be, like complex computer programs, designed by application of well understood systems engineering principles in a straightforward manner-costing time, skill, energy, and money but not involving much, if any, patentable invention. Therefore, a fast but careful look back at the IP protection of software could prevent some of those mistakes when similar issues arise in the biotech and nanotech arenas.<sup>27</sup>

#### II. SOFTWARE AND COPYRIGHT

¶7 Both patent and copyright seek to accomplish the same general goal: protecting the fruits of intellectual creativity for the purpose of encouraging and rewarding the production of intellectual works.<sup>28</sup> They go about their tasks, however, in very different ways. Patents issue only upon formal application and after examination by a skilled examiner for "novelty" and "nonobviousness";<sup>29</sup> they require a complete specification of the invention, the scope of protection is defined and narrowly limited by the claims,<sup>30</sup> and the term of patent protection is twenty years (from filing).<sup>31</sup> On the other hand, copyright arises automatically upon fixation;<sup>32</sup> the scope of copyright protection is defined by the vague idea/expression dichotomy, copyright infringement is determined by the equally vague "substantial similarity" standard, and the term of copyright protection endures for 70 years after the death of the author (or 95 years for so-called "works made for hire").<sup>33</sup> There must be something in the nature of "patent subject matter" that distinguishes it from "copyright subject matter" to justify such radically different treatment. Importantly, that distinction does not lie in "creativity," because creativity is an element of both patent and copyright subject matter, and is also a part of subject matter denied protection under

<sup>&</sup>lt;sup>27</sup> Professor Reichman has suggested an abstract model based on legally supplying the lead time that trade secret law is designed to provide for unpatented technological advances. Trade secret law was preferable to the exclusive rights regimes of patent and copyright for ordinary technological advances, because exclusivity was limited to the time required for a competitor to reverse engineer the product (or negotiate a license) and get into production, and either way both sides made roughly their fair share contribution to the advance of society's technological knowledge. Reichman, *supra* note 12, at 2521–25. This worked well, or at least tolerably well, for most older forms of technology but breaks down for some newer technologies, which he terms "legal hybrids," in which end products bear their technological knowhow on their face (that is, in the terminology used here, the information on which the innovation is based is vulnerable to misappropriation). Id. at 2517. His model would have workers active in a new field of technology—both innovators and borrowers of technology—negotiate a set of default liability rules that would set appropriate artificial lead times for the innovator (which might vary according to the degree the borrower, too, innovates) and define the rights of users and the fees they would pay for various uses. Id. at 2544–51. The current paper is not incompatible with Professor Reichman's approach but is less ambitious, and perhaps more concrete, by focusing on our actual experience with software and limiting analysis to what we now know about the developing fields of biotech and nanotech. Here too we seek a solution to the market-failure, or vulnerability-to-misappropriation, problem arising from a competitor's ability to extract crucial technological information that is difficult or expensive to develop from scratch but can be applied cheaply and easily once obtained.

<sup>&</sup>lt;sup>8</sup> U.S. CONST. art. I, § 8.

<sup>&</sup>lt;sup>29</sup> 35 U.S.C. §§ 101–103 (2006).

<sup>&</sup>lt;sup>30</sup> 35 U.S.C. § 112 (2006).

<sup>&</sup>lt;sup>31</sup> 35 U.S.C. § 154(a)(2) (2006). <sup>32</sup> 17 U.S.C. § 102(a) (2006).

<sup>&</sup>lt;sup>33</sup> 17 U.S.C. § 302 (2006).

# either regime.<sup>34</sup>

<sup>¶8</sup> The key to understanding the proper role of copyright in the protection of computer software lies in recognizing the traditional distinctions between patent and copyright subject matter and asking why an exception was made for computer programs. I have written at length on this question and do not wish to belabor it, but the general failure to take this larger view (patent versus copyright) into account is responsible for much of the judicial fumbling concerning copyright and software. Traditional patent and copyright subject matters seemed so distinct that for nearly two centuries few even thought to inquire into it.<sup>35</sup> Consequently, when copyright was rather abruptly applied to computer programs, courts simply applied traditional copyright notions regarding literary works like novels and plays to a work of technology that was only formally a "literary work" under copyright.<sup>36</sup> That patent might have a useful role to play in the protection of this new technology was almost never recognized in the copyright decisions seeking to determine the appropriate scope of copyright protection.

¶9 Traditional copyright and patent subject matter are most accurately distinguished by a specific definition of the term "functionality."<sup>37</sup> Mere "usefulness" does not do the trick, because much traditional copyright subject matter—such as maps, dictionaries, and instruction manuals—is useful.<sup>38</sup> Traditional copyright subject matter, however, is useful only for the information it conveys, as reflected in the Copyright Act's definition of a "useful article": "A 'useful article' is an article having an intrinsic utilitarian function that is not merely to portray the appearance of the article or to convey information."<sup>39</sup> While many apply the term "functional" to utility that merely conveys information or portrays

<sup>&</sup>lt;sup>34</sup> Creative new systems of accounting, for example, are not protected by a copyright in the book or article first setting them forth. Baker v. Selden, 101 U.S. 99 (1879). The nonobviousness requirement of patent law implicitly contains a creativity element, and of course copyright is no longer available without at least a modicum of creativity. Feist Pubs., Inc. v. Rural Tel. Serv. Co., 499 U.S. 340, 358 (1991); *see* Dennis S. Karjala, *Copyright and Creativity*, 15 U.C.L.A. ENT. L. REV. 169 (2008); Dennis S. Karjala, *Copyright Protection of Computer Software, Reverse Engineering, and Professor Miller*, 19 U. DAYTON L. REV. 975, 996–98 (1994) [hereinafter *Reverse Engineering*]. However, creativity is not a sufficient condition for either copyright or patent protection. Creatively designed mechanical engines or synthetic materials are not protected by copyright, and creative scientific theories or abstract ideas are not protected under either regime.

<sup>&</sup>lt;sup>35</sup> It is common among both courts and commentators to state that patent subject matter includes "anything under the sun that is made by man" subject to exclusions for "laws of nature, physical phenomena, and abstract ideas." *See, e.g.*, Diamond v. Diehr, 450 U.S. 175, 182, 185 (1981). Few ever recognize the implicit exclusion for traditional copyright subject matter, even though almost no one argues that a new and nonobvious novel or painting should be eligible for a patent. *See* Karjala, *Subject Matter*, *supra* note 1, at 445 n.26. Traditional copyright subject matter is a much larger class of exception from patent subject matter than those normally listed. This oversight seems to show that most law professionals who deal with intellectual property simply do not think of patent and copyright together when they get down to the nuts and bolts of analyzing a specific problem.

<sup>&</sup>lt;sup>36</sup> See, e.g., Apple Computer, Inc. v. Franklin Computer Corp., 714 F.2d 1240 (3rd Cir. 1983).

<sup>&</sup>lt;sup>37</sup> Karjala, *Subject Matter*, *supra* note 1.

<sup>&</sup>lt;sup>38</sup> Indeed, *all* copyright subject matter is "useful" if we expand our definition of that term sufficiently. A painting, for example, is useful in decorating a room, music is useful in helping us achieve a particular mood, and novels are useful in helping us pass the time on airplanes.

<sup>&</sup>lt;sup>39</sup> 17 U.S.C. § 101 (2006) (definition of "useful article").

