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## **An Agricultural Law Research Article**

### **Copyright in Living Genetically Engineered Works**

by

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# Copyright in Living Genetically Engineered Works

Irving Kayton\*

God offers to every mind the choice between truth and repose.<sup>1</sup>

— Ralph Waldo Emerson

## I. Introduction

The words you now are reading are a work of authorship<sup>2</sup> protected from unauthorized reproduction by the copyright laws of the United States.<sup>3</sup> Molecular biologists and genetic engineers may be surprised to learn (as may most everyone) that their expressions of intracellular genetic information, novel or otherwise, within living microorganisms or eukaryotic cells<sup>4</sup> are also works of authorship protected from unauthorized reproduction by the terms of the Copyright Act of 1976 (1976 Act).<sup>5</sup> Although this conclusion may appear startling, a careful examination of the statutory and constitutional requirements

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1. *Intellect*, in 2 THE WORKS OF RALPH WALDO EMERSON 318 (1883).

2. The Copyright Act of 1976, 17 U.S.C. §§ 101-810 (1976 & Supp. IV 1980), affords copyright protection for "original works of authorship fixed in any tangible medium of expression." 17 U.S.C. § 102 (Supp. IV 1980). "Literary works" are included in this expansive definition. *Id.*

3. Copyright Act of 1976, 17 U.S.C. §§ 101-810 (1976 & Supp. IV 1980).

4. Eukaryotic cells are complex cells that have a true nuclear membrane surrounding a nucleus that contains two or more chromosomes. Eukaryotic cells contain certain structures that are lacking in simpler cellular organisms such as bacteria and blue-green algae. F. AYALA & J. KIGER, MODERN GENETICS 4-6 (1980).

5. 17 U.S.C. §§ 101-810 (1976 & Supp. IV 1980). The Copyright Act went into effect on January 1, 1978.

for copyright protection indicates its likely validity. The central theses of this article are that virtually all original works of a genetic scientist are copyrighted automatically when he creates them; the scientist generally can enforce his copyrights; those copyrights may provide more effective protection than other forms of intellectual property in many circumstances; and copyright protection for genetically engineered works appears within the constitutional limits on Congressional power.

## II. *The Advantages of Copyright Protection*

Shock value to the reader aside, what is the value in copyrighting genetic information? The answer is that it depends! Under certain circumstances, from a practical as well as legal viewpoint, copyright protection may be the only or the most effective way an "author" can protect a valuable genetic "work". Furthermore, even when forms of legal protection other than copyright suggest themselves as generally more appropriate, the unusually attractive remedies<sup>6</sup> and long life<sup>7</sup> of copyright protection may tip the scales in its favor. A few examples will illustrate the attractiveness of copyright protection.

At this time, two of the major methods for recombinant DNA engineering<sup>8</sup> with greatest commercial potential appear to be hybridoma methodology<sup>9</sup> and the Cohen-Boyer process of DNA cleavage and ligation or gene splicing.<sup>10</sup> The Cohen-Boyer process has been patented<sup>11</sup> and licensed widely by the assignee, Stanford University. Hybridoma techniques are apparently in the public domain as a consequence of their publication.<sup>12</sup>

Policing a patented process or method of manufacture that is car-

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6. See *infra* notes 26-39 and accompanying text.

7. See *infra* notes 40-48 and accompanying text.

8. DNA, deoxyribonucleic acid, is the primary genetic material of all cells. It is composed of a five-carbon sugar, phosphoric acid and four bases or nucleic acid molecules, adenine, guanine, cytosine and thymine. These components are arranged in repeating units called nucleotides which are attached in linear chains. These chains are in the form of a double helix, a ladder-like configuration rotated on a central axis. See L. MAYS, GENETICS 31-33 (1981). Recombinant DNA is "a synthetic DNA molecule containing genes from two or more different organisms." *Id.* at 349.

9. The genetic engineering of cells of higher organisms is a far more difficult undertaking than the engineering of simple one-celled organisms. Recently, however, success has been obtained through hybridoma methodology. The hybridoma process is the fusion by chemical means of a cell from a malignant tumor with a normal cell whose function is to produce a useful protein, such as an antibody for a specific disease. The fused cell reproduces with the rapidity of cancer cells and produces the useful antibody, not the cancerous protein. See J. FALKINHAM, PRINCIPLES OF GENETIC ENGINEERING, § II, at 22-24, (Patent Resources Group 1981).

10. A cell will function in precisely the way in which its DNA molecule directs it to. Artificial or synthetic DNA molecules can now readily be created by the Cohen-Boyer process. One natural DNA molecule in a test tube is broken at a predetermined site simply by mixing a specific protein (restriction enzyme) with it. The same thing is done to another natural molecule in another test tube. After the cleavage of the two, they are combined in one test tube where, in the presence of a ligating enzyme and with some shaking of the tube, the DNA fragments recombine. Many of the new combinations comprise fragments from the different molecules; they form an artificial, spliced DNA sequence. See J. FALKINHAM, *supra* note 9, § II, at 4-9.

11. U.S. Patent No. 4,237,224.

12. See Kohler & Milstein, *Derivation of Specific Antibody-Producing Tissue Culture and Tumor Lines by Cell Fusion*, 6 EUR. J. OF IMMUNOLOGY 511 (1976).

ried out within the quiet of an infringer's plant usually is either impossible or too expensive to justify. The Cohen-Boyer process creates an exception to this wisdom because of its pioneering nature. Absent a decision to give the process away and absent the possibility of effectively policing a pioneering process, however, the only way an inventor or his investors can benefit from a novel genetic engineering process is to maintain it as a trade secret. The owner of a trade secret can either use it exclusively or license it to others for use (with appropriate restrictions to maintain secrecy).<sup>13</sup>

Assume the secret process allows the owner to create two genetically novel microorganisms, A and B. The first, A, is both novel and nonobvious to a microbiologist of ordinary skill and therefore patentable.<sup>14</sup> The second, B, is both novel and valuable, but obvious to those of ordinary skill and, therefore, unpatentable.<sup>15</sup> How can A and B best be protected so as to provide their creator and his financial backers an appropriate return on their efforts, money, and risk-taking?

The answer for protecting A, patentable though it may be, cannot be patenting if the *process* for making it is to be kept secret. To obtain a valid patent, the applicant will have to disclose in the patent, and thus to the world, how to make A.<sup>16</sup> The trade secret in the process for making A will be lost.<sup>17</sup> That secret process may be far more valu-

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13. See 2 R. CALLMAN, *THE LAW OF UNFAIR COMPETITION, TRADEMARKS AND MONOPOLIES* § 53.3, at 388-89 (3d ed. 1968).

14. See 35 U.S.C. § 103 (1976).

15. See *id.*

16. *Id.* § 112, para. 1. The creator of A may be able to obtain patent protection without disclosing the secret process in one narrow and impractical situation. Section 112, paragraph 1, 35 U.S.C. (1976) requires disclosure in the patent specification of both "the manner and process of making" and "the best mode contemplated by the inventor of carrying out" the invention. This almost invariably requires the patentee to disclose the secret process sufficiently to enable those skilled in the art to make the patented invention without undue experimentation. See *In re Cook*, 439 F.2d 730, 733, 735 (C.C.P.A. 1971). If the inventor of A is satisfied to protect it very narrowly, however, he can deposit a culture of microorganism A in one of the established and recognized depositories and assert as his invention in his patent the microorganism deposited and identified by the depository acquisition number. This approach probably will eliminate the need to disclose the secret process, because scientists can learn how to make the invention and the "best mode" for carrying it out by culturing a sample of the deposited microorganism. This method of patent protection, however, poses serious enforcement problems. First, the scope of protection will be limited to the precise microorganism deposited with little or no room for variation as is permitted when drafting patent claims for inventions of varying scope under Section 112, paragraphs 2 through 6. 35 U.S.C. § 112, paras. 2-6 (1976). Moreover, if the deposited microorganism mutates or becomes nonviable, it will become virtually impossible to determine whether an accused microorganism infringes the patent. In short, the patent protection likely will be narrower in scope and more doubtful in enforceability than obtainable copyright protection. See *infra* text accompanying notes 187-89. Depositories recognized by the United States Patent and Trademark Office are American Type Culture Collection (ATCC), Rockville, Maryland; Agricultural Research Culture Collection (NRRL), Peoria, Illinois; Centraalbureau voor Schimmel-cultures (CBS), The Netherlands; Fermentation Research Institute (FERM), Japan.

17. See R. CALLMAN, *supra* note 13, § 53.3(b).

able as a "golden goose" than any of the individual golden eggs it lays.

A and B probably cannot be protected as trade secrets themselves, since the use of DNA sequencing<sup>18</sup> and DNA-DNA hybridization<sup>19</sup> may well disclose their DNA code.<sup>20</sup> Copyright, however, can protect both DNA sequences to the extent that others will not be allowed to plagiarize (by culturing or otherwise) the organism in which the genetic information is fixed. On the other hand, if others independently invent a process (different from or the same as the secret one) for making A and B, then their use of that process to create and reproduce A and B will not infringe the copyrights to A and B, so long as they did not use the copyrighted work as a guide to compiling the genetic information needed to make A or B.<sup>21</sup> In short, "a work is original and may command copyright protection even if it is completely identical with a prior work provided it was not copied from such prior work but is rather a product of the independent efforts of its author."<sup>22</sup>

To further demonstrate the benefits of copyright protection, assume a microbiologist engineers an organism that is superior in important ways to previously engineered microorganisms or to naturally occurring microorganisms. As with microorganism B, the organism's advantageous properties may not be so dramatic as to make it patentable; it may be obvious to those skilled in the art.<sup>23</sup> Nonetheless, it may be quite valuable commercially and much time, effort, insight, and money may have been expended to create it.

