Ethics and Patenting of Transgenic Organisms

This NABC 4 optional symposium was
co-sponsored by the National Agricultural Biotechnology Council
and the Center for Biotechnology Policy and Ethics
at Texas A&M University.

Special funding was provided by the Institute for Biosciences and
Technology, Texas A&M University.

The papers by Hettinger, Thompson, Albrecht and Comstock have been published in the CBPE discussion paper series.
Copies of individual papers may be obtained from CBPE. Call 409/847-8921 for information.

Additional copies of *Occasional Papers #1, Ethics and Patenting,* are available for $2.50 by writing:

NABC
419 BTI, Tower Road
Cornell University
Ithaca, NY 14853

September 1992

The National Agricultural Biotechnology Council (NABC), establis hed in 1988, is a consortium of 13 not-for-profit agricultural research and education institutions:

- -Boyce Thompson Institute
- -Rutgers University
- Cornell University
- Texas A&M University
- Iowa State University
- Tufts University
- University of California, Davis
- -Ohio State University
- University of Georgia
- Purdue University
- University of Missouri, Columbia
- University of Nebraska, Lincoln

Michigan State University

NABC, through sponsorship of annual meetings, provides an open fo rum for exploring issues in biotechnology ; an opportunity for persons with different interests and concerns to come together to speak, to listen, to learn and to participate in meaningful dialogue. The fourth annual meeting (NABC 4) was hosted by the Texas A&M University System in College Station, May 27-30,1992, focusing on *Animal Biotechnology: Opportunities and Challenges,* and organized by John Shadduck, Associate Deputy Chancellor and Dean, College of Veterinary Medicine and Paul Thompson, Director, Center for Biotechnology Policy and Ethics.

An addition to this year's meeting was an optional topic seminar, *Ethics and Patenting of Transgenic Organisms,* immediately following the annual meeting. There were approximately 50 attendees, more than 40 of whom had attended NABC 4. Participants included ethicists, lawyers, environmentalists, administrators, scientists, philosophers, sociologists, as well as representatives of agribusiness and animal welfare.

The sy mposium was organized by the Center for Biotechnology Po hey and Ethics (CBPE) with sp ecial funding from the Institute for Biosciences and Technology (IBT) at the Texas A&M University . Gary E. Varner, a philosopher and research associate at CBPE organized this symposium. His introduction and overview provide a snapshot of an interesting and intellectually challenging symposium, especially for those of us who, as scientists, struggled to follow philosophical and legal arguments.

Several attendees expressed a desire to ha ve copies of the papers so they could re visit the is sues and m ore carefully contemplate the arguments. NABC, in its mission to promote understanding of issues associated with ag ricultural biotechnology, is pleased to st art a new series publication, "Occasional Papers," the firs t of which includes papers from this highly successful symposium. The m odel of an ann ual meeting followed by an optional topic sem inar will be followed again next y ear at NABC 5, *Agricultural Biotechnology: A Public Conversation About Risk,* hosted by Purdue University.

The NABC Occasional Papers series will be published on an irregular basis. NABC hopes this group of papers will contribute to increased understanding of different viewpoints.

NABC extends very special thanks to Gary Varner for his organizational efforts, before and during the symposium, and his help collecting papers from authors when it was decided, during the sy mposium, that NABC would repr oduce and distribute the papers. The coopera tion of the authors and CBPE is also gratefully acknowledged.

June Fessenden MacDonald
Deputy Director
NABC

NABC 4, Animal Biotechnology: Opportunities & Challenges

Optional Activity: Symposium on Ethics & Patenting (pre-registration required)

SATURDAY, MAY 30,1992

Ethics and Patenting of Transgenic Organisms
Introduction and Overview

GaryE. Varner
Assistant Professor of Philosophy
Research Associate, Center for Biotechnology Policy and Ethics
Texas A&M University
College Station, TX 77843-4355

This sy mposium was planned to begin with conceptual and theoretical issues, progressing through a description of the contemporary status quo to consideration of ethical arguments for changing (or sticking with) the status quo, and ending with a roundtable discussion involving all of the presenters. The program began with two philosophers, Edwin Hettinger of the College of Charleston and Paul Thompson of Texas A&M, considering the conceptual issue of whether or not transgenic organisms are the sort of thing which one can legitimately be said to own. Both had previously published related discussions. In his paper, "Owning Va rieties of Life," Hettinger argues that it is a m istake to treat genetically altered living organisms as simply another class of human inventions patentable under the same rules and jus tifications as any other invention. He suggests that the nonexclusive nature of the subject matter of intellectual pr operty makes life patents *prima facie* irrational and gives us a reason to prefer public funding as the mech anism to stimulate genetic innovation. Thompson's paper, "Concepts of Property and the Biotechnol ogy Debate," develops three philosophi cal alternatives for interpreting and evaluating property claims. Criteria that evaluate property claims in terms of natural characteristics of goods provide one approach; criteria that are based upon productive labor provide a second. The most widely discussed category is the third, which takes a property right to be a legal fiction justified in term s of its ability to produce social utility .Historically, philosopher John Locke's work on property has been extremely influential, and Locke makes use of criteria from each of the three categories. Thompson's paper reviews Locke's ideas, and extends each of the three approaches to the discussion of biotechnology.

The second portion of the program was designed to describe the legal and economic status quo. Martin L. McGregor, a patent attorney with the Houston firm of Baker and Botts, which handles biological patent applications for the Texas A&M University System, surveyed the hurdles currently facing attempts to patent transgenic organisms in the United States and the ways universities, corporations, or indi viduals seeking patents can overcom e these hurdles. Because McGregor spoke from hand-written notes, only the abstract he subm itted ahead of time is reproduced here. Judith I. Stallm ann, an agricultural economist from Virginia State University, was scheduled to speak next, assessing the economic impacts of Patent Office and related regulations on the biotechnology industry. Stallmann became ill and was unable to present at the sy mposium, but the paper on which her presentation would have been based is reproduced here.

The final set of presentations turned to ethical considerations, both the beliefs of the pub lie and original arguments by speakers as to how the status quo ought to be changed. Th is segment included an overview of research done on public attitudes towards agricultural biotechnology, a consideration of animal rights issues, and a feminist/environmental critique.

In "Public Perceptions of Agricultural Biotechnology : An Overview of Research to Date," Texas A&M sociologist Donald Albrecht notes that precious little research is currently available on public attitudes towards biotechnology specifically. Working from studies comparing public attitudes towards science in general, Albrecht considers various reasons for public skepticism towards biotechnology specifically, and r ecommends that more detailed research be done, in order better to understand public apprehensions.

In "What Obligations Have Scientists to Transgenic An imals?" Iowa State University philosopher Gary Comstock develops and defends an animal rights view and considers its implications for genetic engineering. Comstock uses a fanciful example to make a point. Suppose that it were possible to cr eate, through a single application of genetic engineering, a biological egg-lay ing m achine, a chicken with a nervous sy stem too crude to support consciousness, but still capable of maintaining respiration, circulation, etc. Becaus e such a "bird" would (by hypothesis) be incapable of cons ciousness, no animal rights considerations would be raised by her development, *if* such a non-conscious "bird" could be achieved in a single "generation" through generic manipulation. However, Comstock argues, expe rience to date with the creation of transgenics indicates that many dysfunctional, but conscious, organisms would have to be created along the way to successfully producing a non-conscious "bird." So, Comstock cone ludes, a commitment to animal rights sometimes forces us to eschew biotechnical research with m orally innocuous goals because the means of achieving those goals would themselves involve violations of animals' rights.

In her presentation to the sy mposium, titled "Why it is Difficult to be an Ethical Biotechnologist," Martha Crouch, a microbiologist in the Department of Biology at Indiana University, mentioned Comstock's chicken example. Crouch said that she would object to such a transmogrification of the chicken ev en if it raised no concerns about animal rights. Crouch said that from an ecofeminist perspective, she objects to the gene ral distancing of ourselves from our food, to which modem agricultural technologies in general, and biotechnology in particular, have contributed. To produce an egg-lay ing machine like the one Comstock describes would be an extension of the factory farming already characteristic of the poultry industry. Crouch argued that the m ost intimate interaction each of us has with another organism is the act of eating him, her, or it. To consume only packaged food from the grocery or to treat the organisms we eat like machines is to deny those organisms the dignity of being individual living organisms. Crouch argued that this lack of respect for the individuals we eat is part of a general pattern, present in sexism, racism, and other forms of social oppression, a patter of denying or ignoring the nature of other individuals.

Crouch discussed at length a second area of ethical concern independent of the animal rights question. She argued that biotechnical innovations are ill-suited to the developm ent of sustainable agricultural sy stems because of the technical infrastructure necessary to support biotechnical innovation and because of their tendency to reduce crop diversity while being relatively input intensive. Crouch's presentation to the sy mposium was extremely eloquent, and even impressed many who disagreed dramatically with her conclusions. Crouch was not reading from a text wh ich could be reproduced here. However, she provided an edited version of a paper covering many of the same issues which is included.

Neither Comstock nor Crouch explicitly addressed patenting in their presentations, but during the discussion period each drew out the implications of their views .Insofar as encouraging the patenting of trans genics furthers reliance on unsustainable agricultural practices. Crouch thinks it unwise to encourage patenting of any organisms. Comstock argues that because an anim al rights view would extend m oral standing only to conscious anim als, the genetic engineering of non-conscious organisms like plants presents no special problems from an animal rights perspective. However, where cons cious organisms are involved (and presumably the lion' s share of agricultural animals — primarily mammals and birds — are conscious) a com mitment to anim al rights requires us not to develop genetically engineered animals whose conscious lives would be wors e-off because of the way s they have been m odified. Insofar as allowing patents on transgenics encourages genetic engineering which might have these results. Comstock argues that the patenting of "higher" transgenic anim als (like mammals and birds) is to be discouraged.

Owning Varieties of Life: Historical, Conceptual, and Ethical Dimensions

Ned Hettinger
Associate Professor of Philosophy
College of Charleston
Charleston, SC 29424

In 1987, the U.S. Commissioner of Patents announced that "the Patent and Trademark Office now considers non-naturally occurring nonhum an m ulticellular living organism s to be patentable subject m atter." ^ The Commissione r wa s simply following the Supreme Court's lead. In allowing the patenting of a genetically engineered oil eating bacterium eight y ears earlier, the Court claimed that Congress intended patentable subject matter to "include anything under the sun that is made by man."[2] "Industrial" or "utility" patents for plants were next (something Congress for fifty years had explicitly considered and rejected), and by the end of the decade, Harvard Univers ity had received the firs t patent on anim al life. It patented the "oncomouse," a mouse genetically altered to contain a cancer causing gene; half of the offspring of such mice develop breast cancer within ten m onths making the mice profitable specimens for cancer research.^ As the major sponsor of the research, E.I. du Pont de Nemours & Co. received an exclusive license and is selling the patented moused

Even human material is now patentab le: the University of California at Lo s Angeles (UCLA) patented a cell line produced from a spleen removed from a leukemia patient named John Moore. ^ The com mercial potential of the pharmaceutical that this cell line can produce reportedly runs over a billion dollars, but in July 1990, the California Supreme Court ruled that Moore had rights to none of it.[6] Culminating this frenzy for life patents, the National Institutes of Health (NIH) recently applied for patents on several thousand gene fragm ents repres enting about 5% of the hum an genom e.[7]

The new biotechnologies promise a lot; in some cases they have already delivered. In medicine, there are tests that can determine the likelihood that a person, potential children, or a fetus will contract genetic diseases (possibly including alcoholism). DNA "fingerprinting" is already used in law en forcement (though not without considerable controversy). In agriculture, pest-resistant and nitrogen-fi xing genetically engineered plants coul d make possible a less chemically based agriculture. Human growth genes inserted into various food animals may produce larger, quick er growing animals that use

---

^Office of Technology Assessment (OTA), *New Developments in Biotechnology,* Vol. 5, "Patenting Life" (Washington, DC: U.S. Governments Printing Office, April 1989), pp. 32 and 93. Reported in "Should We Allow the Patenting of Life?" *Ag Bioethics Forum* (Ames, Iowa: Iowa State University), Vol. 3, No. 1 (August 1991), p. 2 (hereafter, *Ag Bioethics Forum).*

^■*Diamond v. Chakrabarty,* 447 U.S. 303(1979). Reprinted in Lawrence Becker and Kenneth Kipnis, *eds., Property: Cases, Concepts, Critiques* (Englewood Cliffs, NJ: Prentice-Hall, 1984), pp. 6-8. The quotation (see p. 7) is from the majority opinion written by Chief Justice Burger. Note that Donald Quigg, the Commissioner of Patents, was more careful in his proclamation (quoted above) than was Burger: Quigg excluded human organisms that are, after all, "made by man," from patentable subject matter. In "Patenting Life" (p. 24), the OTA remarks that patent "claims directed to or including a human being" will not be allowed since owning human beings is prohibited by the Thirteenth Amendment to the Constitution (which banned human slavery). On owning human material, see the John Moore case and the National Institutes of Health (NIH) patent applications discussed below.

^Kathleen Hart, "Making Mythical Monsters," *The Progressive,* March 1990, p. 22 (hereafter "Mythical Monsters").

^OTA, "Patenting Life," p. 12. This says (as of 1988) "they intended to begin selling the mouse"; I assume they are doing so.

%or a discussion of this case, see Carl Cranor, "Patenting Body Parts: A Sketch of Some Moral Issues," in *Owning Scientific and Technical Information,* ed. by Vivian Weil and John Snapper (New Brunswick and London: Rutgers University Press, 1989), pp. 200-212.

^Jack Kloppenburg, "No Hunting: Scientific Poaching and Global Biodiversity," *ZMagazine,* September 1990, p. 108.

^See Leslie Roberts, "NIH Gene Patents, Round Two," *Science,* Vol. 255 (February 21,1992), pp. 912-913 and Edmund L. Andrews, "Dr. Healy's Big Push on Patents." *The New York Times,* February 16,1992, p. F12.

less feed.l Dramatic increases in agri cultural yields are possible and this would help with the problem of world hunger and enable us to feed an ever increasing human population. The future promises "g ene therapythat is, replacing damaged-disease causing (and perhaps even aging causing) genes and tr ansforming animals into living factories that chum out improved protein-based drugs.^

There is considerable controversy over whether or not modem biotechnology is revolutionary . There is nothing new about human beings manipul ating other living organism for practical purposes. ^ (Consider, for example, using microorganisms to produce wine and cheese.) We have practiced a form of genetic engineering for thousands of y ears by selectively breeding animals (including humans) and plants. ^ Such manipulations of the genetic structure of living organisms for our purposes is a reasonable explanation of the nature of genetic engineering.^

NIH's patent application has created great controversy, as it should have. European countries (Britain specifically) are objecting to such patenting. NIH's Human Genome Advisory Committee fears that these patent applications may undermine international cooperation on the hum an genom e project by spawning an intern ational patent race to get control over human genes. Furthermore, since NIH doesri t know what th ese gene fragments do and has not clearly "isolated or characterized them," they seem to have no business applying for patents in them. How can one specify the subject matter of a patent when one cannot fully characterize or understand what one is try ing to patent? It seems clear that the Patent and Trademark Office (PTO) should reject NIH's applications. But given the decis ions of the P TO during th e last decade and given the Bus h Administration's desire to stimulate the biotechnology industry, some of these patents may well be issued. (Whether human gene patent infringement suits will be successful in court is another m atter.) NIH claim s that their attempt does not m ean that they "believe patenting this material is the proper thing to do now or for the future" and th at their goal is sim ply to pres erve their ability to exclusivel y license these patents to business in order to encourage the e xploitation of this new knowledge through the development of usefu 1 products. According to Roberts, "Genes cl early are patentable once they have been isolated and characterized" ("NIH Gene Patents," p. 912). My view is th at genes (perhaps especially *human* genes) should not be patentable, even when they are identified, characterized, and used for fra itful purposes. Human and other genes are works of nature, found, not created, and so they are not the product of invention. Thus they should not be patentable. If these patents are granted, this would overturn the entire basis of traditional patent law: what is patented must be novel(and this means it certainly can't be a common occurrence in nature) and it must be a non-obvious improveme nt over past inventions. Patenting se quences of DNA that occur in the human genome does not meet either of these require ments. Furthermore, patenting human genes is absurd since then all humans would violate the patent merely by existing (since patents prohibit others from using the patented invention without permission from the patent holder). To avoid this problem, the PTO could, I suppose, issue (along with the patent) a compulsory license to any human individual to use the human genes found in her own system at birth.

1 Another exam pie is the ice-m inus bacterium . Engineers have removed a gene from a naturally -occurring microbe that is involved in ice formation. Plants carry ing this new microbe are better able to resi st frost. By spraying this microbe onto crops, the hope is it will edge out the natural ice-form ing bacteria and thus crops will be better able to resist frost. Som e worry that the application of the ice-m inus bacterium to millions of acres of land for a sustained period of tim e could affect precipitation patterns and climate conditions. See Jeremy Rifkin, "Creating the Efficient Gene," in *Philosophy of Biology* (New York: Macmillan, 1989), ed. by Michael Ruse, pp. 224-225.

^Experiments are under way as well to ma ke chickens and pigs with flesh more suitable for microwaving. Hart, *Mythical Monsters*, p. 22.

^Mark Sagoff claims that "plant and animal breeders have practiced their art for thousands of years and pursued it systematically for centuries. Over the past hundred y ears, in light of Mendelian genetic theory, breeders have given us the crops we eat, the flowers we enjoy , the lives tock we rais e, and pets we keep in our homes. They have not been able to protect their work, however, under [the] utility patent act." See *Ag Bioethics Forum*, p.3.

^The dog was first dom esticated about 12,000 BC; barley , peas, lentils, and squash about 7000 BC. See Andrew Goudie, *The Human Impact on the Natural Environment*, 3rd ed. (Cambridge, MA: MIT Press, 1990), p. 17.

^In an illuminating 1990 unpublished manuscript called "On Patenting Transgenic Animals," Mark Sagoff quotes with approval the view of experts that "the new biotec hnologies do not depart radically from histor ical practices" (p.27, end note 42). (The paper is available from Sagoff who is the director of the University of Maryland's Institute for Philosophy and Public Policy). Of inserting a foreign gene into an organism he say s "rather than invent a different anim al, it leaves the original virtually unchanged" (p. 15). He also cites experts who claim that "centuries of selective breeding have altered domestic animals far more than the next s everal decades of trans genic modifications are likely to alter them " (p. 15). (But is n't it a radical departure to achieve in decades what it once took centuries to do?) Sagoff argues that m odem genetic technologies are not different from traditional breeding practices in any way that justifies allowing patents in the results of the former, but not those of the latter (p. 15-17). In arguing against the charge that genetic engineering undermines " species integrity ," OTA also suggests that the changes produced are minimal: "Mammals...may contain 50,000 to 100, 000 or more genes. W hatever it is in the organization and coordination of activity between these genes that is fundamental to their identity as species, it is not likely to be disrupted by the simple insertion or m anipulation of the sm all number of gene s (fewer than 20) that transgenic anim al research will involve for the foreseeable future" ("Patenting Life," p. 14). But it s hould be rem embered that sm all changes in genotype can produce

Nonetheless, there are notable differences between c ontemporary biotechnologies and those of the past. Recent techniques are faster and far more precise than traditional whole organism cross breed ing. They make it possible to isolate a gene (or parts of a gene) from the genome of a particul ar species, combine it with genes form other species, ^ produce large amounts of these genes and their products (by cloning), and then insert them into the inheritable genetic code of an organism.^ Modem genetic engineers can produce organisms that have a specific desirable characteristic (e.g. frost resistance or salt tolerance), while traditional whole organism cross breed ers produce organisms with a variety of new traits, many of which are undesirable and difficult to breed out. Modem genetic engineering can produce "transgenic" organisms, that is, organisms whose "hereditary material has been augmented by adding DNA from a s ource other than parental germplasm. "[3] Genes have been moved not simply between species (e.g. from a human to a pig), but across the plan and animal kingdoms. ^ Tobacco plants have been made to glow after a firefly gene was inserted into thern.^

The environmental, ethical, and social significance of this technology should not be underestimated. Some have suggested that the changes in the planet that will result from the use and release of biot echnical products will dwarf the changes that have resulted from the use of petrochemical-based products. ^ The W orld Resources Institute sees genetic material as the oil of the Inform ation Age. ^ As one commentator put it, "natural resources are going to m atter less. The real action is going to be in the gathering of genes." ^ According to Bill McKibben, biotec hnology involves "the second end of nature" (global dim ate change is the fi rst) and he finds great significance in beginning to manipulate nature, as he say s, "from the inside out."®

The History of Intellectual Property Protection for Living Organisms

Patenting life forms may not appear to be a new or revolutionary step either. After all, patents on biotechnical processes such as fermentation were first issued in the United States in the early 1800s, and on such patent (issued to Louis Pasteur in 1873) included a claim for a y east as an article of m anufacture. * ® Congress specifically passed a PI ant Patent Act (PPA) in 1930. Why then has there been such recent commotion about patenting microorganism, plants, or even animals?