¶10 Under this definition, computer programs are obviously functional, and if this notion of functionality defines the traditional borderline between patent and copyright, computer programs under traditional intellectual property law equally obviously belong in the patent camp. It is also clear, however, as it was clear to CONTU, that many computer programs—even many programs that are expensive and time-consuming to create—will be the result of direct application of computer science principles to solve a well-defined problem and thus will# not contain any patentable invention.<sup>42</sup> Consequently, patent law cannot deal with the problem of the vulnerability of program code to misappropriation. Because source code meets the formal definition of a "literary work" under the Copyright Act and because copyright protects against the act that is most clearly misappropriative of the costs of creating computer software—namely, literal copying—it seemed natural to use copyright to address the potential misappropriation problem.<sup>43</sup> Having chosen copyright as the protection solution for program code, it

<sup>41</sup> The biggest hurdle to using this limited definition of "functionality" as the distinction between traditional copyright and patent subject matter is a process, because a process is basically just a set of instructions to accomplish a real-world result. I have tried to use the concept of "incremental improvability" to get at those information works that are patent subject matter as opposed to copyright subject matter. Karjala, *Subject Matter, supra* note 1, at 453–58. Whether this is or will be entirely successful perhaps remains to be seen, but it is of minimal relevance to the current topic of computer programs. Computer programs have intrinsic utilitarian functions—to cause a particular type of computing machine to function in a desired way—that go beyond simply conveying information or portraying their own appearance. When stored as electronic signals within a computer, a program quite literally causes the machine to behave as directed by the stored signals (and in that form the signals are not "readable" by human beings).

<sup>43</sup> Computer program classification as a literary work, however, says nothing about the *scope* of protection arising from the program copyright. Some literary works, like novels and plays, are protected broadly so that copyright extends to their detailed plots. Others, however, such as histories, biographies,

<sup>&</sup>lt;sup>40</sup> See, e.g., Lotus Dev. Corp. v. Borland Int'l, Inc., 49 F.3d 807, 819 (1st Cir. 1995) (Boudin, J. concurring) ("Utility does not bar copyright (dictionaries may be copyrighted), but it alters the calculus."); Jane C. Ginsburg, *Four Reasons and a Paradox: The Manifest Superiority of Copyright over Sui Generis Protection of Computer Software*, 94 COLUM. L. REV. 2559, 2566 (1994) ("'[F]unctionality' is not a general bar to copyright protection. Traditionally, copyright subsists in original works of authorship whatever the purpose of the work, so long as a multitude of means of achieving the 'purpose' remain available."); Arthur R. Miller, *Copyright Protection for Computer Programs, Databases, and Computer-Generated Works: Is Anything New Since CONTU?*, 106 HARV. L. REV. 977, 986 (1993) ("[T]oday's copyright law protects a wide variety of disparate 'writings,' including fact compilations, dictionaries, code books, encyclopedias, advertising, and 'how to' instruction manuals, that, like many computer programs, have a primarily utilitarian rather than aesthetic, entertainment, or educational purpose.").

<sup>&</sup>lt;sup>42</sup> CONTU REPORT, *supra* note 2, at 17 ("Even if patents prove available in the United States, only the very few programs which survive the rigorous application and appeals procedure could be patented"). Moreover, a true software patent—that is, one that covers some technological aspect of computer operation as opposed to one that covers the overall function performed by a programmed computer—would likely not be in the code (and certainly not the entire code) but rather in some means for organizing code or modules.). Karjala, *Relative Roles, supra* note 11, at 63–69. Therefore, as long as the patented piece of the program was not copied or used, the remainder of the code would be free for the taking.

necessarily follows that the "process" and "method of operation" exclusions in section  $102(b)^{44}$  are overridden with respect to code. Because code is both a process and a method of operation, to apply section 102(b) as written would be to deny the copyright protection that Congress independently decided should be applied to code.<sup>45</sup>

¶11 CONTU, however, said nothing about nonliteral elements of programs, like structure, sequence, and organization (SSO); user interfaces (to the extent not independently protected as graphic, literary or other traditional works); or compatibility protocols.<sup>46</sup> It is clear that these nonliteral elements are not nearly as vulnerable to misappropriative copying as code, because copying them for use in a new program involves reverse engineering the original program, figuring out its structure and operation, and writing, debugging, and testing independently written code.<sup>47</sup> Because these non-literal elements are no more vulnerable to misappropriation than any other unpatented product or technology, there is no need to bring their functionality under the copyright umbrella rather than leaving them to their fate under the patent and trade secret regimes, as we have done for technology throughout the history of intellectual property

<sup>44</sup> 17 U.S.C. § 102(b) (2006).

<sup>45</sup> The separability test for distinguishing protected from unprotected elements in pictorial, graphic, and sculptural works formally does not even apply to code, which is a literary work. But the fundamental separation of patent and copyright subject matter based on functionality, as articulated in Baker v. Selden, 101 U.S. 99 (1879) and partially reflected in section 102(b), would also deny copyright protection to program code. Because it is clear that Congress intended code to be protected, at least to some extent, even *Baker* must be deemed overridden with respect to program code. There is no evidence, however, that Congress intended to extend computer program protection to nonliteral elements at higher levels of abstraction beyond code, such as SSO and user interfaces. *See, e.g.*, Karjala, *A Coherent Theory, supra* note 10, at 71.

<sup>46</sup> In its section on the scope of copyright protection, the Commission relied heavily on the idea/expression dichotomy without ever specifying what it was in a program that it considered "expression" and what it considered "idea." CONTU REPORT, *supra* note 2, at 18–23. Although it does mention "flow charts" as copyrightable subject matter, it does not relate standard, graphically portrayed flow charts to actual program structure or SSO. *Id.* at 21. In seeking to distinguish between the protected expression in code and the unprotectable processes the program generates, CONTU takes as examples photocopying of "program listings" (presumably source code or printed object code) and electronic copying of code from one medium to another. Copying a program into a computer's memory is also held up as the creation of a copy that requires the copyright owner's authorization. *Id.* at 22. A difficult problem for the future was seen as the development of technology that allowed use of an author's program without copying. *Id.* All of CONTU's examples thus involve direct and verbatim copying of code.

<sup>47</sup> Moreover, interfaces and compatibility protocols are *products* of the program: they are the result of the program's operation rather than parts of the program themselves. Even the *Computer Associates* court recognized this much: "[W]e note that our decision here does not control infringement actions regarding categorically distinct works, such as certain types of screen displays. These items represent products of computer Assocs. Int'l, Inc. v. Altai, 982 F.2d 693, 703 (2nd Cir. 1992). Thus, the straightforward definition of a "computer program" as a set of instructions to be used in a computer to bring about a particular result leads directly to the conclusion that interface elements need their own copyright, independent from the copyright in the program code. Karjala, *A Coherent Theory, supra* note 10, at 73–77.

and legal forms, have a very "thin" scope of protection, under which the copyright protects little more than against verbatim copying. It would seem that a computer program, even as a literary work, is closer to the thinly protected class including instruction books, legal forms and technical works than the more broadly protected class of novels and plays. *See* Karjala, *A Coherent Theory, supra* note 10, at 72–73 and sources cited therein.

law.48

¶12 As briefly mentioned above, the courts have largely settled on interpretations of software copyrights compatible with this more fundamental analysis. Nonliteral elements of program code, such as SSO, are not protected if they are designed with an eye on efficiency,<sup>49</sup> and because programs are never deliberately designed to be inefficient, only the literal code remains to be covered. Graphical aspects of interfaces, such as video game characters, are protected independently by an audiovisual or pictorial work copyright, as they should be, while functional interface aspects are unprotected as methods of operation under section 102(b).<sup>50</sup> It is also permissible as fair use to copy a program to the extent necessary to extract copyright-unprotected elements, such as compatibility information.<sup>51</sup> However, the failure of the judiciary to adopt a coherent theoretical approach to program copyrights still leaves many courts chasing the will-o-the-wisp in trying to separate idea from expression in a functional work.