Although the scientist may not be able to obtain a patent, he may be able to secure a copyright.<sup>24</sup> The copyright precludes another from using the DNA sequence that the scientist originated and fixed in the microorganism to make an identical or substantially similar copy.<sup>25</sup> Preventing others from reproducing the DNA information fixed in the organism can be very profitable, even though the scope of protection may be narrower than that afforded by patent.

### A. Copyright Remedies and Damages

The range of benefits open to a copyright owner is truly impressive. The Justice Department may criminally prosecute anyone who will-

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18. DNA sequencing is a process or technique that reveals the order of nucleotides within the DNA molecule. See F. AYALA & J. KIGER, *supra* note 4, at 750. The process is carried out with laboratory procedures which, very recently, have become partially automated through application of digital computer technology.

19. DNA-DNA hybridization, a complicated laboratory procedure, is "a technique that estimates the overall similarity between the DNA of various organisms." *Id.*

20. The use of DNA sequencing or DNA-DNA hybridization is directly analogous to other forms of "reverse-engineering," such as chemically analysing a product to determine its ingredients. Reverse engineering is a fair and legal method of discovering another's trade secret. See 2 R. CALLMAN, *supra* note 13, § 53.3(a), at 393.

21. See *infra* notes 175-81 and accompanying text.

22. 1 M. NIMMER, COPYRIGHT § 2.01 [A], at 8.

23. 35 U.S.C. § 103 (1976).

24. See *infra* notes 65-92 and accompanying text.

25. For a discussion of the term "substantial similarity" see *infra* text accompanying notes 187-89.

fully infringes a copyright<sup>26</sup> "for purposes of commercial advantage or private financial gain."<sup>27</sup> In addition, upon conviction a court must order the destruction of all "implements, devices, or equipment used in the manufacture" of infringing copies.<sup>28</sup> The convicted copyright infringer is not only out of the copying business, but also out of any microbiological business for want of an industrial plant.

A copyright owner can recover both his own actual damages and the infringer's profits.<sup>29</sup> Moreover, he need only prove the infringer's gross revenue; the burden then shifts to the infringer to prove his deductible expenses and profits not allocable to the infringing work.<sup>30</sup> If actual damages plus infringer's profits are small, a copyright owner can elect to receive statutory damages, which can range between \$250 and \$10,000 in the judge's discretion.<sup>31</sup> If the court finds that the "infringement was committed willfully," it can increase the award of statutory damages to not more than \$50,000.<sup>32</sup>

During litigation, infringing copies and all "articles by means of which such copies . . . may be reproduced" can be impounded.<sup>33</sup> For example, courts have recently ordered the impounding of video games because of copyright infringement of the computer programs that implement the games.<sup>34</sup> As part of a final decree, the court may also order the destruction of all copies and articles used to make the copies.<sup>35</sup> Thus, even without a finding of a criminal violation, a substantial part of the infringer's manufacturing equipment may be ordered destroyed.

A copyright owner may also obtain a temporary or permanent injunction.<sup>36</sup> Temporary injunctions are more readily obtainable in copyright cases than in patent cases because the popular life of a copyrighted work is often short.<sup>37</sup> Finally, reasonable attorney's fees are available to the prevailing party in a copyright action.<sup>38</sup> The copy-

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26. See 3 M. NIMMER, *supra* note 22, § 15.01, at 3 n.13.

27. 17 U.S.C. § 506(a) (Supp. IV 1980). The penalty for conviction is a fine of not more than \$10,000 or imprisonment for not more than one year or both. *Id.*

28. *Id.* § 506(b).

29. *Id.* § 504(b).

30. *Id.*

31. *Id.* § 504(c)(1).

32. *Id.* § 504(c)(2). In this context, "willfully" means with knowledge that the defendant's conduct constitutes copyright infringement." 3 M. NIMMER, *supra* note 22, § 14.04 [B], at 26 (footnote omitted).

33. 17 U.S.C. § 503(a) (Supp. IV 1980).

34. See, e.g., *Stern Electronics, Inc. v. Kaufman*, 523 F. Supp. 635, 642 (E.D.N.Y. 1981), *aff'd*, PAT. TRADEMARK & COPYRIGHT J. (BNA), No. 565, § A, at 1-2 (2d Cir. Jan. 20, 1982).

35. 17 U.S.C. § 503(b) (Supp. IV 1980); see 3 M. NIMMER, *supra* note 22, § 14.08.

36. 17 U.S.C. § 502 (Supp. IV 1980).

37. See, e.g., *Midway Mfg. Co. v. Drikschneider*, PAT. TRADEMARK & COPYRIGHT J. (BNA), No. 541 § A, at 3, 5 (D. Neb. July 15, 1981) (preliminary injunction necessary to safeguard the copyright in a video game, which enjoys short-lived commercial popularity).

38. 17 U.S.C. § 505 (Supp. IV 1980).

right laws do not require the prevailing party to prove that the case at bar is "exceptional," as is required in patent infringement suits to obtain attorney's fees.<sup>39</sup>

### B. *Life of the Copyright Property*

Patent protection exists for seventeen years.<sup>40</sup> Trade secrets last for as long as they can be kept secret,<sup>41</sup> a problematic physical activity, at best.<sup>42</sup> Copyright exists from the time of the work's creation<sup>43</sup> until fifty years after the death of the author.<sup>44</sup> In the case of joint works,<sup>45</sup> the fifty years begins after the death of the surviving co-author.<sup>46</sup> Most importantly for present purposes, the copyright of works made for hire, *e.g.*, by an employee of a corporation,<sup>47</sup> endures for one hundred years after the creation of the work or seventy-five years after publication of the work, whichever is earlier.<sup>48</sup> Thus copyrights last much longer than patents and impose none of the problems or expense attendant to physically safeguarding the integrity of a trade secret.

### C. *The Research Scientist's Need or Desire to Publish Immediately*

Most scientists in molecular biology are or until recently have been employed by universities, non-profit research institutions, or the federal and state governments. In the past, these employers rarely restricted the scientists' right to publish their work. Occasionally, modest delays were imposed or requested to ensure that a United States patent application could be filed prior to scientific publication; the filing ensured that foreign patent rights would not be jeopardized.<sup>49</sup>

The situation has changed rapidly. Universities recognize that gold

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39. 35 U.S.C. § 285 (1976).

40. 35 U.S.C. § 154 (1976).

41. See 2 R. CALLMAN, *supra* note 13, § 53.3, at 387; S. OPPENHEIM & G. WESTON, UNFAIR TRADE PRACTICES AND CONSUMER PROTECTION 300 (3d ed. 1974).

42. See 2 R. CALLMAN, *supra* note 13, § 53.3(a); S. OPPENHEIM & G. WESTON, *supra* note 41, at 301.

43. 17 U.S.C. § 302(a) (Supp. IV 1980). For a brief description of when a work is created, see *infra* notes 53-56 and accompanying text.

44. 17 U.S.C. § 302(a) (Supp. IV 1980). This term specifically applies to works created on or after January 1, 1978. *Id.* Separate rules govern the length of copyright in works created, but not published or copyrighted, before January 1, 1978, *id.* § 303, and in works that had subsisting copyrights on January 1, 1978. *Id.* § 304.

45. "A 'joint work' is a work prepared by two or more authors with the intention that their contributions be merged into inseparable or interdependent parts of a unitary whole." *Id.* § 101.

46. *Id.* § 302(b).

47. A "work made for hire" includes "a work prepared by an employee within the scope of his or her employment." *Id.* § 101.

48. *Id.* § 302(c).

49. Most industrialized countries are signatories of the International (Paris) Convention for the Protection of Industrial Property, a multilateral treaty of 1883 which has been revised several times, the last revision being that of Stockholm in 1967. 2 J. BAXTER & J. SINNOTT, WORLD PATENT LAW AND PRACTICE 132.3 (1981). Each country has implementing legislation analogous to that of the United States, 35 U.S.C. § 119 (1976), which provides that patent rights will accrue in the patenting country when a foreign patent application is filed in a signatory country (subject to certain ministerial conditions subsequent to the filing in the foreign country). See 2 J. BAXTER & J. SINNOTT, *supra*, at 132.4-39.

mines as well as test tubes and Ehrlenmeyer flasks are scattered around their microbiological laboratories and that the gold is recoverable only by perfecting their property rights. Moreover, business arrangements between research institutions and private corporations always center on effectively protecting innovation. The net result is massive ambivalence on the part of scientists and university and research administrators concerning the right of scientists to publish immediately and freely. Half of them says publish immediately, and half says be sure to obtain protection so that funds for further research will be forthcoming.

Fortunately, immediate publication and copyright protection are completely compatible. As will be seen,<sup>50</sup> "creation" of the genetically engineered work itself generates the protection provided by copyright. Publication of research findings on the day they are made will in no way impair copyright protection of those results.<sup>51</sup>

### *III. Copyright Protection of Genetic Works Under the 1976 Act*

The discussion thus far may convince some of the desirability of copyright as one of the array of property rights available for protecting genetically engineered works. If so, we may now proceed to address questions of whether genetically engineered works are registerable for copyright; if registerable, whether the copyright is enforceable; and if enforceable, whether infringers can be brought to task?

#### *A. Copyrightability of Genetically Engineered Works*

##### *1. Statutory Requirements*

All genetically engineered works that came into existence on and after January 1, 1978, are already protected by copyright. Whether the copyright owner wishes to enforce those rights is a matter of choice for him.