---

large and dramatic changes in phenotype. Humans differ from chimpanzees genetically by less than 2%.

' One commentator says that we can even create "s ynthetic" genes, that is, "designer genes (engineered in the laboratory) and insert them into organism s." SeeRi chard Hindm arsh, "The F lawed'S ustainable'Promise of Genetic Engineering," *The Ecologist,* vol. 21, No. 5 (September/October 1991), pp. 196-197.

^Depending on how the procedure is conducted (whether or not the DNA is inserted into the germ cells), the DNA sequence may be passed on successfully to the organism's offspring, thus becoming a more or less permanent part of the variety's genetic code.

^OTA, "Patenting Life," p. 12. Whatnotion of "parent" is presupposed in this definition? If a parent is any being from whom an organism received genetic m aterial, then there can be no "transge nic" organisms in this sense. W ould a better definition of a transgenic organism be any being whose genetic material comes from more "parents" than it would have in natural (non-human directed) reproduction?

^ 11 urn an genes have been inserted into at least 16 animal species. Hart, "Mythical Monsters," p.22.

^Neil A. Campbell, *Biology,* 2nd ed. (Redwood City, CA: Bengamin/Cummings Publishing Company, 1990), p.400.

®Rilkin, "Creating the Efficient Gene," p.223.

^Kloppenburg, "No Hunting," p.104.

^Attributed to Jack Doyle. See article by Ward Sinclair, "Jack Doyle: A Warning Voice Amid the Biogenetic Revolution," *The Washington Post,* March 2, 1987, p. A9. See also Doy le's *Altered Harvest: Agriculture, Genetics, and the Fate of the World's Food Supply (New York: Viking Press, 1987), p.21.*

®Bill McKibben, *The End of Nature* (New York: Anchor Books, 1989), p. 162.

l^See OTA, "Patenting Life," pp. 7 and 31. According to OTA, however, the Plant Pa tent Act of 1930 was taken as a sign that without specific Congressional action, living mater was not itself patentable. Prior to the Chakrabarty decision, the PTO would not issue patents for living organisms (or parts of living organisms) themselves, but it would issue patents for compositions containing living things (e.g., food yeast compositions and sterility test devices containing spores).

The vast majority of major crops grown in North America are not native to this continent. 1 for most of this country's history, importing genetic material, improving varieties of crops (and breeds of an imals?), and distributing seed were publicly funded and performed by the federal government, thr ough the United States Department of Agriculture (USDA), land grant universities, and agricultural research stations. ^ In 1897, the USDA freely distributed 22 million packets of seeds to farmers. But this century has seen a definite trend toward the "privatization of biological material.[3] By 1924, industry had persuaded Congress to end free federal distribution of seeds, and in 1930 industry lobbying culminated in the Plant Patent Act.[4]

The Act only protects plants that could be reproduced ase xually (for example, by rooting clippings) and benefited the horticulture industry. Sexually reproduced plants were not prot ected because of perceived problem s in enforcing patents on them. ^ Unlike asexually reproducing plants (whose progeny are genetically identical to the parent plant), sexual plants do not generally breed "true to type."^ Thus, it would be much more difficult to know if a patent on a sexually propagated plant had been violate, since an infringing plant might be quite different from the patented parent.^

Furthermore, patent law has traditionally been understood to require that an invention be disclosed specifically enough to be identically reproducible. In 1930, sexually reproduced pi ants could not be identically reproduced (much less could breeders explain the genetic proces ses that they m ampulated). ^ Traditionally , patent claim s had to m eetthis so-called "enablement requirement" by including a de scription of the patented invention so detailed that it would enable a person skilled in the field to make and use the invention as a result. ® But this requirement had to be loosened for "living inventions" since they are not as easily specifiable as are mechanical or chemical ones, and the disclosure required by the PPA is weak.l

---

1 According to Kloppenburg ("No Hunting!," p. 104) "the European Colonizers found Native Americans growing maize, beans, tobacco, and squash. But these had been introduced from Central Am erica and the Caribbean. A truly North Am erican meal would cons ist only of s unflowers, blueberries, cranberries, pecans, and ches touts." I as sume that m any of the animals North Americans consume (e.g., cows, pigs, chickens, and s heep) are als o not native to North Am erica. P erhaps turkey s and many aquatic species are "native" in the sense that they were not intentionally introduced by human beings.

2These activities were included in the USDA's founding legislation. See Glenn Bugos and Daniel Kevles, "Plants as Intellectual Property: American Practice, Law and Policy in World Context," *Humanities Working Paper 1944* (Division of Humanities and Social Sciences: California Institute of Technology, Pasadena, CA 91125, October 1991), p.2.

^Hindmarsh, "Flawed 'Sustainable' Promise," p.203.

Frederick Buttel and Jill Belsky, "Biotechnology, Plant Breeding, and Intellectual Property: Social and Ethical Dimensions," in *Owning Scientific and Technical Information,* Vivian Weil and John Snapper, eds. (New Brunswick, new Jersey : Rutgers University Press, 1989), p.l 13.

%or a very useful and interesting discussion of this issue, see Bugos and Kevles, "Pat ents as Intellectual Property ," p.8. The major thesis of the article is that patent law in plants has been partially shaped by changes in the degree of "biological specificity" with which plants could be identified. The greater the detail with which we could specify the nature of a plant type and the more we could control its reproduction, the greater the patent protection that was given to plants.

^Since sexual reproduction joins half the genes from each parent, the progeny can easily be very dilferent from the parental type.

^There are conceptual difficulties in understanding what an organism patent is supposed to be. Patents on chemicals or machines are violated when someone else manufactures, uses, or sells the same chemical or machine. Of course there are questions of the meaning of "same machine" or "same chemical" in these cases, but it would seem to be much more difficult to determ ine what "same organism" means. The clearest definition would be having the same genetic code. This is something asexual progeny have but sexual progeny lack. Perhaps infringement could be based on some notion of "sufficiently similar" genetic structure. What is desired to be owned, however, is a particular phenoty pic characteristic (say frost resistance or the ability to convert feed to meat with less grain). But it is possible these sam e phenot ypical characteris tics could res ult from different genoty pes. Presumably this would infringe a patent if the patent claimed the phenotype, but not if the claim was for the genotype. Claiming a patent on a particular phenoty pe seems overly broad if the characteristic can be the expressi on of different underly ing genetic structures.

^Though not uniformly , today we can "identically reproduce" sexua 1 organisms by cloning technique s, and injection of DNA. We are also getting closer to being able to specify what goes on at the genetic level when we do this.

^For a discussion see Sagoff, "Patenting Transgenic Organisms," p.9. There are m ultiple rationales for this disclosure/enablement requirement: (1) Unle ss one can describe what one has invented, one has not invented any thing; (2) the description helps the courts determine when a patent infringement has occurred; and (3) the granting of a patent is often seen and

Although the PPA is administered by the Patent and Tradem ark Office and issues what it calls "patents" to supposed "inventors," it is quite different in a num ber of way s from the utility patent statutes. It includes a research exem ption that allows competing companies (and universities) to use the plant for further breeding. Furthermore, unlike general utility plant patents, independent invention does not infringe the patent under the PPA: infri ngement only results if the plant was cloned from the patented plant. ^

Although those involved in breeding sexually reproducing plants had hoped for protection under the 1930 PPA, they had to rely on hy bridization and seed certification for the next 40 y ears until the Plant Variety Protection Act (PVPA) of 1970 gave protection to new plant vari eties sexually reproduced using seeds. ^ But again this is not a plant utility patent. It is administered by the US DA (rather than the P TO) and is sues "certificates of protection to breeders ," not "patents to inventors."[4] It does not require that the new variety be useful (general utility patents are issued only for *useful* inventions), but only distinct, stable, and uniform.[5] It also did not prohibit farmers from using seeds from the protected variety in their own fields (as do utility plant patents). Like the PPA (and again unlike utility plant patents), it included a research exemption that allowed any res earcher to us e the protected s eed to de velop new distinct varieties. The property right was further restricted by a "public interest exemption": If the health of the American economy and food supply was negatively affected by a certificate holder not releas ing a crucial variety, the Secretary of Agriculture was allowed to require commercialization through compulsory licensing.^

This longstanding reluctance on the part of the PTO and Congress to allow utility patents for living organism s was finally broken by the Supreme Court' s Chakrabarty decisi on in 1979. The ruling held that although "a new mineral discovered in the earth or a new plant found in the wild is not patentable subject matter" since "such discoveries are 'manifestations of...nature, free to all m en and reserved exclusively tonon',"Chak rabarty's genetically altered oil eating bacterium had "markedly different characteristics from any found in nature...and is not nature's handiwork, but his own; accordingly it is patentable subject matter."^

In 1985, the first plant patent was issued under the "utility patent" laws that protect m echanical and chem ical inventions.^ Kenneth Hibbert received a patent for a variety of com that contained an increased level of an amino acid (and whose progeny did as well). ® Note that Hibbert used conventional cross-br eeding techniques, not the newer biotechnologies that produce transgenic organisms.[10] Thus although utility patents for living organi sms and m aterial resulted in large part from the existence of new transgenic organism producing biotechnologies (e.g., rDNA techniques), it is unclear how many of

---

justified as a trade between the inventor a nd society. The inventor is given a soci ally created monopoly to make, use, and sel 1 the invention, in return for disclosing the nature of his invention to society so th at others can learn from and build on this knowledge.

^ In "Plants as Intellectual Property" (p. 10), Bugos and Kevles suggest that the weakened disclosure requirement undermines the bargain with society to disclose enough for others to be able to improve upon the patented "invention."

^Sec Sagoff, "Patenting Transgenic Animals," p. 11, and compare with Bugos and Kevles, "Plants as Intellectual Property," p. 10.

[3] Sec Bugos and Kevles, "Plants as Intellectual Property," p.13.

^It also lasts for 18 years rather than 17 years. Bugos and Kevles, "Plants as Intellectual Property," p.23.

^ According to Buttel and Belsky, most of the new varieties that were produced and protected under the PVPA differed from each other only cosmetically and were produced for product differentiation and marketing reasons; the varieties protected did not have significant differences in performance. See "Biotechnology and Plant Breeding," p.122. Also see CIT, p.17.

^Bugos and Kevles, "Plants as Intellectual Property," p.18.

^Becker and Kipnis, *Property,* pp. 7-8.

^For discussions of this "Ex parte Hibbert" decision, see OTA, "Patenting Life," p. 11; Bugos and Kevles, "Plants as Intellectual Property," p. 25; and Sagoff, "Patenting Transgenic Animals," p. 20ff.

^The amino acid was try ptophan and the com's offspring had the sa me level of try ptophan (and so in this sense bred "hue to type"). Bugos and Kevles, "Plants as Intellectual Property," p.25.

lOSagoff, "Patenting Transgenic Animals," p.20.

the new organism utility patents apply to the results of traditional breeding m ethods that were previously deem ed inappropriate for patent protection.'

Plant utility patents are significantly different from the two earlier way s of protecting plants. ^ For example, the "plant invention" must be useful and not sim ply distinct. Utility plant patents also prohibit farm ers from saving and using their seeds, a significant restriction given th at almost 50% of wheat and s oybean crops are grown from farmer saved seeds. 3
Utility patents also lack a research exem ption, thus providing a barrier to further innovation. ^ Furthermore, independent inventors are prohibited from using their inventions if they have been previously patented. Utility patents are much broader in scope, allowing patents not only on entir e organisms, but on plant parts, seeds, and other genetic material as well (including genes). Such patents also alio w multiple claims to be filed simultaneously on a variety of different products and processes in different species. Because they provide this broader protection and are cheaper to obtain, general utility patents are the preferred method of protecting plant related innovations. ^

Though one must meet more stringent disclosure requirements to receive a pate nt under the utility patent sy stem than under the PPA, ^ general utility patents lor organism s (like under the PVPA) substitute a deposit requirem entforthe traditional enabling description: Since plant "inventors" are not able to provide a descripti on detailed enough to explain how to build their "organism inventions," depositing a representative sample in a public depository is supposed to make up for this inability.^

After a ruling by the Patent Board of Appeals in 1987 that oysters are patentable subject matter (though the particular variety at issue was not since it had been "found in nature"),^ in April of 1988, Harvard's oncomouse became the first animal to be patented. As of May 1992, the Harvard mouse is the only patented animal. ^

One wonders why utility patents on organism innovations took so long to develop, especially given Congress' specific desire to protect certain kinds of plant innovations as early as 1930. Also, given that com positions of microorganisms have been patented since the 1800s, why has Chakrabarty been seen as such a giant step?

1 do not think there is any clear answer to this question, nor any one decisive factor at wo rk. One suggestion is that as biological science and technology advanced and we becam e better able to understand the processes by which living organisms can be manipulated to possess desirable traits, the idea that we are inventing and creating s omething becomes more plausible. The more control over an organism's traits we have, the more it can be s een as an artifactual creation that

---

^By 1988, three years after issuing its first plant utility patent, forty-two more plant utility patents had been issued. How many of these are for plants bred in traditional way s? The PTO m ust now decide if it will allow patents on all ty pes of dom esticated animals (and plants) humans produce (breeds of livestock, horses, pets), at least after new versions are bred.

^See OTA, "Patenting Life," p.12, for a useful chart showing the differences.

^See OTA, "Patenting Life," p.79, and Buttel and Belsky, "Biotechnology, Plant Breeding, and Intellectual Property," p.122.

^Unlike breeders protected by the P PA and the P VPA, a plant pate nt holder is allowed to prohibit the use of the patented organisms for experimental breeding and research. Unlike the United S tates, most nations have such a research exemption. The only exemption under the U.S. patent statutes is case law that allows for experim entation to satisfy academic curiosity; such experimentation for commercial purposes is not allowed. On commentator sees th is as "unfortunate," arguing that progress and science are best served if all labs, including commercial ones, have the right to experi ment freely with patented organisms. S ee John H. Barton, "Patenting Life," *Scientific American,* Vol. 264, No. 3 (March 1991), pp. 42-43.

^Buttel and Belsky, "Biotechnology, Plant Breeding, and Intellectual Property," p.125.

[6]OTA, "Patenting Life," p.12.

^See Sagoff, "Patenting Transgenic Animals," p. 19-20. Sagoff uses organism inventors' inability to describe howto make their inventions as evidence that they have "no new knowledge" and thus that they should not receive patents.

^See Sagoff, "Patenting Transgenic animals," p.20, for this characterization of *Ex Parte Allen.*

®This suggests that the PTO may have gone into shock after issuing the first animal patent, perhaps realizing (as Sagoff suggests) that it may now have to offer patent prot ection for animals and plants bred in trad itional way s. As of March 1990, fifty patent applications on novel forms of higher life ar e pending. (I assume "higher life forms" means animals, that is, life other than microbes, fungi, and plants). See Hart "Mythical Monsters," p.22.

might be appropriately patented. ^ I also think there is a mystique about the new biotechnologies which gives us a (largely false) sense of power, control, and understanding. Political considerations probably also played a significant role: for the last 15 years (since the Carter Administration) there has been an anti-regulation trend in government and a desire to stimulate private business activity in areas in which the government once had a large role.

One underlying theme of this history is that Congress, the Courts, and the Patent Office have been reluctant to include living organisms under the general utility patent statutes. These statutes were originally designed to protect and promote mechanical inventions, not living organisms. We shall see that there are good reasons for this initial refusal to protect and encourage innovative activity involving living organisms with the same legal tools used to protect and stimulate mechanical invention.

Are Living Materials Justifiably Owned as Intellectual Property?

The question I want to address is: Are living organisms and genetic material justifiably owned as intellectual property? More specifically, I want to explore whether it is appropriate for human societies to issue utility patents for these results of biotechnology. I will consider four arguments for such property:

(1) the natural entitlement to the fruits of labor rationale,

(2) the desert rationale,

(3) the exchange for secrecy rationale, and

(4) the consequentialist incentive rationale.

In assessing the justifiability of intellectual property of any type (e.g., patents, copy rights, and trade secrets) one must consider an important logical feature of this type of property. Unlike things owned as tangible property, e.g., wrist watches, what is owned as intellectual property, e.g., inventions, are *non-exclusive*. Use of a wrist watch by one person excludes others from using it. Use of a genetically engineered tumor causing gene does not: Cancer researchers throughout the world could use animals with this genetic material. By giving Harvard a patent on the "oncomouse," we legaily allow the university to exclude any one else from creating or using such animals.

Because inventions (and other types of things owned as intellectual property, e.g., writings) can be used by everyone at once, justifying exclusive property rights in them faces a burden of justification not shared by the justification of tangible property. It is prima facie irrational, I submit, for society to grant individual monopoly rights to something that by its very nature can be used by everyone at once. It makes sense for society to grant exclusive rights to tangible objects because one person's use of and benefit from them requires excluding others. It is wasteful and inefficient, however, for society to let only one person (or institution) use and benefit from something that all could use and benefit from concurrently.^

Of course without such intellectual property rights there may not be adequate market-based incentives for individuals to produce these inventions. Because of this, I think that just as there is a burden of justification on those who want to grant monopoly rights to inventions, so too there is a strong prima facie reason to use public funding for invention (and to make freely available the results) as the social mechanism for insuring their creation and dispersal. Thus I see the historical trend away from public funding for the creation of new varieties of organisms and toward private ownership of genetic innovations

1 Another possible reason is that until rDNA technology, there did not seem to be enough inventiveness to the process to justify a patent. With rDNA, there is cutting, moving, and fiddling around, and recreating different sorts of entities. With traditional breeding, there is much less of this intricate manipulation of the organism, though the work may be no less difficult. Bugos and Kevles claim that we are now at the point where we can specify the nature of our biological manipulations of organisms and thus that we are finally beginning to meet the criteria for inventiveness necessary for patents. See Bugos and Kevles, "Plants as Intellectual Property," p.24-25.

^Patents on living organisms not only set up a wasteful monopoly on the patented organism, but since living organisms are self-replicating, they establish a monopoly on one way of making these organisms readily available to all. Issuing organism patents is analogous to giving an individual a copy right in a song, and also in a process by which the song can be replicated (e.g., in audiotaping machines).

as unfortunate. On grounds dealing solely with the nature of intellectual property, we have strong reasons to question the social wisdom of allowing the patenting of living materials.

The Natural Entitlement Argument

An often used justification of property rights is that people are naturally entitled to the fruits of their labor. ^ This originally Lockean argument boils down to the intuition: I made it and hence it is m ine; it would not have existed but for me. Baruch Brody appeals to this argument at the end of a lecture defendi ng the patenting of bans genic animals because it s timulates useful animal related inventions . He s ays: "Thes e cons equentialist cons iderations m ay be re-enforceable by an appeal to patents as a way of satisfying the inventor's entitlements to the fruits of his or her labor. "[2]

I have argued in other places that a patent itself as well as the market value of a patent are socially created phenomena; they depend res pectively on the s ocial structures that create and enforce the patent system and on the demand of others. A patent cannot exist in a society without a sy stem of law and a patent has no market value when individuals in a society are too impoverished to buy the patented invention. Since neither a patent nor the market value of a patent are the fruits of the inventor's labor, an inventor cannot be naturally entitled to either on the ground that they are the fruits of her labor.^

Being Naturally Entitled to Other Living Beings

In addition to this general argum ent against inventors being na turally entitled to patents in their inventions, there are m ore specific problems with claim ing that a bio technician is naturally entitled to a patent in genetically engineered organisms as the fruit of her labor.