¶13 Other structural problems have arisen as digital technology, especially the internet, has developed well beyond anything envisioned by CONTU or Congress when the decision was made to place computer programs—functional works—under copyright. Even at an early stage, the seemingly unproblematic notion of RAM copying allowed the owner of a computer operating system copyright to control the market for repair and maintenance of the hardware on which the software was designed to run.<sup>52</sup> Moreover, the failure to distinguish between the copyright protection of application programs and that of operating systems, combined with powerful network effects and the very long term of copyright, has led to the long-term domination of a single firm—Microsoft, as things turned out—over the technological gateway to personal computing.<sup>53</sup> If and when we begin thinking about bringing other functional works under copyright or a copyright-like anti-misappropriation system, we should keep these experiences in mind.<sup>54</sup>

<sup>52</sup> MAI Sys. Corp. v. Peak Computer, Inc., 991 F.2d 511 (9th Cir. 1993). Much of the difficulty has stemmed from the insertion by Congress of the word "owner" of a program copy for CONTU's suggested "rightful possessor" in the new 17 U.S.C. § 117 (2006), which was designed to allow users to engage in such purely technical copying as necessary to use the program on a computer. No one, apparently, knows how or why that change was made, but it has dramatically limited the availability of the section 117 exemption, even after the 1998 amendment adding section 117(c) to address the third-party hardware-repair problem.

<sup>53</sup> See generally Karjala, Copyright Protection of Operating Software, supra note 15 (discussing in detail the causes of Microsoft's dominance).

<sup>54</sup> Professor Samuelson, along with Professor Reichman and coauthors, applied the Reichman model for the protection of "legal hybrids," briefly summarized in note 25 *supra*, to software. Pamela Samuelson, Randall Davis, Mitchell D. Kapor, & J.H. Reichman, *A Manifesto Concerning the Legal Protection of Computer Programs*, 94 COLUM. L. REV. 2308 (1994). In a comment on both papers, I suggested that they were correct in addressing "market failure" as the problem, but critical that they did not remain focused on that concept in finding a solution. In particular, I argued that an emphasis on the methods by which information could be misappropriated, rather than one on specific objects of protection (such as "computer software" or "legal hybrids") would stand a better chance of reducing the untoward effects of a market

<sup>&</sup>lt;sup>48</sup> See, e.g., Karjala, *Relative Roles, supra* note 11, at 53–56; Karjala, *A Coherent Theory, supra* note 10, at 69–70.

<sup>&</sup>lt;sup>49</sup> Computer Assocs. Int'l, Inc., 982 F.2d at 693.

<sup>&</sup>lt;sup>50</sup> Lotus Dev. Corp. v. Borland Int'l, Inc., 49 F.3d 807, 815 (1st Cir. 1995).

<sup>&</sup>lt;sup>51</sup> Sega Enters. Ltd. v. Accolade, Inc., 977 F.2d 1510 (9th Cir. 1992), *amended by* Order and Amended Opinion, D.C. No. CV-91-3871-BAC (Jan. 6, 1993).

### III. LESSONS FOR BIOTECH AND NANOTECH INNOVATION

<sup>¶ 14</sup> The underlying policy goals of the copyright system remain a matter of debate among courts and commentators. Both the instrumentalist view that copyright should supply incentives for the creation of socially desirable works and the natural rights or "fairness" view that creators of socially desirable works deserve some sort of reward for and control over their creations are broadly recognized, though different people ascribe different degrees to their relative importance, especially when applied in specific circumstances.<sup>55</sup> Moreover, there is widespread agreement that the public interest in free or freer use of intellectual creations—arising from the nature of information works as a non-zero-sum game<sup>56</sup>—should be balanced against the rights that intellectual property law affords to authors and inventors, but again different people will disagree on just where to draw the balance.<sup>57</sup>

<sup>55</sup> The Supreme Court has consistently been in the instrumentalist camp:

The limited scope of the copyright holder's statutory monopoly, like the limited copyright duration required by the Constitution, reflects a balance of competing claims upon the public interest: Creative work is to be encouraged and rewarded, but private motivation must ultimately serve the cause of promoting broad public availability of literature, music, and the other arts. The immediate effect of our copyright law is to secure a fair return for an "author's" creative labor. But the ultimate aim is, by this incentive, to stimulate artistic creativity for the general public good.

Twentieth Century Music Corp. v. Aiken, 422 U.S. 151, 156 (1975). Similar language appears in many of the Court's decisions. See, e.g., Dennis S. Karjala, Federal Preemption of Shrinkwrap and On-Line Licenses, 22 U. DAYTON L. REV. 511, 514–15 & n.7 (1997) [hereinafter Federal Preemption]. In upholding the 1998 extension of the copyright term, however, the Court essentially ceded plenary copyright power to Congress, even when Congress acts with respect to an express constitutional mandate (that copyrights endure for only "limited times"). Eldred v. Ashcroft, 537 U.S. 186 (2003). Consequently, it is difficult to maintain that the instrumentalist basis for copyright policy is constitutional to the extent Congress thinks otherwise (as Congress must have been thinking in adopting that particularly anti-public-interest piece of legislation). Still, few would maintain that providing an incentive for the production of socially desirable works plays no role at all in the copyright analysis. For a critique of the Court's deference to Congress in the specific case of the copyright term (and an affirmation of a deferential approach to congressional copyright action in nearly everything else), see Dennis S. Karjala, Judicial Oversight of Copyright Legislation, 35 N. KY. L. REV. 253 (2008) [hereinafter Judicial Oversight]. For support of the deferential approach even on the issue of copyright term, see Paul M. Schwartz & William Michael Treanor, Eldred and Lochner: Copyright Term Extension and Intellectual Property as Constitutional Property, 112 YALE L.J. 2331 (2003); Thomas B. Nachbar, Judicial Review and the Quest to Keep Copyright Pure, 2 J. TELECOMM. & HIGH TECH. L. 33 (2003).

<sup>56</sup> That is, information works are nonrival in use, meaning that more than one person can make use of information at the same time. Moreover, once created, information can be reproduced almost costlessly. *See* Karjala, *Judicial Oversight, supra* note 55, at 269–71.

<sup>57</sup> See, e.g., Error! Main Document Only.Jane C. Ginsburg, Creation and Commercial Value: Copyright Protection of Works of Information, 90 COLUM. L. REV. 1865 (1990) (arguing that the two primary historical themes underlying copyright are Error! Main Document Only.protection of effort expended in creating a work and protection of "personality" reflected in a work); Error! Main Document Only. Justin Hughes, *The Philosophy of Intellectual Property*, 77 GEO. L.J. 287, 314 (1988) (arguing that the ad hoc jError! Main Document Only.udicial approach to idea/expression may

53

failure. Dennis S. Karjala, *Misappropriation as a Third Intellectual Property Paradigm*, 94 COLUM. L. REV. 2594 (1994).