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50. See *infra* notes 53-57 and accompanying text.

51. A problem may arise if copyright proves to be a viable form of property for a genetic work, either in lieu of, or in conjunction with, patent protection. Employment and consulting contracts between researchers in molecular biology and nonprofit or profit organizations have typically carefully defined rights in the researchers' inventions and patents. The researchers usually receive no interest or a small interest in the inventions or patents, with the researchers' salaries viewed as consideration for their work. The researchers receive their salaries whether or not they invent or obtain patents. Those contracts typically do not address the ownership of copyrights in the researchers' works or expressly provide that title belongs to the researchers. If copyright becomes a viable property in genetic works, future contracts should define to whom the property belongs. Old contracts should be redrafted to eliminate any ambiguity. Existing contracts may have to be renegotiated.



Unlike its predecessor statute,<sup>52</sup> the Copyright Act of 1976 provides copyright protection from the moment a literary work is created.<sup>53</sup> A work is created when it is "fixed in a tangible medium of expression."<sup>54</sup> In turn, a work can be "fixed" in any "form, manner, or medium"<sup>55</sup> as long as it is "sufficiently permanent or stable to permit it to be perceived, reproduced, or otherwise communicated for a period of more than a transitory duration."<sup>56</sup> The act of creation may take place in the quiet and secrecy of a private laboratory. Property rights immediately accrue, which may be enforced once the copyright is registered.<sup>57</sup>

Libraries of spliced DNA fragments<sup>58</sup> and cultures of engineered cells with a foreign DNA sequence introduced therein are certainly "fixed in tangible . . . medi[a] of expression." Certainly, they are permanent; a cell that reproduces by fission, for example, is potentially eternal as is the original cell itself even if it never fissions.<sup>59</sup> Moreover, genetic works are stable enough to be perceived and reproduced. Reproduction, in the case of the cell, is the entire point of genetic engineering and the first fission may take place within twenty minutes after the introduction of the DNA fragment or entire plasmid.<sup>60</sup> Perception is currently feasible by the process of DNA sequencing.<sup>61</sup> Under the 1976 Act, perception may be direct or "with the aid of a machine or device."<sup>62</sup> Although most genetic works cannot be seen,<sup>63</sup> the 1976 Act does not require visual perception. To obtain full statutory protection for a work that is either directly or indirectly visually perceivable, a notice of copyright must be affixed to the work when it is published.<sup>64</sup> Because genetic works are not visually perceivable, the genetic engineer is free from the burden of copyright marking in almost all instances.

With this definitional background, consider the direct statutory fiat for copyrightability:

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52. Copyright Act of 1909, ch. 320, 35 Stat. 1075 (repealed 1976). The 1909 statute required publication with an affixed notice of copyright.

53. 17 U.S.C. § 102(a) (Supp. IV 1980).

54. The 1976 Act specifically provides that "[a] work is 'created' when it is fixed in a copy or phonorecord for the first time . . ." *Id.* § 101. "A work is 'fixed' in a tangible medium of expression when its embodiment in a copy or phonorecord . . . is sufficiently permanent or stable . . ." *Id.* (emphasis added); see *infra* text accompanying note 56. Consequently, a work has been created if it is fixed in a tangible medium of expression.

55. H.R. REP. NO. 1476, 94th Cong., 2d Sess. 52, reprinted in 1976 U.S. CODE CONG. & AD. NEWS 5659, 5665.

56. *Id.*

57. Generally, "no action for infringement of the copyright in any work [can] be instituted until registration of the copyright claim has been made . . ." *Id.* § 411(a). If registration of a work is refused by the Register of Copyrights, the author may sue for infringement and have the issue of registerability resolved in the same action. *Id.*

58. Spliced DNA fragments are fragments of DNA chemically bonded together. See *supra* note 8.

59. J. FALKINHAM, *supra* note 9, § I, at 5-7.

60. *Id.* § I, at 8.

61. See *supra* note 18.

62. 17 U.S.C. § 102(a) (Supp. IV 1980).

63. See *infra* notes 132-36 and accompanying text.

64. 17 U.S.C. §§ 401, 405 (Supp. IV 1980). See *infra* notes 130-36 and accompanying text.

Section 102. Subject matter of copyright: In general. (a) Copyright protection subsists, in accordance with this title, in original works of authorship fixed in any tangible medium of expression, now known or later developed, from which they can be perceived, reproduced, or otherwise communicated, either directly or with the aid of a machine or device. Works of authorship include the following categories: (1) literary works; (2) musical works, including any accompanying words; (3) dramatic works, including any accompanying music; (4) pantomimes and choreographic works; (5) pictorial, graphic, and sculptural works; (6) motion pictures and other audiovisual works; and (7) sound recordings.<sup>65</sup>

To the uninitiated, the works of a genetic engineer apparently do not fall into any of the enumerated categories and the quest for protection has ended unsuccessfully. This is not the case.

The enumerated category of "literary works" directly corresponds to engineered genetic works. "Literary works" are works . . . expressed in words, numbers, or other verbal or numerical symbols or indicia, regardless of the nature of the material objects . . . in which they are embodied."<sup>66</sup> A digital computer program or data base is a literary work within the statutory definition.<sup>67</sup> It can be expressed in "indicia," such as magnetic impulses or holes in a punch card; moreover, it is "fixed in . . . tangible medi[a] of expression," such as magnetic tapes or punch cards.<sup>68</sup> Similarly, genetically engineered works are expressed in "indicia," the nucleotides that make up DNA.<sup>69</sup> Genetic works are fixed in tangible media of expression, such as cells and cultures of cells.<sup>70</sup> Indeed, "libraries" of DNA sequences currently exist in hundreds of test tubes; each tube may contain thousands of copies of a DNA sequence awaiting splicing to another sequence or insertion into a cell.

An engineered bacterium stores information, the sequence of nucleotides, in the DNA double helix configuration.<sup>71</sup> It processes that information through messenger RNA<sup>72</sup> and transforms it at the ribosome<sup>73</sup> into a sequence of amino acids.<sup>74</sup> Through the intermediary of

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65. 17 U.S.C. § 102(a) (Supp. IV 1980).

66. *Id.* § 101.

67. H.R. REP. NO. 1476, 94th Cong., 2d Sess. 54, reprinted in 1976 U.S. CODE CONG. & AD. NEWS 5659, 5667.

68. See Boorstyn, *Copyrights, Computers, and Confusion*, 63 J. PAT. OFF. SOC'Y 276, 277 (1981).

69. See *supra* note 8.

70. See *supra* 58-63. "Genes can be thought of as the molecular 'sentences' in which the 'words' consist of certain sequences of nucleotide 'letters.'" F. AYALA & J. KIGER, *supra* note 4, at 340.

71. See *supra* note 8.

72. RNA, ribonucleic acid, is a long molecule consisting of repeating units. The process whereby the gene sequence in DNA is copied to form messenger RNA is called transcription. J. FALKINHAM, *supra* note 9, § I, at 10-11.

73. A ribosome is a subcellular particle containing a type of RNA. *Id.* § I, at 11.

74. Each different protein has a unique sequence of amino acids. *Id.*

transfer RNA, the engineered bacterium produces a protein.<sup>75</sup> The mathematics and underlying bases or radices of the number systems used in all cells correspond directly to those of artificial automatic systems, such as digital computers. In most digital computers, the internal operations are carried out using a two-valued radix: each digit can take on one of only two values.<sup>76</sup> In a cell, the genetic code in the DNA molecule is carried in a quarternary radix: each base location can have one of only four nucleic acid molecules.<sup>77</sup>

Computers output their operations in a number system or radix that is useable by people. Thus, within the computer the binary notation is converted to decimal just prior to printout.<sup>78</sup> In a cell, the genetic information contained in DNA is also transferred into something useable — proteins.<sup>79</sup> Every protein has its structure dictated by a specific gene.<sup>80</sup> Because usually only twenty different amino acids are possible in a protein and only four different nucleotides in DNA, the quaternary notation of the DNA sequence is converted at the ribosome into a number system of base twenty.<sup>81</sup>

Thus, like a computer program, a genetic work uses indicia to transfer information.<sup>82</sup> Whether the genetic scientist or engineer takes pen in hand, invents something patentable or does both, he apparently authors a literary work when he applies the techniques of recombinant DNA to create original DNA sequences.

Even if genetically engineered works are not literary works within the meaning of the 1976 Act, they may be copyrightable. Section 102(a) states that “works of authorship *include*” the enumerated categories.<sup>83</sup> The statute expressly defines the term “including” as “illustrative and not limitative.”<sup>84</sup> Thus, regardless of whether a genetically engineered work fits conveniently into one of the seven statutory categories, it can be a work of authorship so long as the information conveyed is original with the creator and is “fixed in any tangible medium of expression, *now known or later developed . . .*”<sup>85</sup> Through the italicized phrase, the statute expressly provides for the development of new media in which a work can be fixed.<sup>86</sup> As has been demonstrated,<sup>87</sup> the media within which genetically engineered works are fixed certainly conform to this statutory dictate.

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75. *Id.*

76. *See* A. KINDRED, INTRODUCTION TO COMPUTERS 117-18 (1976).

77. J. FALKINHAM, *supra* note 9, § I, at 16-17.

78. *See* A. KINDRED, *supra* note 76, at 117-21.

79. *See* F. AYALA & J. KIGER, *supra* note 4, at 366.