If anything is *naturally entitled* (that is, entitled by nature) to own a living organism, it is that living organism itself. When Locke argued for a natural property right to the fruits of labor, he did so by starting from the claim that we have a natural property right in our own bodies and then extending this right first to the activity of our bodies (that is, our labor) and secondly to the fruits of this activity .4 Having the right to use and benefit from one's own body is a paradigm case of a natural entitlement. I come into the world with a naturally and metaphysically grounded claim to my arms or to my cells. No one else is bom with this special moral relationship to my body. The claims of others to my body are created by social contract (eg., if I promise to sell y ou some of my blood) or by special circumstances such as need; they are not "natural entitlements."

What I am suggesting is that living be ings come into the world with a claim to use their own phy sical characteristics for their own benefit. The DNA in a bacterial cell naturally belongs to that bacterium and not to the researcher, the trunk of a tree is something to which the tree, not the lumber company, is naturally entitled; the calf, not the farmer, naturally owns the flesh of its own body . These features of these organisms exists by nature for the benefit of those organism. Though none of these organisms are able to exercise th ese claims to their bodies on their own be half, humans can exercise the claims for them.

These natural entitlements (or claims) are *not absolute*, however, and can be overridden by other stronger moral claims (for example, genuine human needs can outweigh them). Furthermore, human property arrangements pertaining to animals or plants are not necessarily ruled out on this view (though ownership of living beings will involve duties to the organism s, as well as privileges with respect to them). My claim here is onl y that ownership of another orga nism (or a ty pe of organism)

---

^As John Locke says, "Justice gives every man a Title to the product of his honest Industry ." John Locke, *first Treatise on Government,* I, Sec. 32. See also *Second Treatise on Government,* chap. 5.

^*Ag Bioethics Forum,* p.4.

3 See Edwin C. Hettinger, "Justifying Intellectual Property," *Philosophy and Public Affairs,* Vol. 18, No. 1 (Winter 1989), pp. 36-40.

^For a useful summary and interpretation of Locke's arguments see Lawrence Becker, *Property Rights* (London: Routledge and Kegan Paul, 1977), chap. 4.

cannot be justified on grounds of natural entitlem ent. No living being is *naturally entitled* to own any other living being. ^ This is true, I think, even when one being is casually responsible for the exis tence of another or has manipulated its characteristics.^

Central to this argum ent is the claim that living beings ha ve an individual welfare that their various phy sical features exist by nature to s erve. Unlike artifacts (s uch as m achines), inanim ate natural objects (s uch as m ineral or chem ical compounds), or even parts of living beings, any living being has a good of its own (or welfare interest) and can be benefited or harmed without reference to any other being. ^ (For example, crushing the roots of a tree with a bulldozer harms the tree; it is a setback for its own welfare, and not simply bad for th e homeowner who wants its shade). What specifies the good of a living being is (in part) its genetic program^ which defines its biological functi ons whose fulfillm ents constitute the organism's good.^

Unlike teleological m achines (such as heat-seeking missiles) whose artificial functions ar e programmed into them by purposeful beings and thus are attributable to the programmer, living organisms have biological functions original to them. Though the pressures of natural selection on their species to ad apt to an ecological niche is the (main) causal reason their genetic program is what it is, the biological functions this program specifies determine what is good for that individual itsel f. Just as we would say that a human being's biological needs for food and water constitute its *own good* even though the needs were programmed into it by evolution, so too we should allow that a plant's biological need for nutrients and water constitute its own good even though these needs were programmed into it by evolution.

In the case of non-naturally occurring organisms that bi otechnicians (including plant and animal breeders) have genetically m anipulated for hum an purposes, at least som e of their capacities are artificial and thus not their own. The tobacco plant's ability to glow does not specify something that is good for the tobacco plant its elf; the fulfillm ent of this capacity of the plant is a good m ore properly attributable to the genetic engineer and her purposes than to the tobacco plant itself. ^

Nonetheless, there remain numerous original genetic tra its and consequent biological functions that specify the flourishing of the organism independent of the genetic engineer (e.g., respiration and photosynthesis). The satisfaction of

---

1 What about being naturally entitled to own the *E. coli* bacteria in my own gut?

^As I argue below, organisms are independe nt centers of value whos e existence and well-being we have a prima facie duty to respect. Does claiming that a person is naturally entitled to something entail the appropriateness of viewing the thing as a *mere* resource, thus denying that it is morally considerable in its own right? If so, then if a being is m orally considerable, no (other?) being can be naturally entitled to it.

^Numerous philosophers have argued for this point. They include: Kenneth Goodpaster, "On Being Morally Considerable," *Journal of Philosophy,* Vol. LXXV, No. 6 (June 1978), pp. 308-325; Paul Tay lor, *Respect for Nature* (Princeton: Princeton University Press, 1986), chap. 2; and Holmes Rolston, *Environmental Ethics* (Philadelphia: Temple University Press, 1988), chap. 3. Joel Feinberg is perhaps the most notable opponent of the claim that plants and microbes have welfare interests (though he accepts that sentient animals do). S ee, for example, *Harm to Others: The Moral Limits of the Criminal Law, Volume One* (New York: Oxford University Press, 1984), p. 32.

^Note that the environm ental conditions in which an organism exists may also play a role in what constitutes the organism's flourishing.

^For the most careful defense of this claim to date, s ee Gary Vamer, "Biological Functi ons and Biological Interests," *Southern Journal of Philosophy,* Vol. 29 (1990), pp. 251-270.

^Do patents allow ownership not of the organi sm type as a whole, but of the ability of the relevant class of organisms to express the very characteristic genetically engineered into them? since this characteristic is not original to the organism, it does not exist by nature in the organism for the purpose of serving the organism's own welfare. So is a genetic engineer therefore naturally entitled to this ability of the organism (not the whole organism, but only its artificial function she programmed into it)? Perhaps one cannot be naturally entitled to som ething that is inseparable from what another is naturally entitled to. If the organism is naturally entitled to its own naturally programmed phy sical features and the artificially programmed features are inseparable from them, then perhaps it m ust also be naturally entitled to wh atever is inseparable from what it is entitled to. After all, even the artificial functions are part of the organism's being and not part of the genetic engineer' s (though they are the fruits of the engineer's labor).

these biological functions constitute the organism 's own good. Thus even genetically altered non-naturally occurring organisms have their own goods.

I do grant that the more an organism is genetically manipulated and programmed to serve human purposes, the less plausible it becomes to argue that it has a good of its own. At some point, perhaps living organisms could become so artifactual as to be closer conceptually to teleological m achines (whose functions are parasitic on their designer) than to naturally occurring entities with a good of their own. ' Contemporary genetic engineering which can modify very few genes at a time is far from the creation of such living artifacts.^

That all organism have their own welfare is not sufficient to show that they have a prim a facie claim on us to respect that welfare. (Put in m ore familiar language, that a being ha s a good of its own does not by itself entail that the being is morally considerable.) Sophisticated argum ents can and should be developed to make this connection, but for the present purposes the following argum ent will have to suffice: If we think that the welfare interests of hum an beings ground prim a facie duties not to undermine the satisfaction of those interests, then we should think that the welfare of other organisms als o grounds similar duties to them.

If we accept that we have prim a facie duties to respect th e welfare interests of other organisms, then we should acknowledge their fimdam ental natural entitlem ent to use their own bodies for their own benefit. It seem s incongruous to deny that an organism is naturally entitled to use its own body for its own benefit while acknowledging that the organism has (prima facie) claim s on us to respect its welfare. And if an organism is naturally entitled to its own body , then a genetic engineer cannot be naturally entitled to it as well.

From Non-Sentient to Sentient and then to Human Organisms

It is easier to defend an argument of the above sort to the more limited conclusion that genetic engineers are not naturally entitled to the organism s they manipulate *when those organisms are sentient.*. The ability of sentient beings to feel pleasure and pain and their possession of preference interests (such as, wants and desires) in addition to welfare interests m ake it easier for us to regard them as beings with an independent existence and well-being th at we ought to value. It is respect for these characteristics that undermines the claim that people can have natural entitlements to other living organisms.

It is interesting to note in this connection that we have had a ty pe of plant patenting since 1930 and that in the first three years since utility plant patents were allowed, forty -two were issued. In contrast, there have been no other anim al patents issued in the four years since Harvard patented the one omouse, despite the fact that over twenty animal patents were pending at that tim e. Several bills dealing with anim al patenting have been introduced in Congress, but none (as far as I' m aware) concerning plant or microorganism patents. ^ Clearly there is greater public concern about patenting animals than with patenting other life forms. I think there are serious moral and philosophical problems with justify ing patents on *any* living organism, not just with patenting our closest cousins, the sentient animals.

The poverty of the natural entitlem ent to the fruits of labor argument when applied to living organism s is even m ore evident when considering human organisms. No one thinks that parents are naturally entitled to own as property the fruits of their labor, namely, their children. A parent needing a kidney transplant who claimed a natural entitlem ent to the use of his child's extra kidney because, after all, th e kidney is the fruit of his labor, does not have a compelling argument. Similarly,

---

1 Bernard Rollin has suggested that since the use of anim als in sc ientific and m edical research will continue, genetic engineers should design animals who are permanently non-conscious (and thus not able to be aware of pain). Would animals who have been designed to lack consciousness also lack goods of their own? Unlike a plant's need for water, such an animal's "need" for water does not s eem morally considerable. It is not clear to m e that such a being has any needs (or welfare interes ts) at all. However, it remains to be e xplained why such permanently non-conscious an imals would lack welfare interests, while permanently non-conscious plants have them.

^Sagoff, in "Patenting Transgenic Animals" (p. 15), quotes experts who claim that even with genetic alteration the "essence of the animal remains fixed."

^OTA, "Patenting Life," p.32.

future genetic engineers will not be naturally entitled to own as property the genetically improved human beings they are partially responsible for creating. 1

It is therefore dis tressing to s ee the S upreme Court's decision in Chakrabarty to alio w patenting of microorganisms followed so quickly by the patenting of plants, animals, and even human tissue, without any careful articulation of possible morally relevant differences between the patenting of these various organisms and ty pes of living m aterial. One of the arguments for patenting microbes that was used in the debate leading up to the Supreme Court' s Chakrabarty decision was that allowing such patents would wot result in patents on higher life forms. ^ I frankly will not be surprised if the PTO continues this trend by approving NiI-I's human gene fragment patent applications.

Owning Kinds, Not Individuals

Organism patents do not simply give one ownership of the *particular* animals, plants, or microbes one has engineered. One does not need a patent to own the particular organism one has genetically altered—ordinary property rights are sufficient for this. Rather, organism patents give the patentee rights over all instances of the ty pe of organism she has genetically engineered.^ To say that the patentee is naturally entitled to all of these organism s because they possess a gene that they would not naturally have is, in m y mind, even m ore disrespectful and than claim ing that som eone is naturally entitled to a particular created individual.

Owning Progeny and Troubles with Patenting Self-Replicating "Inventions"

Note further that organism patents grant their owners rights to the future des cendants of the genetically manipulated organisms in those cases were the genetic alteration is succe ssfully passed on. This is why utility plant patents prohibit farmers from saving their seeds and why Harvard can prohib it those to whom it sells th e oncomouse from breeding it. Holders of the future patent on genetically altered food anim als will be able to prohibit the farm ers to whom they sell their patented animals from breeding them. Whose labor are thes e animals the fruit of, the farm er's, the genetic engineer's, or the animals' parents?^

Because living organism s are self-repli eating, to allow patents in them poses unusual problems for the patent sy stem. As one commentator notes, "The sale of a patented product used to take it out of the monopoly: the purchaser could use the product in any way without further restriction." ^ Not so with selling patented organisms. The sale of an instance of a patented organism can at the same time be a sale of the means by which to replicate the organism and thus violate the patent. This is analogous to a compact disc (CD) manufacturer selling both CDs and CD duplicating machines and then claiming that

---

lliut will we allow genetic engineers to patent the im proved human characteristics which their genetic m anipulations m ade possible? Is not the John Moore case mentioned above the first st ep in this direction? Consider the following case. A couple (purposefully) breeds a child because they know that the child will have a genetic tr ait which increases life expectancy by 20 years. Should we allow them to patent this gene (or cluster of genes?) or should we allow the child to patent this gene? Is either naturally entitled to such a patent?

^One judge claimed it was "far fetched" to claim that patenting microbes would make patentable "all new, useful and nonobvious species of plants, animals, and insects created by man." Bugos and Kevles, "Plants as Intellectual Property," p.22.

^ When a patent is in organisms that have the engineered gene, then, I think, the patentee m ust have successfully inserted the gene into any type of organism she is claiming the patent cove rs. A patent for a new gene its elf is different; it would allow one to prohibit any one else from using an organism with that gene, whether or not one had inserted the gene into that type of organism. (Note that having a patent on a gene does not give one an affirmative right to use any organisms with such genes, since they might also include genes owned by someone else.) Harvard owns any non-human mammal containing the oncogene, whether or not they have successfully put the gene into that type of mammal. To patent a gene itself is a broader patent grant than is patenting an organism ty pe, since presumably one thereby has control over any type of organism containing that gene. See Sagolf, "Patenting Transgenic Animals," pp. 2 and 23-24, and Barton, "Patenting Life," pp. 42.43

^For a related discussion, see Paul Thompson, "Designing Animals: Ethical Issues for Genetic Engineers," American Journal of Dairy Science, forthcoming.

^Barton, "Patenting Life," p. 43.

the purchaser is violating copy right by duplicating the CDs. Shall we charge genetic engi neers who sell their patented organisms with the contributory infringement unless the organisms have been designe d so as to be sterile or unable to reproduce "true to type"?'

Owning Organisms versus Owning Genetic Material

My argument has been directed against the claim that genetic engineers are naturally entitled to the organisms they produce. This argument does not apply to *parts or characteristics* of living organisms nor to the *genetic material* underly ing these characteristics. Since these are not living organisms (although they are living material), they are not independent individuals with a good of their own. Thus m y argument that an inventor cannot be naturally entitled to a living organism is not directly applicable here. Might genetic engineers be naturally entitled to pats or characteristics of organisms or rDNA sequences, when they are not naturally entitled to living organism s themselves? Although these things originate in living organism s, they can be removed from them, and so this distinction might have a practi cal significance. Though UCLA doctors and researchers are not naturally entitled to J ohn Moore (nor to Moore's spleen), might they be naturally entitled to the cell line they developed from his spleen?

Claiming natural entitlement to engineered genetic material might be more disrespectful of hfe than is claiming natural entitlement to particular ty pes of organism s. Genetic m aterial, while not itself a living individual organism, is the fundamental information process underly ing all life. It is the vehicle of evolution and the process by which hfe developed on this planet. If one can have moral obligations to respect proce sses, rather than simply individuals (as environmental holists claim), then one might think respect for these processes is even more important than respect for the individuals.^ In any case, it will take a different argum ent than the one given earlier to reach the conclusions that one is not naturally entitled to own genetic material or parts and characteristics of organisms.

Discovering, Creating, or Altering Genetic Material and Organisms

Whether a gene (or gene fragment) has been "invented" rather than merely discovered or altered makes a difference to the plausibility of researchers' claim s to patent it. "I discovered it, hence it is m ine" is much less persuasive than is "I m ade it, hence it is mine." Even more implausible would be the claim that "I discovered it, so it, and anything like it, is mine." Issuing patents on genes or gene fragm ents to researchers because they were the first to discover them is an example of this. This is why I find NIH's patent applications on human gene fragments so outrageous. Being the first to find, identify, and categorize a natural phenomenon does not give one an y moral claim to own any phenomena of that sort. As the Commissioner of Patents said one hundred y ears ago, "to fi nd a new gem or jewel in the earth would [not] entitle the discoverer to patent all gems which should be subsequently found.[3] Similarly researchers who discover naturally occurring genes have no business claiming them as their intellectual property.

1 This is an argument for organism patent s that protect progeny , since otherwise we give genetic engineers an incentive to produce organisms which cannot self-replicate and self-replicating inventions seems a more desirable and efficient sort of invention. This may not matter from the purchaser's perspective, since in either case the additional copies of the organis m are not hers. Perhaps the best sy stem would be to give patent holders a limited right to the progeny of the patented organisms the y sell: purchasers could be given a compulsory license to create progeny from the patent organism they purchase and the patent holder would be given a fee for each offspring produced (som e percentage of the original purchase price). This may be feasible for animals, but is less likely to work with plants. See Thom pson, "Designing Animals: Ethical Issues for Genetic Engineers," for discussion of how genetic engineers of an imals may be able to des ign traits for animals that are not heritable. S ee Barton, "Patenting Life," p. 43, for the suggestion that unless genetic engineers of organism s get rights in the organisms' progeny, they will be reluctant to sell their organism, and will keep them and only "market Hie ultimate products."

^For arguments supporting the view that re spect for natural processes are even more important than respect for living individuals, see Holmes Rolston's *Environmental Ethics*, especially chapters 5 and 6.

^Bugos and Kevles, "Plants as Intellectual Property," p. 5.

Today's Patent Office, however, does consider genes and other genetic materials to be patentable subject matter.' Their position is that "a composition of m atter occurring in nature will not be considered patentable *unless* given a new form, quality, properties or com bination not present in the original article existing in nature." 2 According to one analy sis, this position corresponds to "a long-standing doctrine that the purified form of a chemical can be patented if the chemical is found in nature only in an unpurified form." 3 Since genetic material is only found in nature in an "impure form," that is, as part of organisms, those who isolate the genetic material have come up with something that does not exist in nature (and so is novel), and thus if useful and non-obvious, it is patentable.^

But isolating a piece of nature from the rest of nature is not invention (no matter how difficult it is). Nor should moving pieces of nature around count as invention. Though there is some inventiveness here, isolati ng a gene for straightness from one species of tree and placing it into another is more like moving spruce bud worms from one tree to another than it is like creating or inventing a tree. Even moving a half dozen pieces of nature around is not invention, though when we are talking about genetic material this will be extremely difficult to do. Until genetic engineering advances far beyond its current state, it is best understood as discovery and alteration, not invention. Hence a Lockean labor argument for patents—I created it and so it belongs to me—cannot be appropriately applied to the results of genetic engineering. ^

The Desert Argument, the Source of Value in Genetic Innovations, and the Social Character of Invention

I do not deny that there are important and morally relevant differences between the inventor of a genetically altered organism and other people who did not invent the organism.^ One important difference is that a person who labors and creates something deserves a reward for her effort s (assuming that the efforts are aimed at socially useful and not harm fill results). This desert argum ent is another of the traditi onal rationales used to justify property rights. ^ Can it successfully be used to justify intellectual property in genetically altered life forms?

That a genetic engineer deserves some reward for her labor does not imply that *what* she deserves are property rights in the object (or type of object) created. The created invention that makes a laborer deserving of a reward need not be identical with the reward deserved. On my view, what the laborer deserv es is a reward that is proportional to the degree of effort expended in invention, not a reward equal in value to that of what was created. Given the huge market potential for some of the results of genetic engineering, awarding a patent to the i nventor of a genetic innovation can give her far more of a reward than she deserves.

Consider the following example: A researcher discovers that a combination of two bacterial genes when placed in the inherited DNA of legumes allows them to grow with only 20% of the water they normally need. The value to human beings

---

^See OTA, "Patenting Life," p. 61, for a chart of the sorts of genetic engineering that can lead to patents.

^OTA, "Patenting Life," p. 93. See also p. 39.

^Barton, "Patenting Life," p. 42.

4I'or discussion, see Barton, "Patenting Life," pp. 42 and 43. Barton suggests that the PTO is unlikely to issue a patent for the use of a gene in a species in which it evolved naturally or in a species to which the gene can be trans ferred by normal breeding. Mark Sagoff s claim ("Patenting Transgenic Animals," p. 20) that the first plant utility patent by Hibbert involves a case where a patent was issued on the results of traditional breeding processes seems to contradict this latter claim.

^Property rights in genetics-related innovations may also violate a Lockean restri ction on property ownership. One of the so-called Lockean provisos is that an individual's original acquisition of material from the common stock is legitimate only if "there is enough and as good left in common for others" (Locke, *Second Treatise*, Chapter V, Section 27). A patent right to the use of particular genetic m aterial deprives all others of a similar ability to freely appropriate. Though there is other genetic m aterial that they could use for invention, that particular genetic material combined in that way for that human purpose is denied to them. Even those who come up with the same genetic innovation on th eir own (called "independent i nventors") are prohibited from using it. Patent grants constitute a significant and unfair loss of independent inventors, for they cannot even use their own inventions without licensing them from the patent holder.