¶15 For biotech and nanotech innovation, however, as for computer software, the underlying works are technology. While creativity and indeed aesthetic beauty may appear either in the products based on knowledge from these fields or in some of the devices or processes used in the production of such products,<sup>58</sup> the protection of technology has always been the province of patent law. Patent's inability to address the misappropriation problem for software led to the application of copyright, and I assume here that a similar misappropriation scenario may develop for both biotech and nanotech innovation. However, as long as misappropriation of expensive-to-create but easy-toreproduce *technology* is the problem, the appropriate policy goal is clear. The incentive to create new products in these technological fields should not be undercut by copying that would unduly divert the investment of time, energy, or money in developing such new products. The goal is not to reward creativity for its own sake, but to make sure that the incentive to invest in the necessary research and development will not be reduced by the threat of "piracy." But for that threat, we would leave all of these technological products to their fates under the patent and trade secret regimes, as we do for nearly all other forms of technology. The opposite side of the equation, on the other hand, remains firmly in place. Intellectual property rights stronger than those needed to supply a creation incentive reduce economic efficiency by inhibiting freer distribution and use of innovative products (through higher prices) and slowing ongoing development based on the current innovation (because only the rights-holder can authorize certain kinds of downstream development work). Failure to focus on this anti-misappropriation goal led many courts and commentators astray in analyzing the scope of copyright protection for computer software,<sup>59</sup> and bio- and nanotech would likely suffer a similar fate if blindly

indicate a concern for protecting what we are most confident involves actual labor—the execution of the idea—and may be based on what we feel are people's just deserts as much as society's informational needs); **Error! Main Document Only.**Maureen A. O'Rourke, *Evaluating Mistakes in Intellectual Property Law: Configuring the System to Account for Imperfection*, 4 J. SMALL & EMERGING BUS. L. 167, 169–70 (2000) (summarizing Fisher's models as **Error! Main Document Only.**(1) Lockean labor-dessert theory (natural rights), (2) utilitarian, (3) self-actualization personality (entitlements aimed at human flourishing), and (4) proprietary or social planning (rights aimed at attaining a just culture)), *citing* **Error! Main Document Only.**William W. Fisher III, *Property and Contract on the Internet*, 73 CHI-KENT L. REV. 1203, 1214. (1998).

<sup>&</sup>lt;sup>58</sup> Materials science has been compared to painting and sculpture, and indeed a three part series on Public Television in the 1990's was entitled "The Stuff of Dreams." Karjala, *Reverse Engineering, supra* note 34, at 997 n.66. Albert Einstein has also been quoted as saying, **Error! Main Document Only.**"After a certain high level of technical skill is achieved, science and art tend to coalesce in esthetics, plasticity, and form. The greatest scientists are always artists as well." Gary Johnstone, *The Producer's Story: Why Einstein Was like Picasso*, a program produced for NOVA on PBS, available at http://www.pbs.org/wgbh/nova/einstein/producer.html. Elegant solutions to technological problems, however, do not take them out of patent and into copyright.

<sup>&</sup>lt;sup>59</sup> See, e.g., Eng'g Dynamics, Inc. v. Structural Software, Inc., 26 F.3d 1335, 1346 (5th Cir. 1994), supplemented 46 F.3d 408 (5th Cir. 1995) (creativity in designing data input formats leads to copyright protection); Lotus Dev. Corp. v. Paperback Software Int'l, 740 F. Supp. 37, 79 (D. Mass. 1990) (Copyright protection would be perverse if it only protected mundane increments while leaving unprotected as part of the public domain those advancements that are more strikingly innovative.), *rev'd* **Error! Main Document Only.**Lotus Development Corp. v. Borland International, Inc., 49 F.3d 807 (1st Cir. 1995); see also Jon S. Wilkins, Note, *Protecting Computer Programs as Compilations Under Computer Assocs. v. Altai*, 104 YALE L.J. 435, 452–53 (1994) (arguing for program SSO protection on the ground that that is where the

thrown under the copyright umbrella.

## **IV. BIOTECHNOLOGY**

¶16 As briefly mentioned in the introduction, biotechnological innovation, to the extent it is based on DNA sequences, is very similar to software. Machine language computer programs can be represented as standard-length words ("bytes") of 0s and 1s, even though the programs must take the form of a high or low physical quantity, such as a voltage, that sets physical switches inside a computing machine. Similarly, pieces of DNA can be represented as sequences of the letters ACTG, although the actual DNA is comprised of physical molecules in three dimensions that link the helices of the larger DNA molecule. When a computer program is in an appropriate physical environment that is to say, properly stored in the computer—it responds to inputs representing other variables of interest to the machine's operators. It produces outputs that we may interpret as "information processing," even though all that has happened is that the input data, when transformed into physical signals, has caused a cascade of switching operations and current flows that take the machine into a different physical state. Similarly, when DNA is located in an appropriate physical environment, such as a cell, its "message" can be read by RNA in three-base codons, whose structure is just right for capturing an amino acid from the local environment as the next piece of a protein chain that the DNA is building.<sup>60</sup> In this sense, DNA supplies the "instructions" for building the protein, though in fact the DNA is simply reacting to biological stimuli and doing what comes naturally, just like the stored signals in a computer. From a purely physical point of view, therefore, the analogies between computer programs and DNA sequences are strong, and if computer programs are protected by copyright, it is fair to ask why DNA sequences cannot also be copyrighted.<sup>61</sup> When we understand the policy justification for protecting functional computer software under copyright law, however, the issue becomes whether biotechnological innovation, or any part of it, is or will be vulnerable to inexpensive and easy copying. If so, the question becomes whether patent law—the branch of intellectual property law designed for the protection of technology-is similarly incapable of addressing the misappropriation problem adequately.

¶17 Patent law's inability to deal with the software misappropriation problem was exacerbated by early judicial decisions that seemed to rule out patent protection for computer programs.<sup>62</sup> Much of the pressure to apply copyright to DNA sequences,

real creativity lies). Like most other strong-program-copyright proponents of the time, these observers ignore the availability of *patent* protection for creative new technological developments.

<sup>&</sup>lt;sup>60</sup> Dennis S. Karjala, *A Legal Research Agenda for the Human Genome Initiative*, 32 JURIMETRICS J. 121, 129–38 (1992) (describing some DNA basics).

<sup>&</sup>lt;sup>61</sup> See, e.g., Kayton, *supra* note 16. See also Kumar & Rai, *supra* note 13, at 1763–64 (discussing the difficulties of applying copyright law to synthetic biology today through judicial interpretation of the Copyright Act).

<sup>&</sup>lt;sup>62</sup> Gottschalk v. Benson, 409 U.S. 63, 72 (1972). Computer programs embedded in a tangible medium were ultimately recognized as patent subject matter. *In re* Beauregard, 53 F.3d 1583 (Fed. Cir. 1995) (vacating appeal when the USPTO agreed that the claims were not barred under 35 U.S.C. § 101). While the Supreme Court has upheld the Federal Circuit's denial of subject matter eligibility to a method for hedging commodities transactions, the claims were not tied to a computer. Bilski v. Kappos, 130 S. Ct.

however, was removed by a broad judicial approach to the patent protection of DNA sequences; even naturally-occurring sequences are patentable if isolated and purified.<sup>63</sup> Moreover, at least until recently there were few easy ways to predict the function that a given DNA sequence would perform simply from knowledge of the sequence itself.<sup>64</sup>

given DNA sequence would perform simply from knowledge of the sequence itself.<sup>34</sup> Therefore, the functional design of useful DNA-based products did not follow the systems engineering approaches that developed for computer software. Much of the "invention" in DNA-based products and methods was in discovering the function of a particular naturally occurring sequence, isolating the sequence, and determining how to put it to practical use. It would have been difficult to claim "authorship" or "originality" in these naturally occurring sequences within the meaning of copyright law.