80. *Id.*

81. *Id.*

82. “The hereditary information for the specification of a cell’s proteins is encoded in the nucleotide sequence of the cell’s DNA in a 4-letter alphabet (an appropriate term because an alphabet is a set of symbols used to convey information). That information is also contained in the amino acid sequence of the proteins in a 20-letter alphabet. The genetic code . . . relates . . . the nucleic acid language and the protein language.” *Id.*

83. 17 U.S.C. § 102(a) (Supp. IV 1980) (emphasis added).

84. *Id.* § 101.

85. *Id.* § 102(a) (emphasis added).

86. *See* H.R. REP. NO. 1476, 94th Cong., 2d Sess. 52, *reprinted in* 1976 U.S. CODE CONG. & AD. NEWS 5659, 5665.

87. *See supra* notes 58-63 and accompanying text.

But are the genetic engineers' *forms* of expression comprehended by the statute?

The legislative history of the 1976 Act clearly indicates that Congress intended the phrase "original works of authorship" to be open-ended. The House Report reasoned that "[a]uthors are continually finding new ways of expressing themselves, but it is impossible to foresee the forms that these new expressive methods will take."<sup>88</sup> An author's form of expression can be copyrightable as long as it is not "completely outside the present congressional intent."<sup>89</sup> As one leading commentator has observed, a new form of expression should be regarded as within the congressional intent if it is sufficiently analogous to the seven categories of works enumerated in the statute.<sup>90</sup> As previously demonstrated,<sup>91</sup> genetically engineered works are certainly analogous, if not nearly identical, to computer programs; the mode of expression is simply animate, rather than inanimate. Because of this similarity and because genetically engineered works are fixed in the statutory sense, they should be copyrightable.

*a. Compilations*

Some may argue that recombinant DNA work is not sufficiently original to be copyrightable. Every DNA fragment combined with any other and every plasmid introduced into a host cell already exist in nature. The so-called author is dealing with preexisting information.

This argument is analogous to one suggesting that this article is not original because the words the author is stringing together are all well-known and appear in standard dictionaries. Simply to state this analogy is to render baseless by *reductio ad absurdum* the attack on the originality of uncopied DNA base pair sequences.

Moreover, the 1976 Act states that a compilation of preexisting materials may itself be original: "A 'compilation' is a work formed by the collection and assembling of preexisting materials or of data that are selected, coordinated, or arranged in such a way that the resulting work as a whole constitutes an original work of authorship."<sup>92</sup>

If each DNA fragment or plasmid wants for originality, each combined by man with others does not. At the very least, splicing of DNA fragments and introduction of DNA materials into a host cell are original and often novel compilations.<sup>93</sup>

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88. H.R. REP. NO. 1476, 94th Cong., 2d Sess. 51, *reprinted in* 1976 U.S. CODE CONG. & AD. NEWS 5659, 5664.

89. *Id.*

90. 1 M. NIMMER, *supra* note 22, § 2.03 [A], at 27.

91. *See supra* notes 66-82 and accompanying text.

92. 17 U.S.C. § 101 (Supp. IV 1980).

93. *See* 1 M. NIMMER, *supra* note 22, § 3.03, at 8 ("A collective work will qualify for copyright by reason of the original effort expended in the process of compilation, even if no new matter is added.") (footnote omitted).

b. Section 117

Prior to being recently amended, Section 117<sup>94</sup> possibly blocked enforcement of a copyright in genetic works. Congress attempted to address in section 117 the problems of copyright protection for digital computer programs.<sup>95</sup> Although Congress intended computer programs to be copyrightable under the 1976 statute,<sup>96</sup> it could not decide whether copying a computer program by inserting it into a computer should be considered an infringement.<sup>97</sup> As a consequence, section 117 originally specified that the statutory or common law in effect on December 31, 1977 would determine the legality of such copying.<sup>98</sup> Under that law, entering someone else's copyrighted program into a computer did not infringe the copyright because the copy produced could not be visually perceived.<sup>99</sup>

In 1980, Congress completely rewrote section 117.<sup>100</sup> The new provision, which went into effect on December 12, 1980, eliminates ocular perceivability as a necessary characteristic of a copy and as a prerequisite for infringement.<sup>101</sup> In short, new section 117 applies to computer programs what the 1976 statute previously applied to all other original works and their copies, namely, the sufficiency of perception, reproduction or communication that occurs "either directly or *with the aid of a machine or device.*"<sup>102</sup>

What does all of this have to do with genetically engineered works? Unfortunately, original section 117 included language sufficiently broad under a somewhat strained reading<sup>103</sup> to encompass genetic works as well as digital computer programs. Consider the words of original section 117:

Section 117. Scope of exclusive rights: Use in conjunction with computers *and similar information systems* . . . [T]his title does not afford to the owner of copyright in a work any greater or lesser rights with respect to the use of the work in conjunction *with automatic systems capable of storing, processing, retrieving, or transferring information*, or in conjunction with any similar device, machine, or process, than those afforded to works under the law, whether title 17 or the common law or statutes of a State, in effect on December 31,

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94. 17 U.S.C. § 117 (Supp. III 1979) (current version at 17 U.S.C. § 117 (Supp. IV 1980)).

95. See H.R. REP. NO. 1476, 94th Cong. 2d Sess. 116, *reprinted in* 1976 U.S. CODE CONG. & AD. NEWS 5659, 5731.

96. Computer programs have always been copyrightable under the 1976 Act. See *supra* notes 67-68 and accompanying text.

97. See Boorstyn, *supra* note 68, at 280.

98. 17 U.S.C. § 117 (Supp. III 1979) (current version at 17 U.S.C. § 117 (Supp. IV 1980)).

99. See *Data Cash Systems, Inc. v. JS&A Group, Inc.*, 480 F. Supp. 1063, 1068 (N.D. Ill. 1979), *aff'd on other grounds*, 628 F.2d 1038 (7th Cir. 1980).

100. Act of Dec. 12, 1980, Pub. L. No. 96-517 § 10(b), 94 Stat. 3015, 3028 (amending 17 U.S.C. § 117 (Supp. III 1979)).

101. See Boorstyn, *supra* note 68, at 282.

102. 17 U.S.C. § 102(a) (Supp. IV 1980) (emphasis added).

103. The legislative history of section 117 concerns only copying of computer programs. H.R. REP. NO. 1476, 94th Cong. 2d Sess. 116, *reprinted in* 1976 U.S. CODE CONG. & AD. NEWS 5659, 5731.

1977 . . .<sup>104</sup>

A living microorganism is arguably a "similar information system" to that of a computer and it certainly is an automatic system capable of storing, processing, retrieving, or transferring information.<sup>105</sup> If old section 117 had been construed to encompass genetic works, such works could not have been meaningfully protected before December 12, 1980; unauthorized copies of the works could not have been visually perceived and hence would not have been infringements.

If some doubt existed as to whether genetic works were included within the ambit of old section 117, no question should exist about new section 117. Genetic works are certainly excluded because new section 117 by its terms is limited exclusively to "computer programs" and their use in conjunction with a "machine."<sup>106</sup> Moreover, new section 117 dispenses with the requirement of ocular perceivability even for computer programs.<sup>107</sup> At the very latest, therefore, December 12, 1980 is the date when nonocularly perceivable, reproducible or communicable genetically engineered works enjoy full copyright protection. They may have been protected as early as January 1, 1978.

## 2. *Constitutionality*

The United States Constitution authorizes Congress "[t]o promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries."<sup>108</sup> Would the current Supreme Court view the 1976 Act, construed to comprehend genetically engineered works, as a constitutional exercise of Congressional power?

The question can best be answered by dividing it into two component parts. First, does the constitutional term "writings" comprehend the statutory subject matter of copyright — "original works of authorship fixed in any tangible medium of expression, now known or later developed, from which they can be perceived, reproduced, or otherwise communicated, either directly or with the aid of a machine or device"?<sup>109</sup> Second, assuming the answer to the first question is yes, does the aliveness of a tangible medium of expression (in which the original work of authorship is fixed) preclude it from being a "writing" within the meaning of the Constitution?

The traditional mode of constitutional construction provides per-

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104. 17 U.S.C. § 117 (Supp. III 1979) (emphasis added) (current version at 17 U.S.C. § 117 (Supp. IV 1980)).

105. See *supra* notes 66-82 and accompanying text.

106. 17 U.S.C. § 117 (Supp. IV 1980).

107. See Boorstyn, *supra* note 68, at 282.

108. U.S. CONST. art. I, § 8, cl. 8. This provision is commonly termed the copyright and patent clause of the Constitution.

109. 17 U.S.C. § 102(a) (Supp. IV 1980).

haps the strongest reason for believing that the subject matter of copyright under the 1976 Act satisfies the constitutional requirements for a writing. Constitutional language, unlike its statutory counterpart, is not construed in the United States exclusively as defined by its authors. Courts typically interpret constitutional terms to include unanticipated meanings that are required for developments basically consonant with the general purpose of the original language.<sup>110</sup> The Constitution's flexibility in meeting the conditions of life in the United States for a period of almost 200 years stems specifically from this mode of construction.

In regard specifically to the copyright clause of the Constitution, the Supreme Court has construed the term "writings" broadly to include numerous tangible media of expression.<sup>111</sup> Indeed, courts have upheld the constitutionality of copyright protection for media of expression that were not at the time explicitly designated by statute as copyrightable.<sup>112</sup> Thus, there can be little doubt that Congress stayed within constitutional limits when it broadly defined the subject matter of copyright.