6I have only argued that the difference is not that one person is naturally entitled to the living organism and the other is not.

^See Becker, *Property Rights*, p. 46-56.

of this characteristic would be enormous, as would the market potential of the genetically altered plants. A patent in this innovation could provide its maker with a reward vastly out of proportion to the effort she expended.[1]

Even if one insists that the value of the reward should be equal to the value of the invented product (instead of the effort expended), an idea that I think misconstrues the moral cate gory of desert, a patent in the altered plant variety would be grossly out of proportion. ^ Surely a laborer deserves (I would say is entitled to) only the value she adds to the world. Unless on uncritically accepts the labor theory of value (according to which human labor creates all value), one has to admit that much of the value to human agriculture of these new drought to lerant plant varieties originates in the genetic material removed from the two bacteria.

Genetic m aterial understood as accum ulated instructions for how organisms can successfully cope with their environments is a highly valuable natural good which evoluti onary processes have provided to the Earth' s inhabitants. Allowing engineers who discover and rearra nge rights to any such organism is le tting them capture value way beyond what their innovative activity added to the world. A botanist who objects to plant patents on these grounds puts it this way:

> Such legislation gives credence to breeders who can manipulate one or two genes of a traditional land race that evolved over thousands of y ears and then claim that som ething novel has been created...Few of the edible, nutritional characteristics of the seed plants that now sustain us evolved for our benefit, under selective pressure from our forebears or through conscious breeding by scientists. We are literally living off the fruits of other creatures' labors—those of the birds, bugs, and beasts that loosely coevolved with seed plants over the last hundred million years.[3]

There is undoubtedly value added by the innovative activity of biotechnicians, but it is small when compared to the value of the genetic material itself.

Additionally, a good deal of the value of these drought resistant legumes is attributable to the intellectual predecessors of the genetic engineer who developed it (e.g., Darwin and Mendel). Say ing that the genetic engineer is responsible for the entire value of the invention is like saying the last person to pitch in in lifting a car should get full credit for lifting it. Genetic engineering, like any other intellectual activity , is fundamenta lly social in character. Giving individuals patent rights to exclude the rest of society from the invention ignores the fundame ntally social character of invention. Of course the patent monopoly is not issued in perpetuity, but is limited to 17 years, after which anyone can freely appropriate it. This can be seen as an acknowledgment that the inventor is only partially responsible for the invention.

Holding Genetic Innovations as Trade Secrets and the Exchange for Secrecy Rationale

Trade secrets are another mechanism by which genetic engineers can obtain intellectual property in their innovations. Trade secrets are different from patent in that they only prohibit unauthorized disclosure of and access to the innovation; they do not prohibit others from making, using, or selling the innovation (as do patents). Trade secrets do not protect against independent invention. Nor would a trade secret on an organi sm be violated by reverse engineering or breeding that organism, as long as the organism was acquired in a legitim ate way (by some other means than theft of trade secret). Thus

---

1 There may be more effort involved in identify ing and mapping the location of genes than is involved in inserting a gene into an organism which results in new and useful characteristics. If so, then the first activity deserves more of a reward than does t he second, even though the second activity is more like invention than is the first.

^If one is going to distinguish between m oral claims of entitlement and those of desert (as I do), then one would say that a laborer is *entitled to* the value she created (even if s he expended negligible effort), not that s he *deserves* this value. If a y oung researcher lucks into a cure for cancer she may be entitled to the value of this cure, but she deserves less of a reward for he r efforts than do senior researchers who have spent their careers working to cure cancer.

^The quote is from Gary Nabham, *Enduring Seeds: Native American Agriculture and Wild Plant Conservation* (San Francisco: North Point Press, 1989), p. 6. Quoted in Bugos and Kevles, "Plants as Intellectual Property," p. 33, note 72.

using trade secret law to protect an engin eered organism when that organism self-replicates true to type is not possible if one sells instances of that organism.

Trade secrecy law is thus one reas on that plant breeders have focused their effort on developing hybrids that do not replicate true to ty pe[1] Apparently, reverse engineering a hy bridized organism to discover the nature of the parental stock is also not possible, and thus keeping their breeding techniques secret and selling hybridized seed is an effective way for plant breeders to protect their innovations without the protection of patents. Since reverse engin eering living organisms may be more difficult than reverse engineering of most any other type of innovation, when the self-replication problem is overcome, trade secrets probably afford organism innovations with greater protection than they do any other type of innovation.[2]

A major problem with trade secrecy from the perspective of the good of society is that this institution encourages non-disclosure of innovations. Such secrecy hinders the progress of science and technology which depends on the free flow of knowledge and information. Trade secrecy constraints prohibit scientists from publishing results pertaining to the innovations held as trade secrets.

Thus another traditional rationale fo r patents is the "exchange for secrecy rationale." Patents require enabling disclosure (that is, disclosure in such detail that a person skilled in the field could m ake the patented invention from a description of it available from the patent office). Hence one argument for patents is that they provide for public disclosure of the knowledge and technology behind innovations which would otherwise remain hidden through trade secrecy (perhaps in perpetuity, since unlike patents, protection for trade secrets is not of limited duration). In this way , patents appear preferable to trade secrets from society 's perspective. Thus one can argue that issuing patents to genetic innovators is justified as an exchange: for disclosing to society the knowledge involved in his innovation, the genetic engineer receives a lim ited monopoly to the innovation.

Assuming that there are strong reason for society to protect trade secrets in the first place, this exchange for secrecy rationale for patents has some plausibility.[3] It is not clear how effectively this argument can be applied to the justification of patents in biotechnology, however. According to some analy sts, the enabling disclosure requirement for biotechnology patents has been significantly relaxed and weakened.[4] Thus it is not clear that s ociety is getting sufficient disclosure of new knowledge to justify the granting of patent rights in exchange.

---

[1]Barton suggests ("Patenting Life," p. 40) that the lack of patents has encouraged hybridization and the use of trade secrets. It is my suspicion that development of hy brid plant varieties that do not breed true to type is a deliberate result of breeders who w ant to keep farmers coming back to them y ear after year to purchase seed. On the other hand, Gary Comstock has suggested to me that the biology of hy bridization is a m ore accurate explanation of this phenom enon: Breeding plants to put their energy into quick, vigorous, and large growth takes energy away from their reproductive systems, and thus makes it less likely their progeny will have the same useful characteristics.

[2] The formula for Coca Cola is the clas sic example of a trade s ecret. Why hasn't the formula been revers e engineered? Is it really that difficult to chemically analyze the composition of Coca Cola?

[3]In "Trade Secrets and the Justification of Intellectual Property: A Comment on Hettinger," *Philosophy and Public Affairs*, Vol. 20, No. 3 (Sum mer 1991), Ly nn Sharp Paine has persuasively argued that the justification for th e institution of trade secrets concerns protection of individual rights to confidentiality and the fostering of trust and fair dealing in business. They are not grounded, she claims, on protecting entitlements or deserts based on labor, nor on consid erations of social utility (justifications I had criticized in an earlier paper: see Hettinger, "Justifying Intellectual Property").

[4]In "Patenting Transgenic Animals," Sagoff argues that since biotechnicians cannot describe how to build their organism inventions (from sufficiently less compli cated materials?), they have no new knowledge. Also, in "Biotechnology , Plant Breeding, and Intellectual Property ," Buttel and Belsky argue that plant breeders can patent their hy brid seed (by simply depositing the seed with the patent office) while keeping the parental stock (the real genetic innovation) a trade secret.

The Consequentialist Incentive Argument

On my view, the ability to justify intellectual property, and hence the justifiability of patents in genetic innovations, turns on the question of whether creating and enforcing such property rights serves social goals better than do its alternatives. The previous section dealt with one such argument, the exchange for secrecy rationale. *

The major consequentialist argum ent for patents in the results of genetic engineering is that such property rights are necessary incentives for the production and use of a socially optimal level of genetic innovati ons. If we want oil degrading bacteria, drought, disease, and frost resistant crops, and leaner, cheaper pigs, then the best way to insure the development of these social goods as quickly as possible is to encourage genetically innovative activity by allowing the inventors to patent their innovations and to sell them in the market. Without such a return on their consid erable investment of time, energy, and money, the argument goes, individuals and businesses engaged in this creative work would not have adequate incentive to perform it. Why develop drought resistant plants when once one sells the plants to others, one has no protection against competitors breeding and selling the plants at a lower price which need not reflect development costs? Whenever the costs of research and development are relatively high while imitation costs are relatively low, this argument for patent protection will have some force. The idea is that over the long run we m aximize the widespread use and availability of high quality genetic innovations by allowing short term (17-year) restrictions on their use. Such restrictions, the argument claims, are the cheapest price society can pay to reap the fruits of such innovative activity. Although granting monopolies like patents may raise consumer prices in the short run, it will also stim ulate the developm ent of ne w products for consum ers in the future. Additionally, competition may be enhanced by stimulating the production of product substitutes, and once the patent expires, prices will come down.^

An alternative mechanism for developing and making available genetic innovations is to provide public funding for genetic research and engineering and to make freely available the results. This has the advantage of stimulating the innovative activity without granting any one a right to restrict its diffusion to others, as do grants of monopoly rights like patents. Another benefit of public funding and development is that the public can th en much more easily control what form the technology takes. This, I think, is especially important for socially , et hically, and environmentally significant technologies like genetic engineering.

The Federal government once was the primary source of ne w plant and animal varieties, but increasingly we are relying on proprietary incentives. Molecular biologists are movi ng from the university to industry, and where they are not, corporate money is flowing in, along with pressure to withhold research results . The openness and free flow of ideas so important to the development of knowledge is slowed by this atmosphere of safeguarding information in the hopes of making it proprietary 7 I or exam pie, commentators have argued that organism utility patents have slowed the free exchange of germplasm, plasmids, and cell lines. [4] Publication of scientific results is bei ng delayed until after patents are received, and

---

1 But if trade secrets are grounded on rights to confidentiality , then the exchange for secrecy rationale is a m ixture of social consequentialist considerations and individual rights-based concerns.

^See Barton, "Patenting Life," p. 41.

^ Such funding of universities by for-profit business threatens tr aditional norm s of open scientif ic inquiry and independent replication of results. Once the innovation is patented, the ideas involved are disclosed, since detailed descriptions of patents are available from the P atent Office. However, given that the "e nablement requirement" has been weakened for genetics -related innovation, the ideas may still be hidden even after a patent gran t. This clearly undermines the exchange for secrecy rationale for patents. See the previous section of the paper.

A.J. Lemin mentions a number of "threats to openness." He claims that most industrial organizations andm any academic institutions are working to protect their biotechnological research results. This leads to restraints on free exchange of plas mids and cell lines, delays in publication of pioneering work in order to allow time for filing patents, and the setting up of commercial biotechnology companies based on applicati ons of basic research paid for by th e federal government. See A.J. Lemin, "Patenting Microorganisms: Threats to Openness," in *Owning Scientific and Technical Information,* Weil and Snapper, eds., pp. 193-199.

[4]OTA, "Patenting Life," p. 87.

scientific results concerning biotec hnology innovations held as trade secrets are not being published at all. ^ The domain of biology, once a public domain, is increasingly becoming another domain of private property .[2]

I do not deny that there are drawbacks to public funding and dispersal of both theoretical and (especially) applied research. ^ For example, it has a tendency to narrow the diversity of those making decisions about appropriate directions for research and technological development. But I think it is not obvious that it is an inferior way to provide for technological innovation.^

Some will undoubtedly argue that the recent explosion in genetic innovations is due to the legal sy stem's finally allowing private property rights in these innovations. This is an empirical question about which the evidence speaks ambiguously.^ I think the reverse judgment is equally plausible, that the increase in proprietary protection is the result of the explosion in genetic innovations. With the advent of new methods of genetic engineering, the potential for significant social benefits from biotechnology has dram atically increased. Those involved, including corporate in terests, have successfully pushed for the extension of legal property right s so they can profit from this new technology *P* Far from stimulating innovation, allowing patents on biotechnology may actually stimulate companies to put more energy into patent development and defense than into new innovation. ^

Costs of Patents in Genetic Innovations

Arguing in favor of patents for the results of genetic engineering on the grounds that they are the best way to stimulate genetic innovations assumes that society will benefit from the increased profusion of biotechnical products. But som e environmentalists, ethicists, and analy sts of the farming business deny that bi otechnology is an unadulterated good. If the

1 Remember that utility patents have a very narrow research exemption, allowing use of the invention only for academic curiosity, and not for research that has commercial applications. Barton, "Patenting Life," p. 43.

^OTA, "Patenting Life," p. 87.

[3]Karen Burnett has suggested to me that a large portion of the costs of certain innovations (like drugs and, perhaps, biotechnology innovations) comes in the devel opment phase after patents have been issued. Companies, she argues, would not engage in development of a new drug unless they had received a patent for it. She spoke of "orphan drugs," drugs that have been discovered and could serve useful purposes but that are not being developed because ther e is little market for them. (But is this because of the lack of patent protection or sim ply because there are so few people with enough m oney to pay for the drug that it is not worth it to companies to develop it?) A related issue is that the government is now arguing that it needs to patent the results of government-funded research and then issue exclusive licenses to companies to deve lop and market the innovations, rather than release it for all to use freely. This latter approach apparently often leads to a situation where no one is willing to put the effort into development, since on ce developed and marketed, imitation is easy and can be done without pay ing those development costs. (Would not trademarks be a way of handling some of this?) If this is true, then or public funding to work, not only would we need government to fund basic research, but also the development of products.

4 One reason to think patents can hinder innovative activity in th e development of biotechnology is that the vast number of patents on a variety of genetics-related processes and products can inhibit companies who want to being a biotechnical product to market. Determining what patents one must license (and from whom) can be su ch a time consuming and difficult (and legally dangerous) morass that a business would do better to bring other sorts of products to market.

^Bugos and Kevles, in "Plants as Intellectual Property" (p. 24), claim that PVPA "increased rather than reduced the number of plant varieties available to the Am erican public." Barton, in "Patenting Life" (p. 40), claim s that "the em pirical evidence th at patents actually favor innovation is limited but moderately supportive."

^One example that illustrates this phenom enon involves Agrigenetics. This com pany received a patent on a cloning process for developing new plant hy brids that most in the industry claimed involved commonly -known techniques that had been used for a considerable tim e. Jack Kloppenburg argues that the reason its competitors in the genetic technology industry did not sue Agrigenetics was because they feared the bad publicity would hurt their efforts to extend the reach of property rights in biotechnology. See Kloppenburg' s "Appendix: Ag rigenetics and Agricu ltural Genetics," in *Owning Scientific and Technical Information,* Weil and Snapper, eds., pp. 132-140. The history of th e PPA is another case where patents are a response to aheady burgeoning innovation, rather than a necessary stimulus for it. See Bugos and Kevles, "P lants as Intellectual Property ," p. 6.

7*Business Week* reports a 52% increase in patent litigation in the 1980s. See "Legal Affairs," *Business Week,* December 2, 1991, p. 110. See my "A Patronage Sy stem as an Alternative to Intellectual Property in Com puter Software" (unpublished 1991 manuscript) for development of a similar argument with respect to patenting computer program innovations.

critics of biotechnology are right, then we m ay not want to indi scriminately stimulate this technology by granting broad and lucrative utility patents in genetic engineering.

Of course allowing patents in a particular ty pe of technology does not rule out regulator y control of that technology. ^ Issuing a patent in an innovation gives its owner a right to exclude others from using it, it does not give the owner any positive right to use it. Thus govemm ent regulation and cont rol of biotechnology can go hand in hand with patents in biotechnology.

Although this point is theoretically sound, it does not make practical sense. Allowing patents in a particular technology signals that society is in favor of that technology and that it wants to encourage its deve lopment. Allowing patents in biotechnology will foster sentim ents against regulating it. Co mmercial interests that have spent significant sum s both on developing patentable biotechnologies and securing patents on them will exert considerable pressure on the govemm ent not to regulate their patented innovations. Given the current backlash against environmental regulations on the grounds that they involve government "taking" private property without just compensation, regulation of patented biotechnologies could come under the same legal attack.

The European experience is instmctive on this point. The European Patent Conve ntion prohibits patents for inventions deemed "contrary to the public order or m orality" and it requires the patenting authority to do a cost-benefit analy sis before issuing a patent. The analy sis includes not only cost and benefits to humans, but al so "the suffering of animals and possible risks to the environment." ^ Biotechnical innovations should undergo some such moral scrutiny before they are issued in our country as well.

Costs to Non-human Organisms

Are there costs of biotechnology to the engineered organisms themselves that we ought to consider? A clear potential cost of biotechnology is increased animal suffering. What is life like for on oncomouse who has been constructed to develop cancer, or of the USDA engineered "Beltsville pig" who is "bowlegged, cross-eyed, arthritic, and barely able to stand up?"^

There are other dimensions bey ond the suffering issue. For example, do we want to encourage the development of creatures such as cows that are as big as small elephants and whose mammary glands give off milk twenty-four hours a day? Whether such anim als suffer is an im portant issue but by no means the only one. J. Baird Callicott has argued that the fundamental wrong of "factor farming" is not the suffering of the animal but the monstrous tr ansformation of living beings into am echanical-chemical-arti factual mode of exis tcncc.^ Note that this criticism of biotechnology applies not only to sentient animal life, but also to non-sentient animal and plan t life. Genetically engineered s quare, rock-hard tomatoes that ripen only when put in the microwave may deserve a similar reaction of aesthetic and moral repugnance.

Risks of Release of Genetically Engineered Organisms

Consider, for exam pie, the ris ks of large scale release of genetically engineered organisms into the environment. ^ To date there have been about 300 known releases none of which has led to known adverse consequences. ^ But consider a future in which thousands of such kinds of organisms are present in the environment. The worry is that natural systems may not have defenses and control mechanisms for geneti cally engineered organisms. Naturally evolved organisms are selected against if

lln "Designing Animals: Ethical Issues for Engineers," Paul Thompson makes the poi nt that if we think biotechnology is inappropriate then we should prohibit it outright, rather than simply prohibiting the patenting of it.

^Susan Mayer and Daniel Alexander, "Mice, Morals and the Environment," *New Scientist*, 23 November 1991, p. 12.

^Hart, "Mythical Monsters," p. 22. This article suggests we are creating anim als whose suffering will be transferred from generation to generation. For a euphemistic description of this pig see OTA, *Patenting Life*, p. 16.

[4]See J. Baird Callicott, "Animal Liberation: A Triangular Affair," *Environmental Ethics*, Vol. 2 (1980), pp. 311-338.

[5]See Jack Doyle's *Altered Elarvest* for a discussion of some of the risks.

they are too destructive and harm ful to their environments (since they depend on their environments). This natural check is not present for artificially created organis ms and s o there is a potential for m assive negative environm ental impacts from such organisms. The belief that we coul d control or contain whatever we have created is a kind technological blind faith. Imagine trying to control m icroorganisms that we ha ve released into m illions of acres of farm land.^ Just this y ear the Bush Administration rejected this argument clai ming that genetically engineered products are not inherently dangerous and thus need no special oversight from the Government. ^

It is often claimed that releasing genetically engineered organisms into the environment is no more dangerous than is the importation of exotic plants a nd animals into non-native ecosy sterns.^ But the m assive negative effects of exotics like Kudzu or Zebra Muscles makes this an argument for the opposite conclusion.^

Herbicide Tolerance and the Divergence between Private and Public Good

Consider further *the kind* of incentive patents give to the agribusiness industry. It has been estimated that up to 50% of the industry's resources spent on genetic engineering are aimed at producing *herbicide* res istant crops, rather than *disease* resistant crops. It should be no surprise that the highly vertically integrated agribusiness industry dominated by petroleum, chemical, and pharmaceutical multinational conglomerates would put most of its energies into genetically engineering crops to withstand the chemicals it sells.^

Biotechnology may thus undermine a laudable recent trend towa rd organic farming and further entrench the chem ical approach to agriculture. ^ More ecologically sound genetic engineering like creating nitrogen fixing cereals (that reduce the need for fertilizers) and other less profitable research such as developing stress resistant rice (mainly a third world crop) are frequently left to the public sector. Another drawback of patents is illuminated by the worry that fertilizer companies will buy up patents for genetically engineered nitrogen fixing crops and sit on them in order to protect their market for fertilizers. ^

Once patents are the means by which we stimulate genetic research, this research will serve the purpose of private gain whether or not this coincides with the public interest. ® At the very least we should not allow the patenting of genetic innovations when they are deemed to be contrary to the public good. 1

■^Hindmarsh, "The Flawed 'Sustainable' Promise of Genetic Engineering," p. 202.