<sup>¶</sup>18 The growing interest in "synthetic biology" may change this.<sup>65</sup> Professors Kumar and Rai have described the goals of synthetic biology as making biology a true engineering discipline, in which standardized parts and modules of biological genes or strings of DNA can be arranged and fitted together, perhaps ultimately creating a programmable genome from standard parts.<sup>66</sup> At the lowest level of abstraction would be genetic material in the form of DNA sequences, natural or artificial. These sequences could be used to synthesize protein "parts" that perform a basic biological function. Parts would then be combined into "devices" that perform a human-defined function, such as receiving a binary signal of some sort and inverting it (changing a "1" into a "0" or vice versa in the language of computer science). These devices could be combined into "systems" such as a genetic oscillator that functions like an electronic oscillator in continuously toggling its output between two binary possibilities at a given rate.<sup>67</sup> Just as semiconductor chip fabrication allows systematic building of very complex electronic circuitry out of basic parts like transistors, biological engineers envision building a

<sup>64</sup> Zekos, *supra* note 18, at 319 (2006) ("Uncertainty in predicting the structural features of biotech inventions renders them nonobvious" under patent law).

<sup>65</sup> Dennis S. Karjala, *Thinking beyond patents for the protection of DNA-sequence-related information*, in II THE HUMAN GENOME PROJECT: LEGAL ASPECTS 185, 189–91 (Fundacion BBV ed. 1994). While I certainly cannot claim to have predicted synthetic biology, I did argue over 15 years ago that when and if biotechnology reached the stage at which DNA-sequence information became the crucial basis for new products and processes, the patent nonobviousness requirement might make patents more difficult to obtain. If that were coupled with ease of discovery of the costly-to-create sequence information, we might have to start thinking of some sort of anti-misappropriation approach.

<sup>66</sup> Kumar & Rai, *supra* note 13, at 1746.

<sup>67</sup> Drew Endy, *Foundations for engineering biology*, 438 NATURE 449, 451 (2005); David Baker et al., *Engineering Life: Building a FAB for Biology*, SCI. AM., June 2006, at 44, 48 (2006).

<sup>3218, 3231 (2010) (</sup>denying the claims in question on the ground that they constituted an abstract idea). There was no claim to the software in *Bilski* as an independent piece of technology, so even if the claims had been tied to a computer, they would at most have been a computer-related patent claim rather than one on specific software code or SSO. *See* Karjala, *Relative Roles, supra* note 11, at 57–63 (emphasizing the need to distinguish between patent protection for an actual computer program and patent protection for a larger system or device that makes use of a programmed computer).

<sup>&</sup>lt;sup>63</sup> See Diamond v. Chakrabarty, 447 U.S. 303 (1980) (holding that a live, human-made micro-organism is patentable subject matter under 35 U.S.C. § 101). *But see* Ass'n for Molecular Pathology v. U.S. Patent & Trademark Office, 702 F. Supp. 2d 181, 227 (S.D.N.Y. 2010) (holding that a naturally occurring DNA sequence, even one that has been isolated and purified, does not qualify as patent subject matter); *see also* Demaine & Fellmeth, *supra* note 26, at 331 (cogent critique of extending patent protection to naturally occurring substances).

complex end product without having to figure out exactly what the internal structural details would have to be, eventually allowing the use of computer aided design in managing the very complex products that would result.<sup>68</sup>

¶ 19 A beginning toward these ambitious goals has been made with the Registry of Standard Biological Parts at MIT.<sup>69</sup> The Registry records and indexes biological parts and offers synthesis and assembly services for building new parts, devices, and systems.<sup>70</sup> The Registry maintains its parts as actual biological specimens,<sup>71</sup> but at some point only the DNA sequence information may be necessary, from which the desired parts can be synthesized as needed.<sup>72</sup>

¶20 If biotech design reaches the point at which new products are simply the complex combination of a wide variety of functional parts taken "off the shelf," it begins to resemble the modular object-oriented techniques on which software design came to rely (albeit after literal code had already been covered by copyright). To the extent these off-the-shelf parts are simply DNA-sequence information with interface protocols for joining them together, the analogy to computer software is even closer. In many cases, of course, there will be sufficient human ingenuity in the combining of these off-the-shelf parts that the final product qualifies under the traditional patent requirements. However, if the rules for combining parts become highly standardized, it may be that achieving a given function will simply be standard application of standardized rules, that is, something the person having ordinary skill in the art (PHOSITA) of biotech design could achieve. At that point, patents will no longer be available.<sup>73</sup> Such biotech innovation will be vulnerable to misappropriation to the extent that the design can easily be determined from use or analysis of the product (as is the case for computer software).

¶21 To use copyright to solve the biotech misappropriation problem would almost surely be a mistake. Many objections spring to mind beyond the fundamental one that copyright is designed for the protection of art, literature and music and not functional technology.<sup>74</sup> First, while copyright does solve the legal misappropriation problem for software in its protection of literal code, it is not clear that copyright would be as effective when applied to DNA-sequence information. While there is redundancy in the genetic code, so that there will likely be at least a small variety of ways a given biological function can be accomplished through DNA sequencing, the number may not be large enough to avoid application of copyright's merger doctrine.<sup>75</sup> More importantly,

<sup>&</sup>lt;sup>68</sup> David Baker et al, *supra* note 67, at 44–46.

<sup>&</sup>lt;sup>69</sup> Mass. Inst. Tech., *Registry of Standard Biological Parts*, http://partsregistry.org/Main\_Page. As of June 2009 the Registry had some 3,200 genetic parts that could be combined into synthetic biology devices and systems.

<sup>&</sup>lt;sup>70</sup> Mass. Inst. Tech., *About the Registry*, http://partsregistry.org/Help:About\_the\_Registry.

<sup>&</sup>lt;sup>71</sup> Mass. Inst. Tech., *Add A Part*, http://partsregistry.org/Add\_a\_Part\_to\_the\_Registry\_("Like all parts, a Basic Part is stored in a plasmid, flanked by restriction-enzyme cloning regions ("BioBrick ends")).

<sup>&</sup>lt;sup>72</sup>. Kumar & Rai, *supra* note 13, at 1746.

<sup>&</sup>lt;sup>73</sup> 35 U.S.C. § 103 (2006); *see also* KSR Int'l Co. v. Teleflex, Inc., 550 U.S. 398 (2007).

<sup>&</sup>lt;sup>74</sup> Recall the need for a more precise definition of "functionality" than is found in ordinary discourse. *See supra* notes 39–41 and accompanying text.

<sup>&</sup>lt;sup>75</sup> On the other hand, complex combinations of basic DNA-based parts will likely show an exponentially increasing variety of ways to carry out a given macro-level function. To the extent these

copyright comes with historical baggage and its scope is not easily limited to the misappropriation problem. Early software decisions treated computer programs as literary works like novels instead of applying the more narrowly protected historical, scientific, or technical work analogy.<sup>76</sup> Lawyers will certainly argue that a similarly broad scope of protection should be afforded to DNA-sequence information as "literary works." The appropriateness of doing so will depend on what aspects of the DNA-sequence information are in fact vulnerable to piracy. To the extent the vulnerability is limited to the actual sequence (analogous to the literal code of a computer program), extension of the copyright to cover modular structure (like SSO for programs) should be avoided. Copyright protection is also too long for functional works (and arguably too long for *any* works but particularly so for functional works), because technology improves incrementally by building on the existing base.<sup>77</sup> To tie up the base in intellectual property rights for periods on the order of 100 years simply makes no sense.<sup>78</sup> Such a long period of protection gives no more incentive to create new works than a much shorter period but inhibits technological development for the full term.<sup>79</sup> Finally, the notion of compulsory licensing is, at least in general, anathema to copyright, yet we are considering technological products that almost surely can be incrementally improved. It is difficult to make an incremental improvement to a copyright-protected product without infringing, because the improved product will usually be substantially similar to its starting point.<sup>80</sup> We need a scheme of protection that is either very short term or allows later workers to build directly on earlier discoveries without worrying about being enjoined if a licensing agreement cannot be reached.<sup>81</sup>

¶22 If a sui generis copyright-like anti-misappropriation system is to be applied to biotechnological innovation based on the protection against copying of DNA sequences, even for a short term (somewhere in the range of three to ten years seems about right), the computer software experience also sheds some light on how to handle other details. For example, neither CONTU nor Congress thought to distinguish between operating software and application programs in deciding to apply copyright to software technology.<sup>82</sup> An important result of this failure is the dominance of a single firm in the

ways are roughly equal from the point of view of efficiency and other functional considerations, merger may not apply.