We now address the second question: if the term "tangible medium of expression" were construed to include *live media*, would it fall outside the constitutional term "writings"? The Supreme Court has recently provided helpful guidance on this question. In *Diamond v. Chakrabarty*,<sup>113</sup> the Court considered whether the patent statute's term "manufacture or composition of matter" includes genetically

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110. In discussing the copyright clause of the Constitution, Learned Hand stated that

its grants of powers to Congress comprise, not only what was then known, but what the ingenuity of men should devise thereafter. Of course, the new subject-matter must have some relation to the grant; but we interpret it by the general practices of civilized peoples in similar fields, for it is not a strait-jacket, but a charter for a living people.

Reiss v. National Quotation Bureau, Inc., 276 F. 717, 719 (S.D.N.Y. 1921). Similarly the Supreme Court has noted:

These terms ["writings" and "authors"] have not been construed in their narrow literal sense but, rather, with the reach necessary to reflect the broad scope of constitutional principles. While an "author" may be viewed as an individual who writes an original composition, the term, in its constitutional sense, has been construed to mean an "originator," "he to whom anything owes its origin." [citation omitted] Similarly, although the word "writings" might be limited to script or printed material, it may be interpreted to include any physical rendering of the fruits of creative intellectual or aesthetic labor.

Goldstein v. California, 412 U.S. 546, 561 (1973).

111. See, e.g., *Burrow-Giles Lithographic Co. v. Sarony*, 111 U.S. 53, 58 (1884) (holding photographs to be copyrightable subject matter).

Moreover, the 1976 Act was hardly the product of sloppy draftsmanship. Hundreds of lawyers and the Register of Copyrights spent approximately 21 years drafting the statute. See 122 CONG. REC. 31,979 (1976) (remarks of Rep. Kastenmeier). In providing a broad and open-ended definition of the subject matter of copyright, the drafters carefully considered the constitutional limits on congressional power. See H.R. REP. NO. 1476, 94th Cong. 2d Sess. 51, reprinted in 1976 U.S. CODE CONG. & AD. NEWS 5659, 5664.

112. For example, motion pictures were not specifically covered by federal copyright law until 1912. Act of August 24, 1912, ch. 356, §§ 5(1)-(m), 37 Stat. 488, 488 (current version at 17 U.S.C. § 102(a)(7) (Supp. IV 1980)). In 1905, however, a federal court found motion pictures to be copyrightable subject matter under the Constitution. *American Mutoscope & Biograph Co. v. Edison Mfg. Co.*, 137 F. 262, 265-67 (C.C.D.N.J. 1905).

113. 447 U.S. 303 (1980).

engineered living microorganisms.<sup>114</sup> Although the Court divided five to four over whether the patent laws comprehend living, manmade organisms,<sup>115</sup> it unanimously recognized that this question of statutory construction does not implicate any constitutional considerations.<sup>116</sup> The majority held that the aliveness of a manufacture or composition of matter does not itself bar patent protection.<sup>117</sup> With this guidance, courts could construe the 1976 Act to comprehend living media of expression, *a fortiori*. The express language of the patent statute does not address future events, although the whole tenor of the statute, which concerns inventions, seems to do so *sub silentio*.<sup>118</sup> The 1976 Copyright Act, on the other hand, expressly provides that a work of authorship may be fixed in a tangible medium of expression "now known or later developed."<sup>119</sup> In fact, engineered microorganisms and cells were known on January 1, 1978, when the 1976 Act became effective.<sup>120</sup> Moreover, by stating that the protected media of expression may be "later developed," Congress seems to have purposely left the subject matter of copyright temporally and technologically open-ended.<sup>121</sup>

Although Associate Justice Sandra O'Connor has replaced Associate Justice Potter Stewart, who voted with the majority in *Chakrabarty*, the substitution should not change the Court's approach to aliveness. Irrespective of Justice O'Connor's views, the other eight members will likely follow their unanimous position in *Chakrabarty* and view aliveness as purely a matter of statutory construction. Although the legislative history of the 1976 Act nowhere mentions living microorganisms, the statute on its face certainly comprehends them because they are in fact "a tangible medium of expression."<sup>122</sup>

Finally, even if the aliveness of a work bars its copyrightability, most genetically engineered works will be copyrightable. DNA sequences, unlike the cells into which they are inserted, are inanimate.

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114. *Id.* at 307.

115. Chief Justice Burger wrote the majority opinion, which concluded that the patent laws encompass living, manmade microorganisms. *Id.* at 318. Justices Brennan, White, Marshall and Powell dissented. *Id.* at 318-22.

116. *Id.* at 307; *id.* at 318 (Brennan, J., dissenting).

117. *Id.* at 309-14.

118. *See id.* at 316.

119. 17 U.S.C. § 102(a) (Supp. IV 1980).

120. Indeed, they were known long before that date. *See* J. FALKINHAM, *supra* note 9, § II, at 4. Dr. Chakrabarty filed a patent application for his oil-digesting microorganisms in 1972. *Chakrabarty*, 447 U.S. at 305.

121. *See* H.R. REP. NO. 1476, 94th Cong. 2d Sess. 52, *reprinted in* 1976 U.S. CODE CONG. & AD. NEWS 5659, 5665-66.

122. 17 U.S.C. § 102(a) (Supp. IV 1980); *see supra* notes 58-63 and accompanying text.



## IV. Enforceability

### A. Registration

Although copyright protection "subsists" in a work as soon as it is created,<sup>123</sup> that protection is not legally enforceable until the copyright is registered with the Register of Copyrights.<sup>124</sup> The copyright owner is entitled to recover actual damages from infringements that occur prior to registration, but he cannot generally obtain statutory damages or attorney's fees in a suit for a pre-registration infringement.<sup>125</sup>

Two registration requirements are of interest because of the peculiar nature of genetically engineered works: affixing a copyright notice to the work when it is published,<sup>126</sup> and depositing two copies of a published work or one copy of an unpublished work.<sup>127</sup> The 1976 Act defines "publication" quite broadly.<sup>128</sup> Publication includes not only distribution of copies of a work to the public by sale, rental, lease or lending, but also a mere *offer* to distribute copies to individuals for purposes of further distribution.<sup>129</sup>

Ordinarily, a copyright notice must appear on the work when published.<sup>130</sup> This typically takes the well known form of three alphanumeric phrases in a line: the symbol ©, or the word "Copyright" or its abbreviation "Copr.," the year of first publication and the name of the copyright owner.<sup>131</sup> One significant exception exists, however, to the notice requirement. A copyright notice need not be affixed to a published work if it cannot be visually perceived.<sup>132</sup> For example, a movie sound track can be protected without affixing a notice of copyright to the film, since the sounds are perceivable only aurally.<sup>133</sup>

Like movie sound tracks, virtually all genetic works of interest are not visually perceivable. The cell in which the genetic molecular information is contained can be seen through a microscope,<sup>134</sup> but it is *not* the work; the genetic molecular information is the work. Although certain individual chromosomes may be seen in outline through an electron microscope,<sup>135</sup> the genetic information cannot be observed.<sup>136</sup> As a general proposition, therefore, a notice of copyright does not have to be imprinted upon a genetic work. To provide extra security, a copyright owner could affix a copyright notice to the base of the petri dish, or use a fine pipette to deposit fluid containing the

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123. 17 U.S.C. § 302(a) (Supp. IV 1980).

124. *Id.* § 411(a).

125. *Id.* § 412.

126. *Id.* § 401.

127. *Id.* § 408(b)(1)(2).

128. *Id.* § 101.

129. *Id.* (emphasis added).

130. *Id.* § 401(a).

131. *Id.* § 401(b).

132. *Id.* § 401(a). The 1976 Act expressly requires that a copyright notice be placed on "all publicly distributed copies from which the work can be visually perceived, either directly or with the aid of a machine or device." *Id.*

133. See Boorstyn, *supra* note 68, at 279.

134. See J. FALKINHAM *supra* note 9, § I, at 3-4.

135. See *id.* § I, at 12.

136. See *id.* § II, at 17-21.

engineered cells on agar in a pattern approximating a notice of copyright.

Although the 1976 Act requires the copyright owner to deposit two copies of the best edition of the work,<sup>137</sup> it does not preclude him from depositing a whole petri dish with a million cell-encompassed works. There is no need, as far as the author is aware, to ensure that the works remain alive after deposit at the Copyright Office. Most importantly, the statute permits the Register of Copyrights to exempt by regulation any category of materials from the deposit requirement,<sup>138</sup> moreover, he may by regulation "require or permit, for particular [administrative] classes [of works], the deposit of identifying material instead of copies . . . ."<sup>139</sup> The 1976 Act thus provides the Copyright Office with sufficient flexibility to cope with the registration of genetic works.

### *B. Enforcement — Section 102(b)*

Copyright prevents the unauthorized copying or reproducing of only the *form* of expression of an idea or information; it cannot preclude use of the idea or the information if implemented in a form substantially different from that copyrighted. The Supreme Court made this clear in *Baker v. Selden*<sup>140</sup> and section 102(b) of the 1976 Act now codifies this truism:

(b) In no case does copyright protection for an original work of authorship extend to any idea, procedure, process, system, method of operation, concept, principle, or discovery, regardless of the form in which it is described, explained, illustrated, or embodied in such work.<sup>141</sup>

The central issue in determining the viability of copyright protection for genetically engineered works will be the application of section 102(b). With *Baker v. Selden*<sup>142</sup> providing background instruction, we can apply section 102(b) to a hypothetical situation and resolve the problem inherent in the expression and idea dichotomy.