^Consider genetically altered fish and the potential effects of their release into marine environments.

^The Bush Administration hopes to stimulate the $4 billion biotechnology industry with this change in policy. They expect it to grow to $50 billion by the end of the decade. See the articles by Philip Hilts in the *New York Times,* Tuesday, February 25, 1992, p. A1 and Friday, March 6,1992, p. A9.

^David Kline has suggested to me that the argument usually put forward is that releasing tr ansgenic organisms into the environment is no more risky than is releasing organisms that have been genetically altered in more traditional ways.

^Jeremy Rifkin, "Creating the Efficient Gene," p. 224.

6 Analogously, the pharmaceutical industry has greater incentives to produce new drugs patients can buy rather than better genes that would allow a patient's body to take care of itself.

^According to one critic of genetic engineering in agriculture: "Worldwide, more than 79 corporate/state research program s are developing over 23 herbicide-tolerant crop lines . ...These will further entrench the chem ical approach to agriculture, which in turn will further increase soil and water pollution, pest resistan ce and chemical residues in food. In the process, natural ecological process will be further distorted and the erosion of biodiversity accelerated." S ee Hindm arsh, "The F lawed 'Sustainable' Promise of Genetic Engineering," p. 198.

^According to Buttel and Belsky in "Biotechnology, Plant Breeding, and Intellectual Property ," seed companies are often subsidiaries of agrichemical companies. These m ultinational parent companies have large fertilizer, herbicide, insecticide and fungicide product lines that generally are far more important in terms of total revenue and profit than are seeds. Major benef its biotechnology can offer are the development of nitrogen-fixing vari eties and bacterial pesticides that are safer and cheaper th an synthetic organic chem icals. These biotechnical products would be fertilizer- and chem ical-displacing, and so m any agrichemical-based seed companies might be hesitant to em phasize plant breeding goals that would threaten their fertilizer and pesticide product lines. These ag richemical companies might buy up patents to prohibit the introduction of products that would undermine their current products.

®The development of hybrid plants that do not breed true to type is perhaps an example of this. The argument that if we do not

Distributive Justice

Many predict that the patenting of genetic innovations w ill further squeeze farm ers and increase the power of giant agribusiness conglomerates. ^ One critic suggested the farm er is on his wa y to becom ing "the tender of genes owned by someone else."^ That plant utility patents prohibit farmers from using seeds from the very crops that they have grown seems incredibly wasteful and is as absurd as if software companies insisted that a program they sell may only be used once. This is a significant restriction given that almost 50% of wheat and soybeans crops are grown from farmer saved seeds.^

Another unjust trend dependent on pate nting genetic innovations is the free co llection of genetic material from both wild and cultivated plants in third world countries. ^ This material is then genetically manipulated and patents are taken out on the results. The newly engineered organisms are then sold b ack to farmers in the third world countries from which they were originally obtained. A kind of "genetic imperialism," this practice instantiates th e view that all value is created in the recombination of genes, and that until this takes place, genetic material is worthless and thus free for everyone to take.^

Conclusion

Given these concerns about the legitim acy and social wis dom of patenting life form s, assimilating the results of bioengineering to traditional inventions by including them under the utility patent system is, in my mind, a bad idea. It hides the moral issues from us and helps us ignore the profound significance and effects of this new technology. It encourages us to think of living organisms, the fundamental instructions of living organisms, and even life itself as human inventions. It has us socially organize ourselves with respect to new living things as we do with respect to any other new gadget: we issue a patent.^

Genetic engineering has dim ensions and effects far m ore profound than other recent technologies that our traditional intellectual property institutions have been stretched to cover. W e may be able to extend these institutions to include new computer technologies by allowing the patenting of algorithms or the copy righting of the "look and feel" of computer programs. But doing the same for the results of the biotechnology revolution is a far more serious step. For one thing, the sector affected, namely the farming community, is an established way of life and not a new business in which the players are just emerging and where we can create the social and institu tional structures from scratch. How we shape the property

---

allow patents in biotechnologies then businesses will simply go the trade secret route (which is worse because of non-disclosure) illustrates the problems one gets into once private incentives are used to stimulate certain activities.

1 Incredibly, there has even been public funding for such research. If one assumes, as I do, that we as a society should move away from a chemically-based agriculture toward a more organic and "natural" style of fanning, such funding should cease.

2 Even the seed companies are worried. S ee OTA, *Patenting Life*, p. 11. But see Barton, "Patenti ng Life," p. 41, who says that farmers gets three quarters of the economic benefits of improved seeds (assuming they can afford the costs of buying them).

3 Jack Doyle, "A Warning Voice." According to Hart, "Mythical Monsters," farmers are in the forefront of efforts to stop animal patents as they fear being driven out of business if forced to pay royalties on offspring of genetically altered livestock.

^See OTA, *Patenting Life*, p. 79, and Buttel and Belsky , "Biotechnology, Plant Breeding, and Intellectual Property ," p. 122. Barton, "Patenting Life," p. 43, say s that it is unim aginable that sellers of seeds will insist on this. Prohibiting farm ers from going into business selling the seed (as did the PVPA) is one thi ng; preventing them from using th e seed in their own fields is quite different.

^See Barton, "Patenting Life," p. 41. It is the "over-developed" world and especially the U.S. that is pushing for intellectual property in biotechnology. (In fact, this was the reason Presiden t Bush gave for refusing to sign the Biodiversity Treaty at the June 1992 Earth Summit). The developing world is far more skeptical. This makes me th ink it is in part a rich/poor issue. It is one more way for wealthy countries and i ndividuals to benefit at the expense of less fortunate ones. Another reason for suspicion is that the consequentialist incentive argument for patents is a kind of trickle-down economic theory.

^See Kloppenburg, "No Hunting!" Barton, "P atenting Life," gives arguments for alio wing such poaching. He cites the high costs of identifying, cloning and sequencing natural genes and of inserting them into organisms used for commercial purposes in contrast to the low imitation costs.

^Here I am disagreeing with the OTA report's claim that it is "unclear patents per se substantially redirect the way society relates to animals." See OTA, "Patenting Life," p. 18.

institutions that define the agricultural sector will have a dram atic effect on Am erican farmers and peasants throughout the world. Since it is the institution which supplies hum an nourishment, agriculture is probably the m ost significant practical way that we relate to the land. How we de fine, conceptualize, and structure our relationship to the land is therefore of central moral and practical significance.

Technology is a lens through which we see the world and biotechnology (both traditional and new) has the power to change our understanding of ourselves, of the natural world, and of our place in it. It is not simply another type of mechanical or chemical creation aimed at making the world better for us. In this instance, we are not s imply reshaping matter, but are harnessing life. * By manipulating life and natural evolution, we are taki ng the process that shaped our existence and that of every other living organism on the planet and restructuring it for our own benefit.

I am not arguing that we should cease res earch into or use of genetic technologies , or that there is no need to think about a balance between private incentives and public funding for genetic engineering. 2 But it does us a great disservice to assimilate how we understand a nd relate to such a significant technology to the legal approach with which we understand invented mechanical devices or chemical compounds. Doing so shields us from the social, ethical, and environmental issues involved. It is a manifestation of human arrogance and shows disrespect for the lie processes from which we originated. We ought not to treat genetically altered living organisms and materials as simply another class of hum an inventions patentable under the same rules and justifications as any other.^

^Some say "life is chemistry" and the P atent Office clas sifies organisms as "compositions of ma tter" and "manufacturers." Is this reductionist mindframe compatible with a healthy respect for life?

^One alternative to consider is a bounty sy stem whereby gove mment purchases and makes publicly available the most significant biotechnologies.

[3]I thank Karen Burnett, Gary Comstock, and David Kline for valu able comments on a draft of this paper. I also benefited greatly from discussions with the participants and audience at a Symposium on the Ethics of Patenting Transgenic Organisms held at Texas A& M University, where I presented this paper.

Concepts of Property and the Biotechnology Debate

PaulB. Thompson
Professor, Department of Philosophy, Humanities and Agricultural Economics
Director, Center for Biotechnology Policy and Ethics
Texas A&M University
College Station, TX 77843-4355

The goal of this paper is to outline som e of the philosophical approaches to the theory of property. Each section of this paper will sketch some possible applications to products and processes of recombinant DNA transfer. These comments and applications must be regarded as speculative; it is far from clear how ethical norms should be applied in assessing biotechnology property claim s. Com ments on a pplications should be interpreted as illustrative of theory , rather than as action-guiding. The overall thesis is that we are far from a clear understanding of how property rights *might* be defended for biotechnology, much less how they *should* be.

Framing the Ethical Question of Property Rights

The discussion of patent law has dominat ed the discussion of property claims fo r biotechnology. Philosophical analy sis of property claims in biotechnology has becom e entangled with questions about filing requirem ents, tests for efficacy, and the rules for licensing and defending patents. While patents may turn out to be the best legal instrument for protecting legitimate property claims in biotechnology, exclusive focus upon the patentability of organism s begs se veral philosophical questions that deserve attention.

It is therefore useful to imagine how property claims upon genetically altered organi sms might be recognized and defended without patent protection at all. It may be possible, for example, for a company to engineer sterility into a valuable organism, or short of that, inheritance characteristics that protect valuable genetic tr aits in the way that hy brid vigor protects com varieties marketed by major seed companies. While such a strategy would not protect th ese traits from reverse genetic engineering by other biotech companies, it is possible that the m arket structure could produce corporate norms whereby competitors simply refrain from such actions. Such a situation would confer an effective property right on the genome, but it is still relevant to ask whether a company would be ethically justified in protecting the genome this way.

It is also possible (perhaps even likely) that a company might prefer to retain control over an engineered microbe, plant or animal by refusing to patent or release the organism at all. S uch a strategy is most likely for organisms that are us eful in manufacturing processes. They may wind up being legally protected as trade secrets. The lim it case for illustrating non-patent property rights is a society in which there are robustly shared moral norms for claiming and respecting property rights, so much so that legal protection is unnecessary. While this limit case is far from our own society, it illustrates a situation in which patent law does not exist, but where property claims still do. In each of these cases it is still releva nt to ask whether property claims are ethically justifiable. However unlikely such non-patent forms of intellectual property might be, it is stil 1 useful to bear them in mind as prerequisites to framing ethical questions about property.

The ethical questions to be asked are of two kinds:

1) What sorts of things can become property, or, more simply, what is property?

2) How are assignments of ownership to be made?

Although some approaches to property make it difficult to keep these questions separate, they are separated here because the analy sis that follows is intended to concentrate on the firs t ques tion, giving only incidental attention to the second. Separating the questions also he lps illustrate how the first question m ay or may not be a norm alive one. The matter of what can and cannot be property might simply be a matter of fact, determined by empirically observable characteristics of the good in question. The same question can also be asked in a purely normative vein: what sorts of things is it moral, ethical or otherwise legitim ate to regard as property ? Hum an beings, for exam pie, clearly have been held as chattel property throughout history. One strategy for opposing slavery is to argue that they should not have been. This argument interprets the question of property status normatively . Another strategy is to adm it that human beings can be property , but to argue that ownership rights must be assigned reflexively, and that they are not transferable. This strategy accepts a positivist answer to the first question, and opposes slavery through its answer to the second.

These alternative approaches to the property status of human beings suggest two final observations for framing the ethics of property claim s. F irst, the conceptual res ources av ailable for analy zing any sort of property claims have been influenced greatly by the question of hum an slavery. It will pr ove helpful to revisit this them e in what follows. Second, the ownership of human beings has not been thought to have m uch to do with patentability . Indeed, the Fourteenth Amendment has been interpreted to exclude human beings from otherwise applicable aspects of pa tent law. There are, thus , historically important ethical considerations regard ing property rights that are not only independent from patent arguments, but which establish ethical constraints upon patent law. A hasty discussion of biotechnology property rights in terms of patent provision may lead us to overlook such issues.

Theories of Property

This section will sketch three broad philo sophical theories of property . They are offered as distinct, but not mutually exclusive approaches. The next section w ill demonstrate how Locke's theory of prope rty combines all three. The first is a *natural* theory of property, one which defends the claims that na tural facts determine what is property and who owns what. The second approach is in fact a broad class of theories that understand property as a social construction validated in terms of its *instrumental* capacity to produce or s ecure other ethical goals. The third approach is a *labor* theory that grounds property claims in productive activity.

1) *Natural Theory.* It is possible to believe that certain things are naturally fit to become property, while others are not. The idea that property is a component of natural law has been in fluential in European history . Such a behef is particularly plausible when one's concept of nature includes a benevolent, but also judgmental God, who has designed the fixtures of the earthly realm s in accordance with His plan. Given s uch a theo logy, a natural theory of property becom es an attem pt to ascertain God's intentions. Used to defend the divine right of kings to domain over lands and people, such a theory may depend as much upon theology as upon what we recognize as natural facts in the twentieth century.

Although, frankly, it is difficult to imagine a thoroughly natural theory of property in a postmodern world, a few themes from natural theory continue to be plausible, and potentially influential. The first is that it is certain characteristics of goods that determine their stat us as items of property . *Rivalness,* for example, refers to whether it is possible for more than one person to use or consume the good without diminishing th e amount of good available for ot hers. Goods such as canned food and clean water are rival; goods such as street lighting and national defense are nonrival. A second natural characteristic is how easy it is to exclude others from using or consuming a good. Canned foods are relatively *excludable* in that one may lock them up, preventing their appropriation and use by others. By contrast, it may be fairly difficult to exclude people from access to clean water or street lighting. Natural facts about excludability and riva lness thus provide one way to decide whether or not something can be claimed as property. Goods which are naturally rival and excludable are easily defensible as items of property. The two traits leave considerable grey area where the relative rivalness and excludability of goods do not provide the basis for a secure judgment.

In such cases, a different elem ent of natural property theory may emerge. It is one which treats all of nature as a heritage to be s hared equally by all human beings. Such a principle for deciding property claims would accept that highly rival and excludable goods are "fit" to become property , but would decide the grey cases in favor of a non-property or common-property determination. Works of pur e artifice might also be understood as pr operty, but works of nature would be though held in common by all persons. Justice Burger's majority opinion for the U.S. Supreme Court decision in *Diamond* vs. *Chakrabarty* appeals to such a view im plicitly, holding that Chakraba rty deserved a patent for his bacterium because it was his own handiwork, and not "a manifestation of nature, free to all men and reserved exclusively to none."

2) *Instrumentation theories.* In contrast to philosophies that see property as a natural kind, it is far more common today to see it as a social construction, as an institution or form of social rule that is validated to the ex tent that it is useful to produce some more fundamental kind of good. There are severa 1 ty pes of goods that property rights might be thought to produce. One is liberty . A second is social utility or value. The third is social stability. Social stability most likely would be produced if recognition of property claims were necessary in order to resolve disputes or social conflicts, but such disputes and conflicts would m ost likely arise only when individuals felt them selves to have legitim ate property claim s for other reasons. As such, it seems reasonable to omit further discussion of stability arguments in the present context.

Property rights might be inst ruments for protecting civil liberties to the ex tent that freedom of action, freedom of expression and freedom of exchange depend upon the institution of property rights for their effective exercise. One may feel constrained in one's ability to produce or enjoy some goods if one cannot be assured som e degree of control over their use. Many liberties depend upon one' s ability to have certain goods at one's disposal, and if the protection of such liberties is thought to be a valid social norm, then recognition of such property rights will follow.

Utility- or value-based views are far m ore predominant in discussion of biotechnology. Here, the idea is that property rights are justified because they facilitate the creation and allocation of valued goods in society. The idea that property claims are justified when they create incentives for innovation, incentives that would otherwise be lacking, is an example of utility- or value-based reasoning. Biotechnology and intellectual property often are discussed exclusively in terms of a utility- or value-based approach.

3) *Labor theory.* A labor theory of property holds that a person' s productive work is the basis for a property claim. People are entitled to claim what they make or create as their own. The mere act of discovery does not establish a property claim, but the appropriation of the disc overed good to some further purpose does imply some element of labor. As long as previous property claims upon the appropriated good are discharged fairly, a person's transformation of the appropriated good to some useful purpose establishes a property claim.

Note that a labor theory of property is not a labor theory of value. Claiming that some thing is ownable (and, indeed, owned) by virtue of the labor invested in its appropriation, creation, manufacture or devel opment entails nothing about its value. If value is determined by exchange, it is clearly possible to invest substantial amounts of labor into items which are o f no value whatsoever. A labor theory of property would nevert heless support the claim that such valueless items are the property of their manufacture irrespective of whether they have exchange value or social utility.

Locke's Theory of Property

Although one might offer a philosophically "pure" theory of property based on any one of these approaches, John Locke's paradigm-setting account of property in the *Second Treatise of Government* attains a great deal of its intellectual force in the way it combines elements from all three. Each type of strategy for establishing and assigning property rights appears in Chapter 5, "Of Property." Each type of strategy might be expected to produce very different answers to the two noted above. Locke, however, unites the strategies into a single theory. Although he relies upon economic arguments that are not plausible to contemporary readers, the philosophical subtlety of Locke's achievements should not be underestimated. Undone by its economic assumptions, the ragged strands of Locke's unraveled argument present us with confusing and contradictory alternatives to the property questions of today.

The natural themes in Locke's account of property are stated explicitly, and are, indeed, a framing assumption for the entire corpus of Locke's political thought. Chapter 5 begins with a reassertion of the claim that reason and revelation converge upon the conclusion that the earth has been given to mankind in common. The passage might be read as establishing the origins of property in God's grace to mankind. Since Locke has expressed, in the *First Treatise*, opposition to arguments which establish a monarch's claim upon servants and property through a similar act of God, he is compelled to conclude that God's grace confers a natural right of property to the earth upon all men in common. This interpretation of Locke validates the basis of property claims in terms of natural rights, which, in Locke's view, are conferred by God, but apparent to all who posses reason. It poses a problem, however, in that "...it seems to some a very great difficulty, how any one should ever come to have a *property* in any thing" (Locke, p. 18). Thus, while natural rights establish the metaphysical basis of property, they do not transparently establish the basis for property claims by individuals, as opposed to property held in common by all.

Locke supports two arguments for resolving this difficulty, introducing each in the passages immediately following his opening statement of the difficulty . The firs t is an ins trumental argument: "God, who hath given the world to men in common, hath also given them reason to make use of it to the best advantage of life, and convenience" (Locke, p. 18). The passage may be read as suggesting that r eason will lead us to an interpretation of property that is consistent with, perhaps even shaped by, our mutual desire to obtain advantages a nd conveniences. Individual property rights will, thus, be assigned insofar as they facilitate this end. The second argument follows in the very next paragraph:

> Though the earth, and all inferior creatures, be common to all men, y et every man has a *property* in his own *person.* this no body has any right to but himself. The *labor* of his body and the *work* of his hands, we may say, are properly his. Whatsoever then he removes out of the state that nature hath provided, and left it in, he hath mixed his *labor* with and joined to it something that is his own, and thereby makes it his *property* (Locke, p. 19).

In this passage, Locke rather explicitly introduces the labor strategy. Subsequent passages in the chapter provide m ore evidence for interpreting each of the two strategies.

Locke develops the labor strategy extensively before re turning to the instrum ental them e. his oft cited exam pie concerns the basis for claiming ownership in acorns or apples, picked up or gathered from nature' s bounty. He concludes "...that it is the taking of any part of what is in common, and removing it out of the state nature leaves it in, which *begins the property,"* (Locke, p. 19) and, "The *labor* that was mine, removing them out of that common state they were in, hath *fixed my property* in them " (Locke, p. 20). The argum ent here should be read against a background problem that does not receive explicit treatment in Chapter 5. Locke's case for opposing (or limiting) human slavery is based on the assumption that human beings are owned reflexively. This assumption has two important consequences for his political philosophy. One is that a just conqueror indeed gains absolute power over the lives of those who opposed him; that is, they become his slaves. Those who unjustly place themselves in a state of war against others place their initial right of ownership in their own persons at risk by doing so. An ethically defensible state of s lavery arises when these reflexive property rights are held forfeited following defeat by conquerors acting in a just cause (Locke, p. 45, *also* pp. 93-94).