<sup>&</sup>lt;sup>76</sup> See *supra* note 43 and accompanying text.

<sup>&</sup>lt;sup>77</sup> See Suzanne Scotchmer, Standing on the Shoulders of Giants: Cumulative Research and the Patent Law, 5 J. ECON. PERSP. 29 (1991).

<sup>&</sup>lt;sup>78</sup> Sonny Bono Copyright Term Extension Act of 1998, Pub. Law 105–298, 112 Stat. 2827.

<sup>&</sup>lt;sup>79</sup> Eldred v. Ashcroft, 537 U.S. 186, 254–55 (2003) (Breyer, J., dissenting); Karjala, *Judicial Oversight, supra* note 55, at 261–62.

<sup>&</sup>lt;sup>80</sup> Alternatively, the improver may be liable for violating the copyright-holder's exclusive rights in the derivative work. 17 U.S.C. § 106 (2006).

<sup>&</sup>lt;sup>81</sup> See also Reichman, *supra* note 12, at 2544–45. Professor Reichman's proposal is perfectly compatible with these general thoughts. Although I greatly oversimplify, he argues that, when technological know-how is easily appropriated by competitors, we need to supply some artificial lead time coupled with a set of users' rights that allows users to improve the technology but requires that they contribute to the overall costs of research.

<sup>&</sup>lt;sup>82</sup> Under the language defining a "computer program" in the Copyright Act, there is a legitimate argument that operating software is not included. The statute defines a computer program as a "set of statements or instructions to be used . . . in a *computer* in order to bring about a certain result." 17 U.S.C. § 101 (emphasis added). It is hard to say what the "certain result" is that is achieved by an operating system,

gateway to personal computing (and network effects made it almost certain that some single firm would have achieved such dominance in any event, even if for some reason Microsoft had stumbled).<sup>83</sup> It is not clear whether synthetic biology will present a similar problem, but Professors Kumar and Rai worry that even twenty-year patents in such aspects of the technology as large-scale gene synthesis—a "technology platform onto which many applications can be layered"—might be detrimental to innovation.<sup>84</sup> If the applications based on such platforms are platform-dependent, as application programs are on the operating software for which they are written, we could easily see a rehash of the same debate, and possibly a repeat of the same unfortunate outcome, unless we address the issue in advance when adopting the statutory anti-misappropriation scheme. We certainly would not want rights in such platform technologies to extend for the current period of copyright protection. Perhaps an analysis of the relevant incentives will show that no protection at all is necessary (beyond patent and trade secret) to achieve an appropriate level of innovation in this field, and to the extent some anti-misappropriation protection is deemed necessary, the term should be carefully delimited. Moreover, a compulsory licensing scheme should be adopted to insure against the enjoining of new applications based on whatever standard platform emerges or of improvements on that platform.

¶23 In order to assemble many biological parts together into a single complex end product, standardized interfaces will be needed.<sup>85</sup> We do not want to leave it up to copyright courts to conclude, as one did for computer software, that compatibility considerations are a "commercial and competitive objective which does not enter into the somewhat metaphysical issue of whether particular ideas and expressions have merged."<sup>86</sup> Even if we were to apply copyright to DNA sequences, a court should find interface molecules or parts to be a "method of operation" as the courts ultimately did for software,<sup>87</sup> but again it would be better to deal with the issue explicitly at the time we consider the details of the statutory anti-misappropriation scheme.

<sup>¶ 24</sup> It may be worth asking whether biotechnology presents anything analogous to the random-access memory (RAM) copying problem that has plagued much of the analyses of software cases.<sup>88</sup> The technology of computer software is such that copies must be made in the active part of the machine's memory every time the program is used, and

other than to present an interface for the writing of application programs. Moreover, the term "computer" is not defined at all. Because a computer program written for one operating system will generally not run on another operating system, a computer program brings about its certain result only when executed on a machine that is running the operating system for which the program was written. Therefore, it is not too much of a stretch to say that the "computer" in the statutory definition of a computer program is computer hardware plus a given operating system, so that the operating system itself is simply a part of the machine. The ship sailed on this argument, however, when the defendant failed to make it in Apple Computer, Inc. v. Franklin Computer Corp., 714 F.2d 1240, 1253–54 (3rd Cir. 1983) (establishing that operating software was not *per se* copyright unprotected).

<sup>&</sup>lt;sup>83</sup> See Karjala, Copyright Protection of Operating Software, supra note 15, at 172–76.

<sup>&</sup>lt;sup>84</sup> Kumar & Rai, *supra* note 13, at 1767–68.

<sup>&</sup>lt;sup>85</sup> Kumar & Rai, *supra* note 13, at 1757–58.

<sup>&</sup>lt;sup>86</sup> Apple, 714 F.2d at 1253.

<sup>&</sup>lt;sup>87</sup> Lotus Dev. Corp. v. Borland Int'l, Inc., 49 F.3d 807, 815 (1st Cir. 1995).

<sup>&</sup>lt;sup>88</sup> See, e.g., MAI Sys. Corp. v. Peak Computer, Inc., 991 F.2d 511, 517–22 (9th Cir. 1993).

when the internet is involved, even more copying is a necessary.<sup>89</sup> In the case of computer programs, the program itself is often the end product that the user acquires and uses in his computer, resulting in the necessity of constantly making new copies in RAM. It is not clear, whether a similar problem will arise with respect to end products of synthetic biology. If the product is a medicine, for example, it will likely be consumed in use with no need to make further copies of any of its parts. The *manufacture* of synthetic biology end products, however, seems very likely to involve large-scale copying of individual molecular components. Exact reproduction of itself is probably the single most important feature of the extraordinary DNA molecule, and one would suspect that manufacture of macro-scale products from protected sequences of DNA would involve copying in numbers that would dwarf even the peer-to-peer copying of music that we have seen on the internet.<sup>90</sup> Maybe even some consumer end products will be designed to rely on DNA's reproduction abilities to generate copies of themselves when put to use (for example, internally as a medicine).

¶25 In any event, to the extent that use of a biotech product invokes copying of protected DNA sequences, copyright or copyright-like rights in the sequence may allow the rights-owner a basis for seeking to control not only the market for the product but also the market for its uses, whether or not such copying threatens the market for the product itself.<sup>91</sup> This was rarely the case for traditional copyright subject matter (one need not copy a book to read it, for example), but it arises with increasing frequency pursuant to so-called "licenses" of software, notwithstanding the right under the Copyright Act, 17 U.S.C. § 117, of owners of copies to reproduce programs in RAM to the extent necessary to use the program.<sup>92</sup> If the sellers of these self-replicating biotech products "license" the right to make copies via the biotech equivalent of the end user license agreements (EULAs) and terms of use (TOUs) developed in the software arena, and if they condition the license to reproduce the sequence on compliance with some restriction on use (such as using the product only within a given geographical area), courts may well find that users who actually owns the product cannot legally use it in circumstances of their choice. Others who knowingly assist in the "unlicensed" use of the product may be liable

<sup>&</sup>lt;sup>89</sup> See, e.g., Mark A. Lemley, *Dealing with Overlapping Copyrights on the Internet*, 22 U. DAYTON L. REV. 547, 552–53 (1997).