Assume Dr. Smith succeeds in introducing into *E. coli*<sup>143</sup> a plasmid consisting of two DNA fragments.<sup>144</sup> Plasmid fragment A comes from bacterium A and plasmid fragment B comes from bacterium B. Novel

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137. 17 U.S.C. § 408(b)(2) (Supp. IV 1980).

138. *Id.* § 407(c).

139. *Id.* § 408(c)(1).

140. 101 U.S. 99, 104 (1879). The Court reaffirmed this rule in *Mazer v. Stein*, 347 U.S. 201, 217 (1954).

141. 17 U.S.C. § 102(b) (Supp. IV 1980).

142. 101 U.S. 99 (1879).

143. *E. coli*, *Escherichia coli*, is a bacterium used widely in genetic studies. F. AYALA & J. KIGER, *supra* note 4, at 4.

144. A plasmid is a circular DNA molecule that is self-replicating. *Id.* at 230.

plasmid AB is produced by the Cohen-Boyer method<sup>145</sup> and is introduced into, and is stable in, *E. coli*. Dr. Smith observes that his new bacterium *E. coli* AB (hereinafter *E. smithus*) is a magnificent factory for manufacturing the well known antibiotics A and B. Previously, these antibiotics were produced independently and separately by bacteria A and B and were also artificially synthesized separately by a rather expensive industrial process. Dr. Smith is particularly pleased because antibiotics A and B are typically used commercially (or medicinally) together in each dose (or application); their joint natural production by *E. smithus* eliminates the need for a chemical packaging step previously required. Moreover, *E. smithus* produces far more antibiotics A and B than do bacteria A and B in any given single colony. Apparently, significant amplification<sup>146</sup> takes place in *E. smithus*.

Dr. Smith proceeds to register both his copyrighted compilation of DNA information contained in his plasmid AB and his copyrighted compilation of DNA information in *E. smithus*. He originated both of these compilations.<sup>147</sup>

During the life of Dr. Smith and 50 years thereafter, can the copyright owner prevent any of the following?

(a) The manufacture of antibiotics A and B from their respective bacteria.

(b) The separate artificial chemical syntheses of antibiotics A and B.

(c) The same as (b) but simultaneously in one process to eliminate the step of having to combine the antibiotics.

(d) The reproduction of plasmid AB, on loan from Dr. Smith, by examining significant parts of its DNA base pair sequence and using the Cohen-Boyer technique to produce it from the A and B bacteria.

(e) The reproduction of *E. smithus*, on loan from Dr. Smith, by examining its novel AB plasmid and using the Cohen-Boyer technique to produce it as in (d) and introduce it into *E. coli*.

(f) The reproduction of *E. smithus*, on loan from Dr. Smith, and plasmid AB, by keeping a small sample of the culture and continuing to culture the bacteria in larger and larger amounts.

(g) The production of antibiotics A and B with low amplification by taking plasmid AB, which is produced under the circumstances of either (d) or (f), and introducing it into *Bacillus subtilus*.

(h) The production of antibiotics A and B without any amplification by examining Dr. Smith's plasmid AB DNA sequence using the Cohen-Boyer technique to produce a plasmid whose DNA sequence (AB1) is slightly different from AB, and introducing the plasmid into *E. coli* to produce (and culture) *E. coli* AB1.

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145. See *supra* note 10.

146. For a discussion of amplification, see L. MAYS, *supra* note 8, at 349.

147. Both the new plasmid and bacterium are independently patentable. Dr. Chakrabarty's patent protects his man-made bacterium. U.S. Patent No. 4,259,444 (claims 1 through 6 at column 16, lines 23 through 40); see *supra* notes 113-17 and accompanying text. The later patent of Jack J. Manis, protects, *inter alia*, a pure form of plasmid alone. U.S. Patent No. 4,273,875, (claim 1 at column 12, lines 37 through 40).

Before deciding whether Dr. Smith can prevent the events listed in (a)-(h), consider *Baker v. Selden*.<sup>148</sup> Selden wrote and copyrighted a book that explained a novel bookkeeping system (Selden's Condensed Ledger). The system required special forms, which were included in the book along with a written explanation of how to use the system with those forms. Defendant Baker sold books of forms implementing a similar plan or system but using different forms. The Supreme Court held that Baker had not infringed Selden's copyright.<sup>149</sup>

The Court may have based its holding on the difference between Baker's and Selden's forms.<sup>150</sup> The significance of the decision, however, lies in two general statements that bear on the expression and idea dichotomy. Apparently in response to plaintiff's contention that the copyright in the book gave plaintiff the "exclusive right to the use of the bookkeeping *system*,"<sup>151</sup> the Court stated:

[W]here the art [that the book] teaches cannot be used without employing the methods and diagrams used to illustrate the book, or such as are similar to them, such methods and diagrams are to be considered as necessary incidents to the art, and given therewith to the public . . . .<sup>152</sup>

. . . .  
. . . . On the other hand, the teachings of science and the rules and methods of useful art have their final end in application and use . . . . The use by another of the same methods [i.e. forms] of statement, whether in words or illustrations . . . would undoubtedly be an infringement of the copyright.<sup>153</sup>

The Court's language generally has been construed to mean that copying a copyrighted form is an infringement if more than one form is available for carrying out the art,<sup>154</sup> by contrast, the copyright is not infringed if the only way to carry out the art is by using the copyrighted form.<sup>155</sup> In short, copyright cannot be used to prevent use of the art. If it does not preclude use of the art in some form, however, the form specifically copyrighted is protected.<sup>156</sup>

A highly pertinent copyright case has recently been decided on this type of issue in the directly analogous frontier of computer technology. In *Tandy Corp. v. Personal Micro Computers, Inc.*<sup>157</sup> a federal district court implicitly construed section 102(b) of the 1976 Act in a

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148. 101 U.S. 99 (1879).

149. *Id.* at 101.

150. See 1 M. NIMMER, *supra* note 22, § 2.18 [B], at 198.

151. *Id.*

152. 101 U.S. at 103.

153. *Id.* at 104.

154. See 1 M. NIMMER, *supra* note 22, § 2.18 [C].

155. *Id.*

156. *Id.* at § 2.18[D].

157. 524 F. Supp 171 (N.D. Cal. 1981).

manner consistent with the prevailing interpretation of *Baker v. Selden*. Tandy sued Personal for infringement of Tandy's copyrighted computer program, which was imprinted in a silicon chip. Plaintiff alleged that defendant created the chips either by following a visual display or printout of plaintiff's program or by directly imprinting the contours of plaintiff's chips<sup>158</sup> onto its own silicon chips. According to plaintiff, defendant changed the program only by removing items that identified the program as plaintiff's. In denying defendant's motion to dismiss, the court held that "there can be no doubt that the unauthorized duplication of a visually displayed copy of the program would fall within the reach of the federal copyright laws."<sup>159</sup> Moreover, the court found that a "computer program is a 'work of authorship' subject to copyright, and . . . that a silicon chip is a 'tangible medium of expression,' within the meaning of the statute . . ."<sup>160</sup>

Necessarily implicit in the court's ruling is plaintiff's compliance with 102(b) — plaintiff's copyright of the program — did not preclude practicing the art. Those skilled in computer programs know this to be accurate technologically because a multiplicity of programs (some more and some less efficient) can always be written to implement the same computer process.<sup>161</sup>

We now are ready to answer our seven-pronged hypothetical.

(a) Dr. Smith cannot prevent the separate manufacture of antibiotics A and B by their respective natural bacteria. This method of production uses only art that is in the public domain. No legal mechanism can take out of the public domain what is in it. Moreover, the separate manufacture does not entail copying Dr. Smith's work.

(b) Similarly, Dr. Smith cannot prevent the artificial, chemical synthesis of antibiotics A and B because this process does not involve copying and uses only prior art that is in the public domain.

(c) Dr. Smith cannot prevent the novel, simultaneous, artificial, chemical synthesis of antibiotics A and B simply because there is no need to copy or reproduce either of Dr. Smith's copyrighted inventions, plasmid AB or *E. smithus*, in order to produce the antibiotic by chemical synthesis.

(d) Dr. Smith probably can prevent the reproduction of plasmid AB if it has been "read" by DNA sequencing (or from a verbal version of it on deposit at the Copyright Office) and copied or reproduced by known gene splicing techniques. This situation is analogous to *Tandy v. Personal Micro Computers, Inc.*<sup>162</sup> To produce the man-made plasmid, the copier examined the form of the genetic work and reproduced the same form as the original copyrighted work. Nonetheless, if the art is making *E. smithus*, and preventing the copying of

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158. The contours of a silicon chip electrically define the computer program. *See id.* at 173.

159. *Id.* at 175.

160. *Id.* at 173.

161. *See* NATIONAL COMMISSION ON NEW TECHNOLOGICAL USES OF COPYRIGHTED WORKS (CONTU), FINAL REPORT 20 n.106 (1978), reprinted in COPYRIGHT, CONGRESS AND TECHNOLOGY: THE PUBLIC RECORD 41 n.123 (N. Henry ed. 1978).

162. *See supra* text accompanying notes 157-61.

plasmid AB precludes carrying out that art, there is no infringement because of section 102(b) and the dictum of *Baker v. Selden*.<sup>163</sup> Both assumptions necessary for this result appear to be false, however. A more reasonable construction of the art is the production of antibiotics A and B for joint administration.<sup>164</sup> In the hypothetical, at least two known methods exist (chemical and microbiological) for carrying out this art other than through *E. smithus*.<sup>165</sup> If this construction is correct, then copying plasmid AB infringes Dr. Smith's copyright.