The second consequence is that labor becomes a basis for claiming property in goods external to the person. Locke's concept of the person quite plausibly assumes that self-ownership entails ownership of one's own labor. Indeed, the strategy of reflexive assignment for human propert y rights provides no argument against slav ery without this assumption. A human being as signed to forced labor is effectively a s lave, even if the legal apparatus of property is absent. The forced appropriation of one person's labor by another is morally equivalent to slavery . if the product of any person's labor may be appropriated unilaterally without consent, such a person is hardly in a position of controlling own labor in a m anner consistent with the principle of reflexive property rights in the human person. Thus, one person may not claim property in the product of another' s labor without obtaining free and willing c onsent. In this argum ent, individual liberties becom e a consequence of the labor theory of property. It may now seem more plausible to assign liber ties a more fundamental ethical status, and to define property rights as means for protecting liberties . (*See* Paine.) While civil liberties are clearly included among Locke's natural rights, the reflexive assignment of pr operty in the human person is not offered as a means for protecting liberty, but as a philosophically independent argument entailing civil liberty rights on entirely separate grounds.

Locke's reflexive assignment of property in the human person entails a labor theory of property, but Locke was aware that such a theory was open to objections. The most serious wea kness is an apparent im plication that fairly trivial acts of labor could establish trivial property rights over a broad ra nge of goods. Locke describes two constraints upon the labor theory. One is that an appropriation of some good from its natural state is legitimate so long as "there was still enough, and as good left," (Locke, 21) for others. This constraint has come to be called the *Lockean proviso.* Another constraint, however, stipulates a principle based upon use: "As much as any one can make use of to any advantage of life before it spoils, so much he may by his labor fix a property in: whatever is bey ond this, is more than his share, and be longs to others" (Locke, pp. 20-21). In this passage, the instrumental stra tegy emerges. Arguments which justify property claims in terms of the us e value they create become extremely important in the closing passages of Chapter 5. Here, Locke confronts the fact that the creation of money allows one to circumvent th e problem of spoilage, and to plausibl y claim some use or advantage for the accumulation of property without limit. The argument becomes explicitly instrumental in a passage where Locke provides a justification for the enclosure of lands that sent many rural citizens to the cities, looking for opportunities to sell their labor:

> He who appropriates land to himself by this labor, does not lessen, but increases the common stock of mankind: for the provisions serving to the support of human life, produced by one acre of enclosed and cultivated land are.. .ten times more than those which are y ielded by an acre of land of an equal richness ly ing waste in common. And theref ore, he that enclos es land, and has a greater plenty of the conveniences of hfe from ten acres, than he could have from an hundred left to nature, may truly be said to give ninety acres to mankind: for his labor now supplies him with provisions out of ten acres, which were but the product of an hundred lying in common (Locke, pp. 23-24).

This passage rather explicitly stipulates a principle of social utility whereby property claim s are justified as an institution for optim izing (or increasing) the total am ount of valued goods, or, in Locke' s phrase, the com mon stock of mankind.

Chapter 5 can thus be seen to propose the following burden of proof for establishing a philosophical basis for property rights:

1) At first, a natural criterion for identifying and assigning property confers the status of property upon the entirety of nature, but assigns the ownership of nature to all in common, with a single exception.
2) The single exception is that property in the human person is assigned reflexivel y and is forfeited only under conditions of just conquest over those who have initiated an unprovoked declaration of war.
3) This establishes a labor criterion of property , whereby individuals may claim property in all goods they appropriate from the state of nature through the work of their hands.
4) Property claims established on the basis of this labor criterion are constrained by the Lockean proviso, and by a doctrine limiting acquisition to amounts wh ich can be used. The latter constr aint introduces an instrumental criterion for property rights.
5) Finally, when institutions such as m oney or enclosure increase the potential fo r use to the point that increases in productivity make up for whatever value would be lost by creating the institutions, the Lockean proviso is satisfied by the increased value. Hence the property claims created by the institutions are justified.

Locke's intricate interweaving of natural, labor and instrumental criteria provides a theory of property in which burdens of proof shift back and forth among each. The inclusion of reflexive rights in the human person makes the natural component of the theory an im portant safeguard against slavery and infri ngements of liberty , and it also lay s the basis for the labor criterion as a test which m ust be met if the presumption in favor of common ownership is to be reversed. The instrumental criterion places an important check on labor arguments, but as developed so far is ambiguous.

As stated above, the instrumental criterion might be applied across the board to all goods, including both the common stock of nature an goods already appropriated from nature thr ough the labor of others. That is, there m ight be institutions which would increase social utility, even if no labor has gone into the productive activity that establishes the property right. Locke's examples are of acquisition through labor, but bey ond the capacity for use. There m ight also be cases of acquisition by fiat which would also withstand the productivity test. Furthermore, it may be quite possible for one person to create more social utility by appropriating the property of another. As such, if the instrum ental criterion is taken to supersede the four preceding tests in this theory of property, both natural and labor claims will turn out to be vacuous.

Locke might have responded to this problem by stipulating that instrumental criteria can be applied only in those cases where the previous tests have already been met. Instead, the balance of Chapter 5 undertakes a complicated and unconvincing metaphysical argument. It is at this point that the labor theory of value is introduced in a passage that begins,

> To make this a little clearer, let us but trace som e of the ordinary provision of life, through their several progresses, before they come to our use, and see how much they receive of their *value from human industry. ...labor makes the far greatest part of the value* of things we enjoy in the world. ...[L]and that is left wholly to nature...is called, as indeed it is, *waste'*, and we shall find the benefit of it amount to little more than nothing (Locke, 26).

Locke goes on to argue that money economies arise through mutual agreement as a mean s for preserving the labor value of perishable goods, increasing the common stock of provi sions for mankind. The labor theory of value, of course, receives extensive development at the hands of Adam Smith, who seems to be following Locke's sentiments when he argues that exchange value and social utility are reflections or m anifestations of the underly ing labor value of manufactured goods. If this view were true, it would turn out that the labor cr iterion for property would converge upon the same institutions as the instrumental criterion, and that they would, indeed, do so in virtue of a natural feature of production and exchange. Such a result fuses the three strands represented by natural, labor and ins trumental criteria into a single cord, unified by metaphysical necessity.

The conceptual elegance of this result may explain part of its attraction to Locke and Sm ith. Furthermore, the labor theory of value might be interpreted as a normative theory of exchange value, rather than as a positive or metaphysical theory of values that actually are being exchanged. Such an interpre tation would allow a critique of property institutions that create effective distributions of property at odds with the dist ributions that return value based upon on individual' s labor contribution to the m anufacturing process. The possibility of so combining libertarian and Marxist them es is intriguing, but diverts the current argument from its central theme. The more typical response among contemporary theorists has been to dismiss all passages in Locke that refer to labor criteria on the grounds that the labor theory of value has been discredited i n contemporary economic theory . Hettinger (1989) does this in whittling Locke's three-stranded approach down to a single instrumental one, which Hettinger interprets in utilitarian term s. This response to Locke confla tes the labor theory of value with the labor theory of property , and begs the question ag ainst both natural and labor criteria for legitim ating property claims. A m ore accurate conclus ion is that the unity of Lock e's theory has indeed com e unraveled, leaving contem porary theorists with three criteria that establish rather different and relatively incompatible burdens of proof.

Property Claims and Biotechnology

This final section will examine how each of the now divergent threads of Lockean property theory point in different, though not necessarily contradictory, directions when applied to questions in biotechnology . One reason why it is difficult to say anything very definitive about property rights for biotechnology is that each of the thr ee criteria at work in Locke's theory is now subject to form s of interpretation that differ substantially from those of the late seventeenth century . Another reason, however is that the products and processes of biotechnology are them selves very different. Until recently , discussion has focused upon genetically altered organisms, with considerably more interest in animals than plants. A new controversy has emerged over NIH filing of patent claim s on various and sundry fragments of genetic code. While some have criticized this action, it should be noted that the act of filing allows the deci sion on patentability to be made by experts at the patent office and in the courts, while the act of not filing effectively makes the decision on the basis of the relatively less inform ed judgment of NIH scientists. Criticism of NIH should probably be tern pered. However, the storm of criticism undoubtedly reflects a widespread judgment on the part of the scientific community that the sequences under consideration should be understood as discoveries, rather than as inventions. Again, without imply ing anything about technical questions of patentability under existing law, it will be illustrative to consider how each of three sets of criteria might be applied both to whole organisms and to fragments of genetic code.

Natural criteria for property survive into the present in a form significantly altered from their application in Locke's theory. In the firs t ins tance, the theological warrant for property has all but vanished, with theological arguments being offered most commonly to limit the application of property claims. Thus, the new strategy is to reverse Locke's original judgment that all things, including human beings, are property, and to make the normative argument that some things should not be considered to be property at a 11. It goes without say ing that hum an beings will be the paradigm example of a non-property good. From this starting point, at least two rather diffe rent strategies for applying natural criteria are available. One stresses analogy to the human case, the other stresses natural facts about goods that arise in connection with their use by humans.

One way to arrive at the conclusion that hum an beings cannot legitimately be understood as property, even as property reflexively owned, is to argue that the c oncept of property implies a status of subser vience that is inconsistent with certain natural facts about human beings, to wit, that humans are free and autonomous agents , acting in pursuit of rationally chosen interests. Regarding oneself as one's own property might, on such a view, be self-contradictory, since one would be seeing the potential use or sale of oneself as a potential means for realizing those interests. The Kantian spirit of such an argum ent should be evident, and the details need not concern us here. While one might still be able to exchange labor for other goods on a Kantian view, the autonomous agent that is at the core of the Kantian person could not, with moral justification, be owned, by self or other. Recent attem pts to extend this notion of personhood to non-human animals entail that ownership of any subject of a life, to use the phrase favored by Tom Re gan, cannot be justified on ethical grounds. This view, which provides the basis for a radical critique of chattel property rights, would pres umably extend to any transgenic animals that also possess the requisite moral characteristics.

This argum ent from analogy to the metaphysical status of the human person may prove far too much to be very influential in assigning property rights for products of biotechno logy .It may well provide some motivation for vague or underspecified feelings that it is morally wrong to own living things, but so long as the organisms in question are unarguably not human, the analogy will be persuasive only to those few who are willing to abandon the cons iderable existing edifice of institutions establishing property rights in non-hum an organism s. If taken seriously , the criterion suggests science fiction scenarios, where autonomy is engineered out of organisms as a way to establish ownership rights in a species of drone zombie organism s which can be treated legitim ately as slaves . Furtherm ore, the Kantian view applies m ost clearly to individual organisms, not to their genom es. If the Kantian view proves any thing, it proves that individual human beings cannot ethically be classified as property. The genome of an individual human being, however, fully sequenced and sitting on a magnetic data base, is not an autonomous, Kantian moral agent. As such, while this view might remove individual animals, human or other, from property status, it may not protect even the full human genome, much less fragments of genetic code.

An interpretation of natural property criteria that stresses properties of rivaln ess and excludability presents far more applicable norms for biotechnology. On this view, the property rights would be recognized to the extent that natural features of excludability and rivalness are present. Such a view favors chattel property rights, or owne rship of a specific individual, but provides strong grounds for rejecting a 11 intellectual property rights. Biotechnology might even be used to engineer rivalness and excludability into certain organisms, by introducing and eliminating traits that affect reproduction, or uses tha t deviate from intended purposes. One might, for example, increase the rivalness of a hen that lay s golden eggs by engineering traits that would preclude her use as fried chicken. Such strategies would not, however, protect others from reverse engineering any organism s they legitim ately could acquire. Ownership would be limited to that which one could easily control in virtue of its physical characteristics, and property rights would primarily protect against common forms of theft.

While such a view is also very much at odds with many current practices, it is nonetheless the currently viable core of Locke's use of natural criteria. In Locke' s theory, natural criteria establish universal co mmon property rights in all goods. Although Locke's discussion of natural rights is theological, his references to the natural state of goods imply what we would regard as a naturalistic account of m aterial goods for whic h rivalness and excludability are obvious characteristics. In stipulating that all such goods are held in common, Locke stipulates a burden of pr oof that is biased far more radically against individual property claims than one which resolves such claims relative to the natural excludability and rivalness of the good in question. A natural property criterion is plausible to the extent that it is assumed to establish a heavy burden of proof against property status for non-excludable, non-rival goods. To say this is not to say that such a burden of proof can never be met. As in Locke's in own theory , labor or instrument al criteria may be advanced to meet it. If the natural criteria are to be meaningful at all, however, there must be some weight to the test that labor or instrumental criteria are expected to meet.

It is, in fact, labor criteria that es tablish the strongest and most plausible claim for property rights in biotechnology . There can be no deny ing that transgenic organisms and even fragm ents of code become available to us as a result of a great deal of labor. This labor is both intellectual and phy sical, though perhaps not as onerous as that involved in clearing and improving land. If labor establishes a claim upon a parcel of land, it should also establish a claim upon the fruits of biotechnology research. There is, however, one potential qualification. Locke' s examples of labor establishing a property claim are restricted to productive activities such as clearing land or gathering apples. These are activities directed rather immediately to processes of production and consumption. It is less clear that discovery, particularly intellectual discovery , involves labor exerted in the form that has traditionally been taken to establish a property right. If it is possible to argue that discovery does not involve labor in the rele vant sense, it is likely that the transgenic organism will be defensible as property, while the fragment of code will not.

The distinction between production and discovery can be developed by combining the labor criterion with the natural criterion implied by excludability. Once a physical object such as a farm, a bag of apples, an automobile, or words on a page, has been created, it is vulnerable to appropriation by persons other than those whose labor created it. If labor indeed originates the property claim, then appropriation without cons ent violates a property right. Ideas and discoveries are, in themselves, immaterial, and prior to pubh cation, invulnerable to appropriation by others. While we think of intellectual products as non-rival and non-excludable, knowledge and other purely intellectual goods are potentially the most excludable goods of all, capable of being carried to one's grave without others even suspecting their existence. We do not need legal property rights to protect the labor which went into the cr eation of knowledge and ideas, though the papers, notes or data used in the process of discovery would certainly be persona 1 property in virtue of the phy sical work of writing, and vulnerable to appropriation by others. None of this, however, says anything about how we should regard the act of publishing what one knows, suspects, or otherwise thinks. The labor theory would entail that a scientist may not be compelled to publish against her will, but it need not entail that society must allow her opportunities to publish under whatever terms she demands.

The labor theory thus has a seam with regard to intellectual property. While the intellectual laborer is as entitled to own the immediate fruits of his or her labor as any other, this entitlement does not establish the term s on which publication will take place. In a totally laissez-faire system, such terms would presumably be negotiated between the intellectual laborer and others desiring the intellectual good. The intellectual labor er knows that upon publication, the intellectual good is both non-rival and non-excludable, hence he or she may negotiate a system of rights or licenses with every person in the society who is likely to use the good prior to publication. People in the society are likely to agree to such te rms, since such an agreement may be the only way that they will get to use the good at a 11. They will not, however, agree to rights and licenses over knowledge that is easily obtained. One might pay for knowledge about a short cut to the airport, but it is unlikely that everyone in society would be willing to recognize any individual's exclusive right to such knowledge. Judgm ents about the novelty of the relevant knowledge will therefore becom e part of the negotiations. Such negotiations are likely to prove time consuming and expensive, however, and one can eas ily im agine how a s ystem much like patent law would arise to standardize the problem of assigning ri ghts and licenses. The procedure solves the problem of missing criteria for publication, and would provide the intellectual laborer the option of seeking protection, or of publication with such future rights.

At this juncture, it is im portant to stress that instrum ental or utilitarian considerations have not been introduced at all. A utilitarian interpretation of instrum ental property criteria w ould justify the recognition of a property claim just in case recognizing the claim optimizes the creation of social value. Hettinger (1989) has done a fine job of laying out a framework for analyzing an intellectual property claim's ability to produce benefits and costs to society as a whole. Some more general points are worth noting, however. As a unilateral theory of property, utilitarian criteria provide no basis for distinguishing between production and discovery, hence organisms and fragments of code will presumably both be evaluated in terms of whether recognizing property claims creates more social utility than not. Indeed, they provide no basis for recognizing property rights based upon labor at all, and would justify appropriation of all goods so long as doing so optimizes social efficiency. While cavalier appropriation of property would not be likely to promote social efficiency, it is precisely such likely inefficiency that is the only utilitarian hedge against property rulings violating some of our most deeply held beliefs about who can and does own what. This is a theme that has been visited so thoroughly by libertarian theorists since Nozick that there is little point in rehearsing it here.

What is surprising is the extent to which utilitarian theories have held sway in debates over intellectual property, generally, and with respect to biotechnology in particular. The argument most prominently introduced for recognizing property rights in genetically altered organisms or in segments of genetic code is that doing so will establish incentives for research that will ultimately be socially beneficial. The argument is offered without qualification, despite the fact that similar arguments produce absurd conclusions for other forms of knowledge and ideas. Teachers would have more incentive to educate their students if they were entitled to a share of each student's lifetime earnings. Scientists would have more incentive to develop broad theories if they could capture royalties in every instance where the theories are republished or applied. Musicians would have more incentive to produce catchy harmonies and melodic themes if they could capture the value created when other musicians incorporate these fragments into best selling songs. Parents would have more incentive to teach their children common sense if they could reap more of the benefits from doing so.

It seems likely that utilitarian analysis of intellectual property claims is actually being carried out against a background of assumptions about property rights that cannot, in themselves, be justified on utilitarian grounds. In addition to the natural and labor criteria discussed here, instrumental criteria for property that examine impact upon liberty and upon social stability may also be a component of those background assumptions (though arguments about social stability can be readily given a utilitarian interpretation). If so, the utilitarian or instrumental arguments are effectively functioning as modifications of broad judgments that previously have been made on the basis of natural or labor criteria. An application of natural criteria would establish a prejudice against recognizing property rights in the products of biotechnology, but an application of labor criteria would reverse this judgment. Labor criteria are themselves modified in response to the problem of distinguishing production from discovery. Only then would utilitarian criteria become relevant as final elements in concluding a judgment for a particular case. If this is indeed the pattem that should be applied to biotechnology, the discussion thus far is an instance of flailing away at a rough hewn slab with tools that have been designed for finishing touches and final details. A broader and more sophisticated view of the conceptual tools at our disposal will improve the quality of debate.

References

Diamond v. Chakrabarty, 447 US 303 (1980).

Hettinger, Edwin. "Justifying Intellectual Property." *Philosophy and Public Affairs* 18 (1989), pp. 31-52.

Locke, John E. *Second Treatise of Government,* ed. C.B. Macpherson. Indianapolis, IN: Hackett Publishing Co. (1980).

Paine, Lynne Sharp. "Trade Secrets and the Justification of Intellectual Property: A Comment on Hettinger." *Philosophy and Public Affairs*, 20(3): 247-263. (1991).

Barriers to Patent Protection for Biotechnology and Alternatives for Removing Them

Abstract

Martin L. McGregor, Esq.
Baker & Botts
910 Louisiana
Houston, TX 70002-4995

The tools of biotechnology now make it possible to produce naturally occurring, biologically active molecules in quantities never before possible. This feat is often accomplished by inserting DNA coded for the desired biologically active molecule into a microorganism, growing the organism in a fermentation medium, and then isolating the desired material from the fermentation mixture. The process is not very different from the ancient method of using yeast to produce alcohol. The availability of the active molecules by genetic engineering promises new treatments where none previously existed.