<sup>&</sup>lt;sup>90</sup> See, e.g., Metro-Goldwyn-Mayer Studios, Inc. v. Grokster, Ltd., 545 U.S. 913, 919–20 (2005).

<sup>&</sup>lt;sup>91</sup> We must bear in mind that the potential for unfair competition (misappropriation) in the market for the product is the only justification for any deviation from classical patent and trade secret law for the protection of technology in the first place.

<sup>&</sup>lt;sup>92</sup> See MAI Sys. Corp., 991 F.2d at 517–22. Customers of MAI Systems owned computers running MAI software that the Ninth Circuit accepted without analysis was "licensed" rather than owned by the customers. The customers therefore did not get the benefit of section 117, and the defendant Peak Computer, a computer service company, could acquire no derivative rights either, making Peak a copyright infringer when it turned the machines on. Although the specific problem of third-party hardware servicing has now been addressed by section 117(c), the more general problem of using "licenses" of programs to regulate under copyright even uses that do not otherwise call any of the copyright rights into play continues to arise; Ticketmaster v. RMG Tech., 507 F. Supp. 2d 1096, 1108 (C.D. Cal. 2007) (holding that violation of website's terms of use concerning accessing the website by an automated program revoked the "license" to make RAM copies of the copyright-protected portions of the website, which necessarily occurred by simply visiting the website).

as contributory infringers.<sup>93</sup> Consequently, it seems clear that something akin to section 117 will be necessary to insure that such biotech products that are legally possessed can be freely used without fear of intellectual property rights violations (at least in the absence of bargained-for restrictions).<sup>94</sup>

### V. NANOTECHNOLOGY

¶26 Nanotech innovation does not yet appear to be anywhere near the stage at which complex end products will be built up from much smaller and standardized components. Indeed, most nanotech products that are actually on the market may not even make use of the major factor that distinguishes nanotechnology from everything else: the dramatic changes in physical properties that often occur at the nanoscale. True nanotech will involve manipulation of matter at the atomic and molecular levels, and it is not limited to any particular field or type of material.<sup>95</sup> At present there is nothing equivalent to the 1s and 0s of computer software or the AGCT molecules of DNA strands that provides the basis for a language, and ultimately larger scale platforms, for combining elements in a standardized way. It may also be easy to keep many nanotech innovations secret, because trying to disassemble a macro-scale product may not reveal much about how it was put together.<sup>96</sup> As two commentators have noted, "Nanotechnology in the long term is not about making small things—it is about making large things with exquisitely precise control of the smallest parts."<sup>97</sup>

<sup>93</sup> See, e.g., MDY Indus. v. Blizzard, 616 F. Supp. 2d 958 (D. Ariz. 2009), rev'd 629 F.3d 928 (9th Cir. 2010). Here, the EULA for a popular online video game prohibits playing the game by means of a program that automates play (thereby getting the player to higher levels without the tedium of going through the lower levels). MDY Industries offered a product known as Glider that automates play and sought a declaratory judgment that the player's use of Glider was not copyright infringement. Because the game software was already legally copied onto the players' hard drives, the copyright "hook" came solely from the technological requirement that copies of pieces of the game software are constantly loaded into and out of RAM during play. The district court held that the players were not owners of their copies of the game software, so that the section 117 exemption did not apply. Therefore, the players lost their "license" to play the game when they ran Glider to automate play. MDY Industries was held liable as a contributory infringer. The Ninth Circuit reversed on the ground that the non-copyright-related term in the EULA and TOU was a covenant and not a condition of the license. MDY Indus. v. Blizzard Entertainment, 629 F.3d 928 (9th Cir. 2010). That approach, however, is incompatible with true licenses that are negotiated between knowledgeable parties, which often condition the continuation of the license on compliance with promises that have nothing to do with the exclusive rights of the copyright owner under section 106. Karjala, *Federal* Preemption, supra note 55. The same panel of the Ninth Circuit earlier held in Vernor v. Autodesk, 621 F.3d 1102 (9th Cir. 2010), that determining whether software was licensed or sold, even in a mass-market transaction, depended on whether the copyright owner specified the grant of a license, whether there were significant restrictions on transfer, and whether there were "notable" use restrictions. All of these are solely within the control of the software copyright owner, so "ownership" of software copies, and therefore user rights of first-sale and section 117 RAM loading, are optional with the copyright owner. Thus, the "licensing" issue for mass-marketed computer software remains far from resolved, and we would do well to try to avoid a repetition of this sordid story when misappropriation becomes a major issue for biotech. [Disclosure: I have acted as a consultant to the attorneys for MDY Industries in this matter.]

<sup>&</sup>lt;sup>94</sup> Karjala, *Federal Preemption*, *supra* note 55, at 531–32.

<sup>&</sup>lt;sup>95</sup> Zekos, *supra* note 18, at 314–15; Roe, *supra* note 18, at 128 (2006).

<sup>&</sup>lt;sup>96</sup> Zekos, *supra* note 18, at 316.

<sup>&</sup>lt;sup>97</sup> Drexler & Wejnert, *supra* note 20, at 7.

127 When nanotech matures, however, some believe that the production of just about anything (not just information) will be very inexpensive provided one has the "blueprint" for directing the nanotech device to build what is needed.<sup>98</sup> Using nanotechnology, production would be carried out by large numbers of tiny devices operating in parallel, in a way comparable to the molecular machinery already found in living organisms.<sup>99</sup> This future atom-by-atom construction will have a somewhat longer set of "letters" (atoms or molecules) to choose from in putting pieces together to create a new nanotech product, in comparison with the two- or four-letter alphabets in software and biotech. Nevertheless, it seems likely that certain combinations of atoms or molecules will be found to be useful in achieving certain functions that must be repeated numerous times. As things develop, this knowledge will be systematized, very likely into something roughly analogous to computer software. From there it is not hard to imagine higher level design "languages" for the development of nanotech products as well. Of course, at least in the early stages, patents should be available for technological innovations in this field, but once the basic technology has settled into place, creations of new products using nanotechnological methods will become routinized, as it did for computer software and seems likely to occur soon in biotech. At that point, patents will become increasingly difficult to obtain, because most new products—albeit the results of a heavy infusion of time, energy, and money—will not contain any patentable invention.

¶28 Therefore, it seems that one branch of the analogy to software and biotech is or will be in place: namely, the key to the production of useful products will lie in systemized packets of information concerning how to choose and combine individual atoms and molecules. The remaining question is whether this crucial production information will be readily discoverable by a would-be competitor and, if so, whether the information would give the competitor such a leg up in the marketplace by having avoided the initial development costs that the incentive to create the product in the first place will be eroded. It is probably too early in the development of nanotechnology to predict with precision where or even whether a vulnerability to misappropriation might occur. Two commentators have asserted, however, that while today software is inexpensive to copy, future nanotech developments will make even hardware easy to copy.<sup>100</sup> Indeed, one visionary has predicted the possibility of cloning any physical article, including a new nanotech invention, by standard procedures.<sup>101</sup>

¶29 If this future cloning process is sufficiently inexpensive, we will be faced with a misappropriation problem that transcends even what we faced for software. Indeed, it will make the problem faced by the Supreme Court in  $Feist^{102}$  seem small in comparison. *Feist* addressed the copyright protection of a factual compilation (a telephone directory) and overruled—on statutory but also purportedly on constitutional grounds<sup>103</sup>—the judicially created "sweat of the brow" doctrine. This doctrine fit clumsily with the

<sup>&</sup>lt;sup>98</sup> *Id.* at 11–12.