(e) Dr. Smith should be able to prevent the reproduction of *E. smithus* if it has been read by DNA sequencing (or from a verbal description of it on deposit at the Copyright Office) and copied or reproduced by known gene splicing and plasmid-to-cell transfer techniques. This is directly on point with *Tandy v. Personal Micro Computers, Inc.*<sup>166</sup> Because the art is not making *E. smithus*, but rather making antibiotics A and B, enforcement of the copyright does not preclude individuals other than Dr. Smith from carrying out the art. The hypothetical lists two other ways of producing the antibiotics.

(f) The reproduction of *E. smithus* and plasmid AB by culturing borrowed samples of *E. smithus* certainly should be preventable. First, it violates Dr. Smith's common-law property rights. Whether or not Dr. Smith's copyright can be enforced, the specific *E. smithus* culture created as new by Dr. Smith belongs to him. He never gave the borrower permission to keep and culture a sample of the bacteria. Under age-old principles of property law, the increase in the culture also belongs to him.<sup>167</sup> Moreover, the copyright also prevents the unauthorized copying or reproduction by culturing. This form of copying is analogous to reproducing a written page using an office copier. It is direct physical contact or imprint, rather than reproduction by the guidance of DNA sequencing or verbal description, as took place in the two immediately preceding hypotheticals.

(g) The fixing of plasmid AB in *B. subtilis* produces a different compilation than the *E. smithus* copyrighted work. The two produce antibiotics at different rates, which is some evidence that they are different works. Thus, there is no infringement of the copyrighted *E. smithus* work. Nonetheless, there may well be infringement of the copyrighted plasmid AB work. If the art is making antibiotics A and

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163. See *supra* text accompanying notes 151-56.

164. This construction is more reasonable because antibiotics A and B were well known before the creation of *E. smithus* and Dr. Smith created *E. smithus* as another means to make A and B.

165. In theory, a scientist might create a genetically engineered work that provides the only way to practice new art. Obviously, he could not obtain copyright protection. In reality, however, genetic scientists and researchers almost always attempt to create a better way to practice existing art.

166. See *supra* text accompanying notes 157-74.

167. See W. RAUSHENBUSH, *BROWN ON PERSONAL PROPERTY* §§ 6.1-6.7 (3d ed. 1975).

B rather than making plasmid AB or *B. subtilus AB*, copyright may be used indirectly to prevent the making of *B. subtilus AB*, since it prevents the making of plasmid AB.<sup>168</sup>

(h) Plasmid AB1 and *E. coli AB1* may be different enough from the copyrighted plasmid AB and *E. smithus* to preclude Dr. Smith from preventing the unauthorized making of antibiotics A and B. On the other hand, they may be substantially similar and constitute infringement. That antibiotics A and B can be produced both by *E. coli AB1* and by the copyrighted *E. smithus* is irrelevant to copyright enforcement, even though it is added evidence that the art of making the antibiotic is not blocked. The possibility of carrying out the art is not the issue in this instance. Because the author of the new work examined Dr. Smith's work in making his own, the issue turns on how different or similar the form of the copyrighted material is from the form of the alleged infringing material.<sup>169</sup> This is purely a factual and highly subjective determination.

### C. Comparative Effectiveness of Patent Rights and Copyrights

A summary view of the seven-pronged hypothetical (a)-(h) reveals the following:

(i) (a) through (c) are in the public domain, are not copies or are otherwise not precludable by either copyrighting or patenting plasmid AB or the genetic contents of *E. smithus*;

(ii) (d) through (g) likely *are* precludable (with varying degrees of probability) by either copyrighting or patenting plasmid AB and the genetic contents of *E. smithus*; and

(iii) (h) may or may not be precludable by copyright, depending upon whether plasmid AB1 is substantially similar to plasmid AB; it probably is precludable by patenting plasmid AB or *E. smithus* or both.

A fascinating and unexpected picture is being unveiled. Under conditions when both copyrights and patents may be obtained for genetically engineered works/inventions, copyright will be as effective as patent from an enforcement viewpoint in virtually every situation in which either is effective. When the underlying process for producing the genetically engineered work/invention is to be maintained in secrecy, patent protection cannot be sought since the process will almost always be disclosed.<sup>170</sup> Copyright will provide protection, however, without compromising the secrecy of the process.<sup>171</sup> If the genetically engineered work is an obvious, though valuable, innova-

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168. In this hypothetical, *B. subtilus AB* can be considered a "derivative work," which the 1976 Act defines as "a work based upon one or more preexisting works." 17 U.S.C. § 101 (Supp. IV 1980). The statute gives the copyright owner the exclusive right "to prepare derivative works based upon the copyrighted work." *Id.* § 106(2). The maker of *B. subtilus AB* has created that work by copying the copyrighted work, plasmid AB. Hence, Dr. Smith should be able to prevent the creation of this derivative work in the same way that the copyright owner of a musical score can prevent an unauthorized new arrangement of that work. See M. NIMMER, *supra* note 22, § 3.03.

169. See *infra* text accompanying notes 187-89.

170. See *supra* notes 16-17 and accompanying text.

171. See *supra* notes 21-22 and accompanying text.

tion, it cannot be patented.<sup>172</sup> Nonetheless, it can be copyrighted and thereby effectively protected at least against substantially similar copies. To all this must be added the genuinely attractive remedies and duration of rights available under the copyright statute.<sup>173</sup> On balance, copyright protection for this technology is not the poor cousin to patents, contracts, and trade secrets it once was in the field of computer programmable processes.<sup>174</sup> To the contrary, in many circumstances it may be the single most vibrant and flexible form of protection for man-made genetic sequences.

#### *D. Infringement*

Copying or reproduction of the copyrighted work is an indispensable ingredient of copyright infringement;<sup>175</sup> it is its *sine qua non*. If someone other than the copyright owner subsequently originates the very same work as the one copyrighted, the subsequent author is free to (a) copy and reproduce his own work, even though it is identical to the earlier copyrighted work; (b) obtain a copyright on his own work, although it is identical to the copyrighted work; and (c) prevent others, including the earlier author, from making copies of or reproducing his work.<sup>176</sup>

These rights of a subsequent author are conditioned upon his truly originating the work. If the work is long and detailed, and identical to an earlier one, for example, Shakespeare's *Macbeth*, the probability is virtually zero that the subsequent author originated, rather than copied, it. For this common-sense reason, evidence of copying may be circumstantial and yet very persuasive. An alleged infringer's access to a copyrighted work,<sup>177</sup> coupled with identity or substantial similarity between the allegedly infringing work and the copyrighted work<sup>178</sup> establishes a *prima facie* case of infringement.<sup>179</sup> To overcome it, the alleged infringer must present evidence of independent origination to the satisfaction of the trier of fact.<sup>180</sup> Without convincing rebuttal evidence, access plus substantial similarity establishes copying.<sup>181</sup>

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172. 35 U.S.C. § 103 (1976). Copyright protection, however, inheres in a work with even the smallest amount of originality. See 1 M. NIMMER *supra* note 22, §§ 2.01, 2.01[A], 2.01[B].

173. See *supra* notes 26-49 and accompanying text.

174. See Kayton, *Status of Proprietary Rights in the United States for Computer Program Listings and Processes* (1971), in 4 D. DUNNER, J. GAMBRELL, & I. KAYTON, PAT. L. PERSP. app. 17, 31-32 (1981).

175. See 3 M. NIMMER, *supra* note 22, § 13.01, at 3.

176. The latter author, of course, cannot prevent the earlier author from copying his own work.

177. Access has been defined as the "opportunity to copy." 3 M. NIMMER, *supra* note 22, § 13.02 [A], at 10 (footnote omitted).

178. *Id.* § 13.03 [A].

179. *Id.* § 12.11 [D], at 83.

180. *Id.* at 83-84.

181. *Id.* at 84-85.



By contrast, patent infringement sweeps with a much broader net. Substantial similarity between the patented invention and the accused activity or device or its equivalent may establish liability for patent infringement.<sup>182</sup> Even if the infringer independently invented and originated the work, he is liable if he did so after the patentee's rights were fixed.<sup>183</sup> Therefore, whenever both patent and copyright are options for protection, the distinction between copyright infringement and patent infringement must be borne in mind.

In deciding upon which form of protection and enforcement to elect, one should also evaluate the nature of the infringement most likely to be encountered. In this regard, the technical details of the work/invention itself and the state of the relevant science and technology will be paramount considerations. For example, a creator of genetic works seeking protection should consider the following questions:

(a) For an infringer to usurp the benefits of the work/invention, would he need to reproduce it virtually identically or would he merely have to make a variant that could appear quite different from the specific form of the work/invention? In the former case, the copyright would be infringed, while in the latter case, only the patent possibly would be infringed.

(b) Has the work been published widely so that access may be legally inferred from its accessibility, even if direct evidence of access is not available? Wide publication would support a case of copyright infringement.

(c) Is the genetic sequence of the work/invention such that the currently available and soon-to-be-available techniques of DNA sequencing and DNA-DNA hybridization effectively show substantial similarity between the infringing work and the protected work? In this regard, it is noteworthy that scientists at the Massachusetts Institute of Technology recently analyzed the entire 7,410 nucleotide sequence of the polio virus.<sup>184</sup>

(d) Could and did the author/inventor include in his DNA compilation one or more redundant gene fragments that were totally unnecessary and unrelated to the function of the DNA compilation? These so-called "housemarks", if found in the plagiarist's work, will be virtually conclusive proof of copying.