If the biologically active molecule has never been isolated and characterized, patent claims covering it are possible, and adequate protection is available for the product. However, when the biologically active molecule is already known, adequate protection becomes very difficult because the Patent Office often rejects claims to the process of producing molecules by genetic engineering. Congress has recently revised the patent statutes to give U.S. companies greater protection by barring the importation of products made by processes which would have infringed U. S. patents if practiced in the United States. However, when biotechnology companies are unable to obtain process claims for previously known but unavailable materials, there is no adequate patent protection for these companies. The Association of Biotechnology Companies, the Industrial Biotechnical Association, the Pharmaceutical Manufacturers Association, and the U.S. Patent Office have endorsed a proposal by Rep. Boucher to amend the patent statutes to extend patent coverage to processes utilizing novel starting materials, even if the process and products are otherwise old. While the Boucher bill is an attractive solution for the biotechnology companies' dilemma, it may produce from time to time—not entirely satisfactory.

The biotechnology industry has at least two other alternatives if the Boucher bill continues to be rejected. One alternative is to convince the Court of Appeals for the Federal Circuit that biological processes are not as predictable as chemical processes, and therefore, producing molecules by genetic engineering is not always obvious. *Amicus curae* briefs by the industry in a suitable test case might help the Court of Appeals to understand the importance of such a ruling.

A second alternative is to amend the Food, Drug and Cosmetic Act to provide registration exclusively for materials produced by host cells patented in the United States, even if the importation does not constitute patent infringement. Similar amendments could be made to the other federal statutes covering agricultural and pest control applications of biotechnology. By substituting regulatory exclusivity for patent protection, Congress might find a more precise remedy to biotechnology's problems.

Economic Impacts of Regulations Governing the Development and Dissemination of Animal Agricultural Biotechnologies*

Judith I. Stallmarm
Assistant Professor
Department of Agricultural Economics
Virginia Tech
Blacksburg, Virginia 24061

*"this paper was prepared for the NABC 4 Saturday Seminar but was not presented due to illness.

I would like to begin my discussion with some words of wisdom garnered from the past:

> That the automobile has reached the limits of its development is suggested by the fact that during the past y ear no improvements of a radical nature have been introduced. {*Scientific American,* January 2, 1909)
>
> I think there is a world market for about five computers. (Thomas J. Watson, Chairman of the Board, IBM, 1943)
>
> There is some work best done by horses for which tractors are not suited {*Farm Journal*, 1923)

I suspect that m uch of the discussion today , several y ears from now will sound very much like these quotes. In the area of new technology the final outcome of that technology is difficult to predict from the first produc ts that appear on the scene because there are so m any unknowns — the developm ent of transistors and integrated circuits in the case of com puters and equine fever in the case of tractors — and new uses that come on the scene.

Risk Management

Regulations are a way of m anaging ris k. Ris k m anagement includes hazard reducing or ris k reducing actions and enforcement of actions believed to reduce risk (Marois, Grieshop and Butler). Regul ation of biotechnology has created a lot of controversy with one side say ing that biotechnology needs more regulation and th e other side say ing existing regulations are sufficient.

From a toxicology approach some biotechnology products ha ve different characteristics th an chemical substances for which the toxicology approach was developed. Chemical substances degrade over time and space so residue analyses is used. Some biotechnology products are living organism s which repli cate and spread, rather than degrade, over tim e and space (Marois, Grieshop and Butler). Thus, whether existing regulations are sufficient is open to question given that some biotechnology products may increase rather than degrade over time and space.

Approaches to Risk Management: Regulation and Judicial Law

Risk management tools are *ex-ante,* (regulation), and *ex-post,* (judicial law). Both are intended to reduce the probability and/or size of an event occurring. An *ex-ante* approach imposes controls "before the fact" or independent of the occurrence of a specific event (Marois, Grieshop and Butler). Standards and guidelines are examples of an *ex-ante* approach to risk management, *ex-post* (judicial law) or an "after-the-fact" approach is dependent upon the occurrence of an event and it allows damages to be recovered for harm done (Marois, Grieshop and Butler). Liability and negligence rules are examples of the *ex-post* approach.

For those of y ou interested in modeling of the impacts of various approaches I refer y ou to the USDA publication by Larson and Knudson. They examine both *ex-ante* and *ex-post* approaches. They examine each individually . In actuality we usually have both *ex-ante* and *ex-post* approaches combined. Although Larson and Knudson's models can be modified to combine approaches, they have not done so. An article by Segerson suggests that when the consumer and the producer have different risk preferences, rely ing on just one approach will not achieve a socially optimal allocation of risk damages and incentives for hazard reduction. Both *ex-ante* and *ex-post* approaches may be needed to achieve an efficient public policy solution (Marois, Grieshop, and Butler).

Ex-post or Judicial Law

The *ex-post* approach requires an occurrence, such as an injury. The intention then is to compensate the victims of the injury or to recover damages.

Under strict liability one party must take the precautions and the injured party must show that the dam age was caused by that party. Since the injured party must prove causation there is some uncertainty in the outcome. The uncertainty can lead to too much or too little precaution.

The negligence approach requires both s ides to take precautions. The burden of proof on the injured party is more difficult because the injured party must *also* prove that they were not negligent. Since there is even greater uncertainty of outcomes under negligence than under strict liability , Johnson a nd Ulen find negligence is even less likely to result in socially optimal outcomes than is strict liability.

Larson and Knudson find that when the re search firm is small (i.e ., wealth relative to the potential returns) and the potential damages from the firm's activities exceed the value of the firm, the liability rule re duces the incentives to take precautions. Uncertainty in legal outcomes also reduce the incentive for precautions.

Ex-ante Regulation

First I want to clarify the definition of the work "regulation" which I have been using very broadly to this point. There is also a narrower use of the word: s pecific rules which *must* be followed, to avoid the confusion of the broad and narrow senses of the word I will try to use the word "standard" when speaking narrowly . Standards are an *ex-ante* approach. They tend to be highly specific, defining procedures that must be used or that cannot be used. Failure to follow these standards carries legal penalties, including fines, even if no injury occurs. If injury occurs there will be liability . Because of the legal codificati on, standards tend to be difficult to change. In a new area of tec hnology, changes of standards will be needed. (I refer you to my opening three quotes to underline this point.) Outdated standards may become a large burden on research.

Another *ex-ante* approach is guidelines. Guidelin es are suggestions or recommendations of acceptable practice. There are no legal penalties for not following guidelines (Marois, Grieshop and Butler). There may be institutional penalties for not following guidelines, such as loss of funding. If guidelines are not followed and dam age results, there will be liability for damages. Guidelines tend to be more easily changed than standards as more information becomes available.

An open question is whether there is liability if standards and guidelines are followed and damage occurs anyway.

Larson and Knudson find that with standard s alone, the firm loses wealth to safe ty measures, whether or not an event occurs. If the firm engages in both risky and non-risky activities it will have an incentive to put m ore assets in the risky activity to equalize the rates of return between the two ac tivities. I will point out here that Larson and Knudson did not analyze the situation of standards and liability combined.

Current Regulatory Environment

Regulations on transgenic animals can be on the research pr ocess, field testing, manufact ure and production of the product and/or on the end product. For transgenic animals there are currently regulations in place on experim ental animals - how the experimental animals are treated, the precau tions to be used, and how anim als are disposed of. Bey ond that point it is very unclear what is to be done (Figure 1). For example, how do y ou dispose of an animal from a production herd that produces a human protein in its milk? Will it have to be burned, can it be buried, can it be sold as food?

In the area of transgenic fish the regulatory issues are even more uncertain. In fact the uncertainty at the moment may be a bigger hindrance to research and product development than the regulations.

Mackenzie and Vidaver report researchers were most likel y to be discouraged from conducting field test by press reports and by regulatory uncertainty. They go on to obs erve a "near-passive acceptance by the private-s ector scientist of regulatory requirem ents..." I have not obs erved pas sive acceptan ce by the private s ector. But, if uncertainty is a m ajor problem then any regulations which decrease uncertainly may be seen as preferable.

Figure 1: Current Regulations on Transgenics

Plants		Animals	Fish
Research	XX		
Field Testing	X?		
Manufacture/ Production			
End Product	XX?		

The Future of Biotechnology Regulation

One question for the future is whether the regulations will come in the form of standards or guidelines. Guidelines will allow more flexibility for the individual research project.

A second big question for the future is the issue of who will regulate. When I say this many of you are thinking FDA, EPA, NUT, USDA, etc., which the Coordinated Framework is supposed to have worked out. That framework does not discuss transgenic anim als. In addition it focuses m ainly on sm all-scale introductions and has little guidance on com mercial introductions (Nicholas).

But there is also an issue of whether the federal government or the states will regulate (or even local govemm ents). Take the example of product labeling. When it came to nutritional labeling, the food industry opposed federal regulation until it realized that without federal regulations each of the 50 states might impose their own standards which would be much more costly. At that point the industry was willing to work with the federal government to get la beling requirements they could live with. The NIH guidelines also cam e about because scientists decided to take a role in regulating themselves rather than leaving it up to someone else.

The third issue is, are y ou going to regulate the product or the process? The Coordinated Framework say s the product is the regulatory focus, not the process (Nicholas). Yet to da te the regulatory focus has been on the process and I doubt that those regulations will disappear.

Patenting of Transgenic Animals

Everything I have read on the patenting of transgenic animals (which is very little because not m uch has been written) concentrates on "farm animals". The dis cussion focuses on the rights of farmers to use the progeny and mechanisms for royalty collection. The concern about the difficulty of roy alty collection leads me to sugge st that the emphasis on farm animals is misplaced.

Patent law say s y ou may be eligible for a patent but it does not guarantee y ou that the product will be profitable. In addition the government does not enforce the patent for y ou, you must enforce or police it y ourself. Research on plants suggests that because of the difficulty of policing or enforci ng a patent when the patented product is widespread and easily copied, there will be very little investment in these types of products (Stallmann).

Based on these observations it seem s likely that investment will concentrate on specialty animals because the potential return per animal is much higher and policing will be easier. For example, a pig which produces a hum an protein in its milk has a much higher potential return per animals than does a pig with a leaner carcass. In addition, the specialty pig will be kept in herds easily policed by the company (maybe even owned by the company) rather than being spread among thousands of farms where policing becomes nearly impossible.

As the industry increases in concentration (such as poultry) policing of a patent becomes easier. Concentration becomes easier as the number of offspring per animal increases so that few animals are needed for the breeding herd.

It should also be remembered that a patent, by making a product valuable, creates incentives for infringement.

Summary

Both *ex-ante* and *ex-post* approaches to ris k-management are needed to achieve the socially optim al allocation of risk damages and incentives for hazard reduction. Uncertainty about regulation is also having an impact on animal biotechnology research. How the issues of standards ve rsus guidelines, federal versus state regulation and product versus process regulation are resolved imply different costs. Because of the structure of patent law, research will more likely concentrate on specialty, rather than "farm" animals.

References

Johnson, Gary V. and Thom as S. Ulen. "Designing Public Policy toward Hazardous W astes: The Role of Adm inistrative Regulations and Legal Liability Rules," *American Journal of Agricultural Economics* 68(5): 1266-1271. 1986.

Larson, Bruce A. and Mark K. Knuds on. "Public Regulation of Agricultura 1 Biotechnology Field Tests: Economic Implications of Altemativ e Approaches," Technical Bulletin No. 1793. Economic Research Service, United States Department of Agriculture. August 1991.

MacKenzie, D.R. and Anne K. Vidaver. "U.S. Biosafety Regulations: Too Much or Not Enough?" in Bill R. Baumgardt and Marshall A. Martin (eds.). *Agricultural Biotechnology Issues and Choices.* W est Lafay ette, Indiana: Purdue University Agricultural Experiment Station, 1991.

Marois, James J., James I. Grie shop, L.J. (Bees) Butler. "Envi ronmental Risks and Benefits of Agricultural Biotechnology." in Bill R. Baum gardt and Marshall A. Martin (eds.) *Agricultural Biotechnology: Issues and Choices.* W est Lafay ette, Indiana: Purdue University Agricultural Experiment Station, 1991. pp. 67-80.

Nicholas, Robert B. "Is Regulation the Gatekeeper?" in June Fessenden MacDonald (ed). *Agricultural Biotechnology at the Crossroads: Biological, Social and Institutional Concems,* NAIiC Report 3. Ithaca, New York: National Agricultural Biotechnology Council, 1991. pp. 111-119.

Segerson, Kathleen. "Risk Sharing in the Design of Environmental Policy ." *American Journal of Agricultural Economics* 68(5): 1261-1265. 1986.

Stallmann, Judith I. "Impacts of the 1930 Plant Patent Act on Private Fruit Breeding" Investment. Ph.D. Dissertation. East Lansing, Michigan. Department of Agricultural Economics, Michigan State University, 1986.

Public Perceptions of Agricultural Biotechnology: An Overview of Research to Date

Don E. Albrecht
Associate Professor
Department of Rural Sociology
Texas A&M University
College Station, Texas 77843

During the past few centuries, rapid developments in science and technology have dramatically altered all aspects of human life. In medicine, antiseptic surgery and the control of disease-causing microorganisms helped ease human suffering and lengthened average lifespan. The use of machines greatly increased the amount that an individual could accomplish, and reduced the physical burden that humans had to carry. In numerous other areas, the effects of science and technology on human society were extensive (Catton 1980).

The consequences of science and technology are perhaps as evident in agriculture as any other human endeavor. Mechanical developments greatly increased the amount of work that an individual could perform, while breakthroughs in genetics, pesticides, and fertilizers have greatly increased per acre production. As a result, in two hundred y ears we have gone from a nation of subsistence farmers where nearly everyone was involved in agriculture to a nation where, with less than 3 percent of the population living on farms, we are ne vertheless able to produce sufficient food and fiber for our nation's needs and to have considerable surpluses for export abroad (Albrecht and Murdock 1990; Cochrane 1979).

As a consequence of the perceived benefits of science a nd technology, their glories were widely espoused, efforts to promote further developments were suppor ted, and attempts to diffuse the use of these developments to the general population were encouraged. At one tim e in our society , it was accepted, aim ost without question, that scientific breakthroughs and technological developm ents were progress that would improve the quality of our lives. As a result of science and technology, the present was better than the past, a nd the future would be even better than the present (Boulding 1978; Dunlap 1980).

Like other segments of our society, there was a time when the benefits of science and technology in agriculture were accepted without question, and the Agricultural Experiment Stations were created to encourage further such developments. In fact, the failure of producers to adopt new technologies was considered an important soci al problem, and the Cooperative Extension Service was created to help in the process of transferring technology from the laboratory to the farm (Rogers et al. 1988; Fliegel and van Es 1983). A massive literature emerged in rural sociology where the underlying theme was to increase the speed of the diffusion process (Rogers 1983). In recent y ears, the growth of scientific knowledge has continued, and technological breakthroughs abound. One of the prominent areas of scientific a nd technological advance is biotechnology . The biotechnology revolution is based on advances in molecular biology that permit the identification, alteration, and transfer of genetic materials that control fimdame ntal characteristics of organisms. Devel opments in biotechnology are occurring so quickly that work is often outdated even before it is publishe d (Bentley 1987). At the present tim e, it is estimated that there are over 300 private firms engaged in the developm ent of biotechnology, and billions of dollars have been spent do date on biotechnology research (Klassen 1987).

While developments in biotechnology are expected to impact all ar eas of human life, the imp acts are expected to be especially great in agriculture. Some of the developments include experimentation to improve photosynthesis and crop yield, improvements in the natural pest resistance of plants, and e fforts to create nitrogen-fixing abilities that will make plants self sufficient for nitrogen fertilizer. Further developm ents include crops that are resistant to drought an frost and that can thri ve where the soil is saline. Through biotechnology , there are improved means of testing for and trea ting animal diseases. In the environmental area, there are specialized micro-organisms to degrade dioxins and other pollutants in chemicals. Other micro-organisms will devour oil spills and clean kitchen drains (Godow n 1987). This list could go on, but the point is that these breakthroughs are impressive, and the potential benefits to society from these breakthroughs are enormous.

However, unlike the previous generation of scientific and technological developments where breakthroughs were accepted almost uncritically, biotechnology was met with a storm of controversy and debate. The purpose of this paper is to attempt to determine public perceptions of biotechnology by examining available research. Attempts will be made to understand some of the reasons for changing attitudes toward science and technology in general, and biotechnology in particular. Finally, since there has been so little social research on biotechnology, an effort will be made to describe the types of research that should be conducted in order to avoid further public perception problems.

Changing Views of Science and Technology

In 1957, a survey by the National Opinion Research Center revealed that over 90 percent of the U.S. pubhc agreed that "On balance, the benefits of scientific research have outweighed the harmful results." Further, almost 100 percent of the U.S. public agreed that "Scientific discoveries are making our lives healthier, easier and more comfortable" (Berrier 1987).

In recent years, significant changes have occurred in the views of the general pubhc toward science and technology. No longer are developments in science and technology accepted uncritically. No longer are science and technology directly equated with progress and an improved life. By 1979, a follow-up study of the National Opinion Research Center found that the proportion agreeing to each of the above statements about the benefits of science and technology had declined significantly. Although still supported by the majority of Americans, the extent to which science and technology were uncritically supported had definitely eroded.

In 1986, another major study of the attitudes of the general pubhc toward science and technology was conducted by the Office of Technology Assessment (OTA). This study is of interest both because it revealed a continuation of the erosion of faith in science and technology revealed by the 1979 study and because is the most in-depth study to date of public perception of biotechnology specifically. The OTA study was conducted between October 30 and November 17 of 1986 by Louis Harris and Associates. Surveys were completed with a national probability sample of 1,273 American adults. The study found that 71 percent of the respondents believe that developments in science and technology pose at least some risk to them and their families. When faced with the fundamental choice between the risks and benefits to society from continued scientific and technological development, 62 percent feel that the benefits outweigh the risks. This is down from 90 percent in 1957.

When questioned specifically about biotechnology, a slight majority (52 percent) believe that genetically engineered products are at least somewhat likely to represent a serious danger to people or the environment. With other factors equal, the public is more favorably disposed toward the genetic alteration of plants, animals, and bacteria than manipulating human cells. The reason for this difference appears to be a concern about the moral status of such actions. Despite the concerns expressed by some segments of the population, a majority recommend continued biotechnology research. However, a vast majority — 82 percent — favor the application of genetically altered organisms on a small-scale experimental basis prior to more widespread use. Further, the public strongly supports the strict regulation of biotechnology and its products.

These findings represent a substantial departure from the views of the public in the past toward science and technology. The reasons for these changes in public opinion are no doubt numerous and complex. Perhaps some of the more important reasons include the fact that it has become readily apparent to many that technological developments often have severe negative social consequences. While some individuals benefit, others pay the cost. For example, while mechanical advancements in agriculture led to vastly increased per farm production, these technologies also resulted in rapid increases in the size of the average farm, with a corresponding decline in the number of farms. In 1940 there were over 6 million farms in the United States, however, as a result of major technological breakthroughs, this number had declined to about 2.1 million in 1987 (Albrecht and Murdock 1990). Such reductions in the number of farms resulted in severe economic and demographic declines in agriculturally dependent rural communities. Further, many of the farm people forced to leave agriculture migrated to urban areas without the job skills to compete successfully in that job market. There were also numerous other social consequences (Rodefeld et al. 1978).

A second reason for the reduced public acceptance of science and technology is that the public now has major concerns about the health and safety consequences of science and technology. Part of this concern is a result of major disasters related to modem technology such as Three Mile Island, Chemoby 1, and Bhopal. In each case, prior to the disaster the public was assured that the technology was safe. Now the public appears less willing to accept the word of either industry or the government about the safety of modem technology.

Finally, the environmental consequences of modem science and technology have come under question in recent years. The ecological problem s associated with agricultural pesticides, the leaching of fertilizers into surface and groundwater supplies, and other m ajor air and wate r pollution problem s resulting from recent de velopments in science and technology have raised serious questions in the minds of the general public. Additional environm ental concerns such as ozone depletion and global warming have further raised public concern.