<sup>&</sup>lt;sup>99</sup> Zekos, *supra* note 18, at 315.

<sup>&</sup>lt;sup>100</sup> Drexler & Wejnert, *supra* note 20, at 12.

<sup>&</sup>lt;sup>101</sup> Stephen E. Weil, *Cloning and Copyright*, 19 CARDOZO ARTS & ENT. L.J. 137, 139–40 (2001).

<sup>&</sup>lt;sup>102</sup> Feist Publ'ns., Inc. v. Rural Tel. Serv. Co., 499 U.S. 340, 359–60 (1991).

<sup>&</sup>lt;sup>103</sup> For a critique of *Feist* and the problems it has raised, *see* Karjala, *Copyright and Creativity, supra* note 34.

statutory language at best, but it tried to address the market failure presented by works whose cost of creation was much greater than the cost to copy them.<sup>104</sup> Feist created a problem for copyright-unprotected material, such as factual information, that was costly to gather together into a single easily accessible format. If the predictions for nanotechnological "cloning" become a reality, a new method for producing all kinds of copyright-unprotected material, such as food or computers, will be vulnerable to misappropriation to the extent it is not eligible for a patent, much like a complex computer program containing no patentable invention. It obviously seems strange to consider something like copyright protection for beef or computer monitors, but the argument will not go away if these products are indeed initially expensive to create but easy to copy once publicly available. We will need, or at least there will be a demand for, something copyright-like in the informational blueprint for producing even these mundane and traditionally copyright-unprotected products.

¶ 30 We can again look to the problems that have surfaced for computer software to inform our consideration of the details of such a nanotech-information-protection statute. Will there be something akin to the operating software/application program divide? It should not come as a surprise if we find an apt analogy. Nanotech production will likely involve detailed and repetitious production by smaller devices of larger parts that are then fitted together to form a final macro-scale product. At first there may be a bewildering array of possibilities, as there were when the first computer hardware became available, which had to be programmed directly in machine language. A program that allows designers to work at a higher level of abstraction will almost surely become necessary if such production is to be routinized. One can further imagine the likelihood that these programs can be constructed in a large variety of ways. To the extent that each such program works with specific parts or in a specific environment, they may well be incompatible with one another, leading to competition in the marketplace for these "operating" programs. As more application programs are written for one such operating program—that is, programs that govern operation of a specific manufacturing machine to produce end products, like food or computer monitors-we can expect the same sort of network effect that we saw for operating software in the computer field.<sup>105</sup> We should distinguish between nanotech "operating" and "application" programs in formulating the legal response to their protection, with an eye either to denying protection beyond patent to the operating programs if the misappropriation problem for them is not too great, or to limiting rights by allowing unauthorized improvements subject to payment of a license fee (compulsory license). It also goes without saying that the term of protection should be vastly less than that for copyright—again, somewhere in the range of three to ten years seems reasonable.

¶31 It is not clear whether or to what extent the SSO and user interface protection problems for software will have analogies in nanotech. SSO, like the underlying "program" itself, should only be protected to the extent that it is equally vulnerable to incentive-eroding misappropriation. For computer software, the SSO is no more

<sup>&</sup>lt;sup>104</sup> For an analysis of many of the old "sweat of the brow" problems and how they might be affected by *Feist*, see Dennis S. Karjala, *Copyright and Misappropriation*, 17 U. DAYTON L. REV. 885 (1992). <sup>105</sup> See Karjala, *Copyright Protection of Operating Software*, *supra* note 15.

vulnerable to misappropriation than any other patent-unprotected technology.<sup>106</sup> Whether that will also be true for nanotech "programs" is something that needs to be investigated. Similarly, it is presently unclear to what extent, if any, copying of the protected program will be a necessary part of using the program to produce other goods. Nanotechnology appears to differ from both computer software and biotechnology based on DNA sequences, and it may well be that no problem analogous to RAM copying will arise.

¶32 User interfaces, however, do seem likely to play a role in nanotech similar to what we have seen for computer programs. Oversimplifying, a nanotech application program for making, say, ground beef will likely require an input of various materials containing the necessary molecules for production, possibly in some temporal or spatial order. The underlying nanotech program that organizes all of the tiny nanotech devices inside the machine will call those devices into play in such a way that they produce ground beef when the input materials have been properly administered; otherwise, perhaps, they produce literal garbage. Thus, the program itself defines or specifies the user interface, just as computer programs do.<sup>107</sup> That interface is no less a "method of operation" than the menu command hierarchy in *Lotus v. Borland*,<sup>108</sup> and it is no more vulnerable to misappropriation, provided the competitor in a ground-beef-production program has to write his "code" independently. Steps should be taken in designing the anti-misappropriation protection statute to insure a similar result.<sup>109</sup>

## VI. CONCLUSION

¶33 Computer software is technology that looks like a literary work. It is also a technology that is very easy to replicate. In order to encourage investment in the creation of software, some sort of anti-copy protection, beyond the stringent demands of patent law, seemed appropriate. Because copyright does prohibit the unauthorized copying of program code, which is the aspect of computer software that is vulnerable to easy copying, copyright was chosen as an additional vehicle of protection. This occurred essentially without inquiry into the fundamental distinction between patent and copyright subject matter, that is, between technology and nonfunctional information. As a result, Congress did not consider the nuances that would be necessary in applying copyright to technology, and the courts continue to fumble by treating computer programs as "literary works" like novels and plays instead of sui generis works of technology whose policy basis for copyright protection is very different.

¶ 34 It now appears that innovation in biotechnology is on the verge of reaching a similar point. Moreover, innovation in nanotechnology seems likely to reach the same stage in the future. In both cases the crucial technological advance will often be in the

<sup>&</sup>lt;sup>106</sup> See supra notes 44–46 and accompanying text.

<sup>&</sup>lt;sup>107</sup> See, e.g., Copyright Protection of Computer Software, Reverse Engineering, and Professor Miller, supra note 34, at 990.

<sup>&</sup>lt;sup>108</sup> Lotus Dev. Corp. v. Borland Int'l, Inc., 49 F.3d 807, 815 (1st Cir. 1995).

<sup>&</sup>lt;sup>109</sup> Simply copying section 102(b) of the Copyright Act into the anti-misappropriation statute will not do the trick. Computer programs themselves are methods of operation and therefore are implicitly excepted from the operation of section 102(b). *A Coherent Theory, supra* note 10, at 68, 71. See also notes 54–55 *supra* and accompanying text.

sequence or blueprint for assembling molecules, pursuant to well established principles of systems design. Like computer software, much of this innovation will be ineligible for patent protection because it will be the product of a straightforward application of engineering design principles. To the extent that the underlying designs—the sequences or blueprints—are readily discernible from the distributed final product, those designs will, like computer software, be vulnerable to cheap and easy copying, allowing competitive replication of the final product without absorbing the costs of design development. In both cases, the sequence or blueprint will be capable of representation in terms of letters or other symbols, formally bringing them into the category of "literary works" under copyright law. We should resist the temptation to repeat our example of applying copyright law directly to these new technologies, but we should learn from the problems with which the software copyright courts have been wrestling for over thirty years to better design a sui generis statutory scheme that will protect against incentive-eroding misappropriation while fostering healthy competition in the underlying technologies.