In most cases, one should be able to produce the evidence of access and substantial similarity needed to establish copyright infringement of a genetically engineered work. The author can increase his likelihood of success by extensively publishing his work and by inserting undisclosed "housemarks" in his work. The proof needed to establish copying in a copyright context will also establish copying as an ele-

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182. See 7 A. DELLER, WALKER ON PATENTS § 532, at 308.

183. See *id.* § 514, at 178.

184. See Racaniello & Baltimore, *Molecular Cloning of Poliovirus CDNA and Determination of the Complete Nucleotide Sequence of the Viral Genome*, 78 PROC. NAT'L ACAD. SCI. 4887 (1981).

ment of willful infringement in a patent context.<sup>185</sup> The latter may establish the "exceptional case" needed for treble damages and provide a basis for an award of attorney's fees.<sup>186</sup>

The true reach of copyright infringement for genetic works turns, in the final analysis, as it does in all copyright cases, on whether the copied work is "substantially similar" to the copyrighted work. Accurately generalizing in this largely subjective area is as difficult as determining whether a challenged device, not identical to a patented invention, is an infringing "equivalent."<sup>187</sup> Nonetheless, two works certainly need not be identical for one to infringe the copyright of the other.

When a major portion of the words or musical notes of a work appears in a copied work, the literal similarity is typically comprehensive enough to satisfy the substantial similarity requirement.<sup>188</sup> Moreover, if that which is copied is a qualitatively important part of the copyrighted work, substantial similarity may exist even when the magnitude of literal similarity is not great.<sup>189</sup>

In regard to genetically engineered works, the pirate's copy typically will have significant literal similarity to, and will appropriate qualitatively important parts of, the protected work. The peculiarities of the technology account for this fact. Every DNA sequence is made up of triplets of nucleotides. Each triplet is a specific code for a particular amino acid which in turn is a building block of a protein.<sup>190</sup> Thus a DNA sequence may be 1,200 nucleotides long, which means it codes for 400 amino acids (1,200 nucleotides divided by three nucleotides for each triplet), to produce one protein which has a permutation of 400 amino acids. The triplet that codes for a particular amino acid almost always has a particular nucleotide in each of the first two locations, but the third, for unknown reasons, often, but not always, may be any of the four nucleotides,<sup>191</sup> Guanine (G), Cytosine (C), Adenine (A), and Thymine (T). For example, the same amino acid may be coded GCG, GCC, GCA, and GCT. Consider a novel and original man-made DNA sequence with 400 triplets for which a copyright has been registered. A plagiarist copies the sequence but makes sure to use in every ambiguous third location a different base from that used in the registered work. His 400 triplet sequence probably will produce the same protein as that of the copyrighted sequence; it will have literal similarity to the extent of 2/3 of the sequence and that

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185. See *American Safety Table Co. v. Schreiber*, 415 F.2d 373, 378-79 (2d Cir. 1969), *cert. denied*, 396 U.S. 1038 (1970).

186. See *American Safety Table Co. v. Schreiber*, 415 F.2d at 378-80.

187. See *Graver Tank & Mfg. Co. v. Linde Air Products Co.*, 339 U.S. 605, 609 (1950).

188. 3 M. NIMMER, *supra* note 22, § 13.03 [A], at 31.

189. *Id.* at 32.

190. Proteins are life-essential chemicals. See J. FALKINHAM, *supra* note 9, § I, at 17.

191. See L. MAYS, *supra* note 8, at 546-47.

2/3 necessarily will be qualitatively important. The differences in the 1/3 ambiguous locations are qualitatively not important. Consequently, all instances of DNA sequence plagiarism should satisfy the two traditional requirements of substantial similarity: literal similarity and qualitatively important similarity. These two factors have established infringement in copyright cases dealing with various works. There appears to be no reason why these factors should not be sufficient in relation to works of genetic engineering.

## V. *Perspectives on Protection*

### A. *Simultaneous Copyright and Patent Protection*

Perhaps the best of all possible worlds is available to the author/inventor of genetic works. If copyright protection can inhere in his specific DNA compilation simultaneously with patent protection that encompasses the idea which that DNA sequence and its legal equivalents represent, his genetically engineered works/inventions can enjoy significant protection. For approximately one hundred years,<sup>192</sup> neither the specific DNA compilation nor a substantially similar one could be legally copied or reproduced<sup>193</sup> and for seventeen of those one hundred years, the idea comprehended by the DNA sequence and its equivalents could not be legally implemented by others making, using, or selling the DNA sequence or its equivalents.

Impressive authority supports the proposition that copyright and patent, being different, non-coextensive modes of protection, can apply simultaneously to the same work/invention of the same author/inventor. The United States Court of Customs and Patent Appeals expressly so held with respect to simultaneous copyright and design protection for the face of the "Spiro Agnew" cartoon wristwatch.<sup>194</sup> The unanimous court concluded that the existence of copyright protection for the wristwatch face could not be the basis for denying the watch patent protection.<sup>195</sup> Some three years later, the same court unanimously reaffirmed in dictum that patent, trademark, and copyright protection are not mutually exclusive rights.<sup>196</sup> The United States Supreme Court has not ruled on this subject.<sup>197</sup>

### B. *The Reasons for Extending Copyright Protection*

A four-tined fork designed and used for holding and lifting a large beef roast is most effective when all four tines pierce the meat and contribute to the desired end. The use of such a fork on a different

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192. See *supra* notes 47-48 and accompanying text.

193. It could be used, however, by a subsequent author who independently created it. See *supra* notes 175-77 and accompanying text.

194. *In re Yardley*, 493 F.2d 1389, 1394 (C.C.P.A. 1974).

195. *Id.*

196. *In re Penthouse Int'l Ltd.*, 565 F.2d 679, 683 n.3 (C.C.P.A. 1977); see 1 M. NIMMER *supra* note 22, § 2.19, at 16 ("It would seem on principle that if a work otherwise meets the requirements of copyrightability, it should not be denied such simply because the claimant happens to be entitled to supplementary protection under other legislation.") (footnote omitted).

197. 1 M. NIMMER, *supra* note 22, § 2.19, at 15.

item of food, such as a large fowl or a pork rib roast, may be possible only with two or three of the tines piercing the meat because the shape of the item may preclude the entry of all four. That is the nature of geometry and reality. When geometry and reality permit supportive contributions by more rather than fewer tines, however, the work is accomplished more efficiently and effectively.

The same is true with legal protection for all forms of intellectual property. If copyright properly may be added to the already orthodox supportive prongs of contract, patent, and trade secret in protecting and creating property in genetically engineered innovation, the job will be carried out more efficiently and effectively.<sup>198</sup> The addition of another legal resource to the innovator's spectrum of remedies can result only in his greater confidence that the risks, costs, burdens, and emotional traumas attendant upon innovation are justified because, should he succeed, he will be justly rewarded.

One may reasonably ask, however, whether copyright protection, with its attractive remedies and length of protection, is too great a reward for innovation in genetic engineering. Should the market have to pay that high a price simply because of governmental fiat? Would not the same quantity and quality of innovation be forthcoming with fewer and smaller legislated rewards? These questions have no easy answer. When the queen's life was at stake should she fail to carry out her father's boastful promise to the king that she would weave straw into gold, she was quite willing to promise delivery to Rumpelstiltskin of her first-born child in exchange for his performing alchemy for her. What would it be worth to the world were a modern-day Rumpelstiltskin to offer us an implantable gene sequence that would extend all human lives to five centuries or a millenium or longer? What would a gene sequence be worth that could increase grain production a thousandfold per acre, thereby literally eliminating famine and want from the face of the earth? The rewards provided by copyright are not excessive to induce efforts toward innovation that may produce such results. Indeed, even if the results of genetic research never rise to the level of "nirvana," surely any genetic contribution should be deserving of at least the same reward given to the author of a detective story, cookbook, rock-music record, or computer program used to idiot-proof an accountant's work product.

Perhaps more to the point is that copyrights (and patents) teach the world the state of the art rather than hiding it as occurs with secrecy. Those of skill are then enabled either to take the next step beyond (and then negotiate for an exchange of rights) or to innovate

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198. *Cf. Kewanee Oil Co. v. Bicron Corp.*, 416 U.S. 470, 493 (1974) (both trade secret and patent law have a "particular role to play, and the operation of one does not take away from the need for the other.")

around the protected work so as not to have to pay for its use. In either event, society benefits. Even secrecy should not be scorned absent some more effective mode of obtaining a reasonable return for the money, effort and risk inherent in innovation.

### *V. Epilogue*

Should the analysis of this paper prove sound and copyright be available as a useable incentive to create in molecular biology, society will benefit and the author will be pleased. Should it prove unsound and this investigation show this alley to be blind rather than opening into a grand technical-legal sunrise, the author will be satisfied nonetheless — the same mistake will not have to be repeated.

The author confesses, however, that he wishes he never had been forced to go through this exercise. Before and during this exercise, every intellectual and emotional prejudice, both sophisticated and primitive, to which he is subject opposed coming to the conclusions finally reached. Copyright protection for engineered DNA sequences seemed ludicrous.

Why, then, did he start the investigation? During March of 1981, when the author was administering a continuing legal education program on copyrights, a lawyer-attendeo approached him and asked why genetically engineered organisms could not be copyrighted? The author, shocked and perplexed by the question, responded by promising to think about it. That began the inordinately trying conflict between the discomfort of going forward to seek the truth and the joys of quiet repose that wrapping oneself in the blanket of accepted prejudice provides.

In any event, this paper is his answer to the question. The author unfortunately does not remember the name of the seminal questioner, but he thinks he would like to thank him.