The Public Perception Problems **of Biotechnology**

In addition to the general public perception problems of scie nee and technology just discu ssed, biotechnology may have several other specific problems that result in negative reach ons among some segments of the general population. One such factor may be that the level of understanding of the genera 1 public is extremely limited, for example, a 1985 national poll found that only 16 percent of the general population believed th at they had a clear understanding of DNA, while 57 percent felt they had little understanding (Berrier 1987). Keep in m ind that members of the general public tend to overestim ate then- knowledge on public poll questions such as this. In addition, those groups a nd organizations that are opposed to biotechnology are well-organized and vocal, and may have ha d a major effect on public perceptions (Rifkin 1987). With industry making little effort to educate m embers of the general public or to understand their concerns, m uch of what people believe about biotechnology is based on what the opposition groups tell them. Further, some segments of the population seem to be concerned about the moral impli cations of gene manipulation. In disc ussing public perceptions of biotechnology, Klassen (1987) maintains that opposition falls into the following four categories:

1) *There is concern that the release of genetically-engineered microorganisms may result in some unintended, yet perhaps permanent damage or loss.* Many believe that our knowledge of the factors that affect the ability of species to excel in nature is insufficient, and that some microorganisms may proliferate out of control after releas e in nature. Once releas ed, these living organisms cannot be recalled or sealed in a dr um. These organism s can grow, reproduce and m igrate. Rifkin (1987) states that introducing new organisms into an envir onment is analogous ecologically to the introduction of exotic organisms. While most have fit in or died out, a few have become major pests. These include the starling, Dutch elm disease, chestnut blight, fire ants and the gy psy m oth. Am ong them, these exotics cost Am ericans hundreds of m illions of dollars annually.

2) Similarly, *there is concern that some genetically-engineered crop plant may themselves become uncontrollable weeds because resistance to major herbicides has been spliced into their genetic make-up.*

3) *Many are concerned that genetically-engineered farm animals may experience pain and suffering because of dysfunctional changes in their physical structure.*

4) Finally, *there is concern that large farm operators have a substantial advantage over small farm operators in benefiting from breakthroughs in biotechnology.*

Public Perception Research Needs

As this review has indicated, the extent of the research on public perception of biotechnology is extremely limited. It is difficult to imagine that while industry and universities have spent billions of dollars on biotechnology research, there has been barely a cent spent on researching public perceptions of biotechnology or the social consequences of biotechnology . This research has not been neglected because social scientis ts have not attem pted to obtain research funding. Num erous efforts to obtain funding have met in failure.

Perhaps industry and govemm ent didri t think it was needed or necessary . perhaps industry is afraid of what this research will find. In one of the few studies completed on the social consequences of biotechnology , economists at Cornell

University concluded that within three y ears of the time that bovine somatotropin reached the market place, there would be a 25 to 30 percent reduction in the number of dairy farms. However, isn't it better to have such information available sot hat planning can be m ade to accentuate the positive and avoid th e negative? Isn't it better to know in advance what the consequences will be, rather than struggle to adapt to them after the fact?

This lack of public perception research m ay be a major factor in the negative public attitudes that abound. Thus, early in the development of modem biotechnologies, the public was obtaining information from the opposition groups, but nothing from the biotechnology industry. When biotechnology industries belatedly realized there was a public perception problem and did launch a public relations campaign, they did not deal with the issues that concerned the general public. Using bovine somatotropin as an example, Homig (1991) found that the approach of the biotechnology industries instead emphasized the idea that technological development is progress, that biotec hnology has been developed at great expense and that the industries wouldn't have gone to such great expense if the bene fits were not extensive, that the use of biotechnology was inevitable and that if we didn't use it first we would use our competitive advantage to other countries, and that biotechnology was only a tool and therefore it was value neutral.

It appears that a number of individual scientists are now recognizing the public perception problems that biotechnology faces. Often those scientists view c oncem with the social consequences of biotechnology , the public acceptance of biotechnology, or the variety of government controls and regulations as hindrances that prevent the natural progress of society. Bentley (1987) noted that when fire was introduced in to ancient human societies, it was done without the vast array of government regulations to allay concerns about health and safety and the soci al consequences. Rather, human beings accepted fire and used it to help build a civilized world. It now appears that the problem s with public perception of biotechnology are so severe that the future of biotechnology is very much in doubt. Opposition organizations are strong and they will not easily go away . Public pe rceptions and attitudes do not readily change. The failure of the biotechnology industry to determine public perceptions ear ly and to develop educational programs to deal with the concerns of the pubhc has been a m ajor blunder that will not be easily overcome. Berrier (1987) notes that no one would attem pt to market a new breakfast biscuit or a new brand of toothpaste with as little information about public attitude s as the biotechnology industry has.

Given that there is so little available research to review on public perceptions of biotechnology , this final section will be used to outline important lines of research that should be conducted in the near fu ture. It appears that there are three ty pes of social research relative to biotechnology that are critically needed. Each will be briefly discussed below.

The Use of Biotechnology by Producers

If developments in biotechnology are to achieve the benefits that many scientists believe to be possible, they first have to be adopted and used in the farm ing practices of American producers. However, initial evidence indicates that m any farmers are reluctant to utilize biotechnologies in their farm ing operations. Some of the factors that m ay inhibit this adoption include negative perceptions, misinformation, allege d risks, and fear (Vogler 1986). It is e ssential that researchers gain a much greater understanding of the process of adoption of biotechnology by producers. It is also important to identify the segments of the farm population that are most and least likely to adopt agricultural biotechnologies. Such information would be helpful in developing educational program s to reach nonadopters. There is a long history of adoption-diffusion research in rural sociology that can provide the basis for this research on th e adoption and diffusion of biotec hnology. Literally thousands of studies have been done, and there is a fairly solid understa nding of the characteristics of how both the innovation and the producer are related to decisions about whether or not to adopt (Rogers 1983).

Perceptions of Biotechnology by the General Public

Another critical obstacle that m ust be overcom e if the poten tial positive benefits from biotechnology are to be achieved is that consumers must be willing to purchase goods produced using biotechnology. Without a m arket, even those producers utilizing biotechnologies cannot continue. Som e preliminary evidence indicates that m any consumers are concerned about factors such as the long-term health a nd environmental effects of biotechnology , and are therefore reluctant to consume biotechnology products (Batra and Klasse n 1987). Perhaps these fears are unfounded and based on misinformation, but the consequences will still be a negative effect on the market for biotechnology products. To what extent do consumers perceive that there are risks in utilizing commodities produced with biotechnology? How extensive are these perceived risks, and what degree of risks are consumers willing to take? This type of information will prove vital to those marketing biotechnology and biotechnology products as it will help them know where their problems lie and may suggest educational and other strategies to help overcome existing problems.

Social Consequences of Biotechnology

Previous experience has taught us that t echnological developments in agriculture can have dramatic effects on farm families and rural communities. During this century, technological breakthroughs in agriculture helped make the American farmer the most efficient producer the world has ever known. With the us e of modem technologies the Am erican farmer is able to provide the American public with food that is plentiful, relatively safe, and cheap . At the same time, these technological developments have had dramatic effects on families, as they resulted in a tremendous reduction in the number of farms and a corresponding increase in the size of the average farm as describe earlier.

A half century of social science research on the consequences of technology will be helpful in doing this ty pe of research (Berardi and Geisler 1984). Past re search in this area has found that there are major differences in the consequences of technology depending on whether the technology is "yield enhancing" or "labor saving." For the most part, the mechanical breakthroughs of the past (such as the tractor) were "labor saving" technologies, while mo st biotechnologies are "y ield enhancing" technologies (Domer 1983). However, there were some technologies of the past that had yield enhancing aspects, and some biotechnologies may have labor saving implications. Labor saving technologies make it possible for individual producers to greatly increas e the s ize of the operation that they can operate. In the past, this led to the trend of rapidly increasing farm sizes, and a corresponding d ecrease in the number of farms. In comp arison, the impacts of y ield enhancing technologies are substantially different. Th e increasing yields for a particular produc t tends to result in a surplus of that product. This m arket surplus operates to drive the price th at producers receive for that product down. Thus, producers who are not as efficient and cannot produce the product profitably will be forced out of the business or into the production of other products. The long term effect will be that there ar e fewer producers of som e good since fewer production units are needed.

Conclusion

The completion of these three ty pes of research would result in the biotechnology industries being aware of the ty pes of educational programs needed. In addition, planners and decisionmakers would have in formation available to assist them in deciding whether or not to allow the release of various biotechnologies. However, before these benefits can be achieved, the research must be accomplished.

References

Albrecht, Don E. and Steve H. Murdock (1980). *The Sociology ofU.S. Agriculture: An Ecological Perspective.* Ames, Iowa: Iowa State University Press.

Batra, L.R. and W. Klassen, eds. (1987). *Public Perceptions of Biotechnology.* Bethesda, Mary land: Agricultural Research Institute.

Bentley, Orville G. (1987). "Global status of agriculture and food production." In Batra and Klassen 1987, pp. 13-20.

Berardi, Gigi M. and Charles C. Geisler(1984). *The Social Consequences and Challenges of New Agricultural Technologies.* Boulder, Colorado: Westview Press.

Berrier, Robert J. (1987). "Public perceptions of biotechnology." In Batra andKlassen 1987, pp. 37-52.

Boulding, Kenneth E. (1978) "The limits to progress in evolutionary systems." In K.E. Boulding, M. Kommen, and S.M. Lipset, eds., *From Abundance to Scarcity: Implications for the American Tradition.* Columbus: Ohio State University Press.

Catton, William R., Jr. (1980) *Overshoot.* Urbana: University of Illinois Press.

Cochrane, Willard W. (1979) *The Development of American Agriculture: A Historical Analysis.* Minneapolis: University of Minnesota Press.

Domer, Peter (1983) "Technology and U.S. agriculture." In Summers 1983, pp. 73-86.

Dunlap, Riley E. (1990) "Paradigmatic change in social science: from human exemptions to an ecological paradigm." *American Behavioral Scientist* 24, pp. 5-14.

Fliegel, Frederick C. and J.C. van Es (1983). "The diffusion-adoption process in agriculture: changes in technology and changing paradigms." In Summers 1983, pp. 13-28.

Godown, Richard D. (1987) "The science of biotechnology." In Batra and Klassen 1987, pp. 21-35.

Homig, Susanna (1991). "Monsanto Corporation and Bo vine So matotropin: A Case Study in Failed Public Relations." Discussion Paper #91-10. College Station, Texas: Texas A&M University Center for Biotechnology Policy and Ethics.

Klassen, W. (1987). 'Executive summary." In Batra and Klassen 1987, pp. 7-10.

Office of Technology Assessment (1987). "New Developments in Biotechnology : Public Perceptions of Biotechnology ." Background Paper 2. Washington: Office of Technology Assessment.

Rifkin, Jeremy (1987). "Biotechnology: major societal concerns." In Batra and Klassen 1987, pp. 53-72.

Rodefeld, R.D., J. Flora, D. Voth, I. Fujimoto, and J. Converse (1978). *Change in Rural America: Causes, Consequences, and Alternatives.* St. Louis, Missouri: C.V. Mosby Company.

Rogers, Everett (1983). *Diffusion of Innovations.* New York: Free Press.

Rogers, Everett M., Rabel J. Burdge, Peter F. Korsching, and Joseph F. Donnermey er(1988). *Social Change in Rural Societies: An Introduction to Rural Sociology.* Third edition. Englewood Cliffs, New Jersey: Prentice Hall.

Summers, G.F., ed. (1983). *Technology and Social Change in Rural Areas: A Festschrift for Eugene A. Wilkening.* Boulder, Colorado: Westview Press.

Vogler, Jean Marie S. (1986). "Final report." North East Re gional Center for Rural Devel opment, the Pennsy lvania State University.

What Obligations Have Scientists to Transgenic Animals?

Gary Comstock

Associate Professor of Philosophy
Coordinator, Bioethics Program
Iowa State University
Ames, IA 50011

Imagine yourself fifty years from now standing in the middle of a huge antiseptic warehouse staring at rows of tan colored objects that look something like footballs. Shiny stainless steel pipes descend from the ceiling and disappear into a mouth-like orifice on top of each object. Black rubber tubes are attached by suction cups to the bottoms. The only attendant in the building tells you that the pipes bring water and rations to what he calls "the birds," while the rubber tubes carry excrement and urine to a sewer beneath the floor. Every twelve hours each bird drops a no cholesterol egg onto a conveyor belt. "Regular as clockwork," he adds with a wink.

You are staring at thousands of living egg machines, transgenic animals genetically engineered to convert feed and water into eggs more efficiently than any of their evolutionary ancestors, lay er hens. The science fiction objects I am asking y ou to imagine are biologically descended from the germplasm of many species unrelated in nature, including humans, turkeys, and today's chickens, so the worker is not speaking in mere metaphor when he calls the objects "birds." But unlike today's poultry varieties, which are only treated as machines, the brave new bi rds I have in mind really seem to be m ore machine than animal. For, in coming up with the new bird s, poultry scientists have not only selected for the trait of efficient conversion o f feed into eggs; they have also selected for lack of responsiveness to the environmen t. The result is not a bird that is dumb or stupid, but an organism wholly lacking the ability to move or behave in dumb or stupid way s. Scientific research shows that the egg machine's complete lack of any externally observable behaviors is paralleled by its lack of phy siological equipment necessary to support behavioral activity. The brain of the bird is adept at controlling the digestive and reproductive tracts, but the areas of the brain required to receive and process sensory input and to initiate m uscular movement have been selected against, bred away. The new bird not only has no eyes, no ears, no nose, and no nerve endings in its skin, it has no ability to perceive or respond to any information it might receive if it had eyes, ears, or a nose.

The unlikely organism I have just described is a philosopher's fantasy, inspired by a remark of Bemie Rollin' s4 I have never heard a poultry scientist or agbiotech enthusiast describe anything like it as a viable goal at which agricultural geneti c engineers should aim. But why not? Are the moralists ahead of the gene-splicers here? Suppose we find them some funds, set them up in a lab, and encourage them to get to work?

I will return to this question in m y conclusion. In order to answer it, however, we m ust first explore a prior issue, whether it is morally permissible to make transgenic animals (TAs) in the first place.

Some think not, and have called for a moratorium on TA re search and development. Such a statement was included in a 1989 "Consultation on Respect for Life and the Environment," which was signed by the National Council of Churches, the Foundation on Economic Trends, the Center for the Respect of Life and the Environment (one of the offices of the Humane Society of the United States), and four other organizations. It claims that transgenic technology is "a matter of deep philosophical and spiritual concern" insofa r as it "portends fundam ental changes in the public' s perception of, and attitude towards animals, which would be regarded as hum an creations, inventions, and com modifies, rather than as God's creation and subjects of nature."^ Jeremy Rifkin and Michael Fox share the group's position, and have offered their own arguments in opposition to TA production. ^

^See Bernard Rollin, article in *Between the Species* 2 (1986: 88-89.

^"Statement: Consultation on Respect for Life and the Environment," printed in U.S. Congress, Office of Technology Assessment, *New Developments in Biotechnology: Patenting Life — Special Report,* OTA-BA-370 (Washington, DC: U.S. Government Printing Office, April 1989), p. 134.1 should point out that I participated in the Consultation, and helped to draft the statement.

^Michael W. Fox, "Genetic Engineering Biotechnology: Transgenic Animals," manus cript, available from the author, The

Others think so, and have prevailed over the opponents of TA research. Powerful groups, believing TA production can benefit humans, have underwritten this research program for more than a decade. The U.S. Department of Agriculture, along with dozens of private corporations and public universities, have invested millions of dollars in the field. The position of th e U.S. government, the Industrial Biotechnology Association, and the American Medical A ssociation, is that the consequences of TA research will be medically and economically beneficial, and should go forward. In its publication, *Patenting Life,* the U.S. Congress' s Office of Technology A ssessment summarizes the ethical arguments for and against patenting TAs, and concludes by responding to the concern raised by the "Consultation on Respect for Life" statement: " *It is unclear that patenting per se would substantially redirect the way society uses or relates to animals*"[1] The implication is that the OTA finds moral arguments against the production of TAs unpers uasive, and believes transgen ic production and patenting justified.

But who is right?

The Science

Transgenic animals are animals into whose DNA humans have inserted a foreign gene, a gene from an animal with which the TA's mother could not naturally have bred. The first TA was produced by Palmiter in 1982, who injected a growth hormone gene from a rat into a mouse. ^ sine then, the mouse has served as the model of choice, with the vast majority of TAs being mice with genes taken from many different species, including humans. Typical is the Oncom ouse, a m ouse genetically modified so as to develop malignant tumors. ^ Transgenic farm animals (TF As) have also been "genefactured": cattle, chickens, pigs, rabbits, sheep fish, and goats. ^ The "geep," an animal with the body of a sheep and the head of a goat produced at the University of Wyoming, has probably attracted the most public attention, although the Beltsville hogs, swine with human growth hormone genes, might run a close second.^

Humane Society of the U.S., 2100 L Street NW, Washington, D.C. 20037, n.d. In this brief paper, Fox concedes that biotechnology "could indeed help us heal our selves and the Earth" (p. 5), but the gene ral tone of the paper is not positive. Fo x says "the situation is critical" with regard to the present suffering of transgen ic animals, and calls for a Congressional moratorium on animal patenting (p. 4). The front cover of the page carries three cartoons: one of a dairy cow with a shriveled head and inoperative back legs whose garg antuan udders require support from a hoist; another dairy cow with an even dozen teats; and an otherwise healthy looking Angus beef steer whose m idsection stretches twenty feet. More in line with reality , the paper also presents pictures of a mous e carrying the gene for human neurofibromatosis with a huge cancerous tumor growing on its foot, and a picture of one of the deformed Beltsville hogs carrying the gene for human growth hormone.

^*Patenting Life,* p. 137 (emphasis in original).

^R.D. Palmiter, R.L. Brinster, R.E. Hammer, M.E. Trum bauer, M.G. Rosenfeld, N.C. Brinberg , and R.M. Evans, "Dramatic Growth of Mice that Develop from Eggs Microinjected with Metallothionein-Gro wth Hormone Fusion Genes," *Nature* 300 (1982): 611-615; R.D. Palmiter and R.L. Brinster, "Transgenic Mice," *Cell*41 (1985): 343-345; and R. D. Palmiter, G. Norstedt, G.E. Gelinas, R.E. Hammer, and R.L. Brinster, *Science* 222 (1983): 809.

^As of 11 May 1992, the U.S. Patent and Tr ademark Office had issued only one patent for an animal, the Oncomouse. Harvard University received the patent in 1988, and then licensed the m ouse exclusively to DuPont Com pany, the chem ical firm. A patent is "a form of property protection granted by the federal government that alio ws the inventor to exclude others from making, using or selling the invention for 17 years. The basic requirements are that an invention be novel,' nonobvious', and useful" (Alex Bamum, "M ouse patent expected," *Des Moines Register* 10 May 1992). According to Bamum, there is now a huge backlog of transgenic anim al patent applications. The National Institutes of Health has applied "to patent 3,000 hum an genes, or as much as 5 percent of the human genetic code," and the patent office has 179 TA patent applications pending. GenPharm International, a biotech firm , has recently been told that it will receive the second patent, for the TIM m ouse, or transgenic immunodeficient mouse. "In experiments, TIM mice are implanted with human immune tissue and used to study AIDS and other immune system diseases" (Bamum).

^For transgenic swine, see R.E. Hammer, V.G. Pursel, C.E. Rexroad, Jr., R.J. Wall, D.J. Bolt, K.M. Ebert, R.D. Palm iter, and R.L. Brinster, *Nature* 315 (1985): 680-683; C.A. Pinkert, V. G. Pursel, K.F. Miller, R.D. Palmiter, and R.L. Brinster, *Journal of Animal Science* 65 (Suppl. 1,1987), Abstr.: and C.A. Pinkert, "Gene Tr ansfer and the Production of Transgenic Livestock," *Proceedings of the U.S. Animal health Association {*in press): 122-133. For further background on transgenic farm animal research, see Bob Church (University of Calgary):, "Bio-Technology's Impact on the Livestock Industry," paper presented at a conference titled "Managing Agricultural Technology for Profit," March 5-8,1989, Kananaska, Canada, p. 16.

5See Gary Comstock, "Should We Genetically Engineer Hogs?" Between the Species, forthcoming.

At present, most TAs do not express the inserted gene. Hammer, et al., (1985), inserted human growth hormone (hGH) into 1032 sheep ova. Of this num her, 73 ova developed into ne wboms, but only one of them successfully incorporated the hGH gene. Of 2035 transgenic pig ova, only 10.4 percent incorporated hGH. Experiments with mice have been more successful, but even with this species th e success rate is still only about 25 percent. That is, according to the reports I hav e seen, only one quarter of all injected mouse embryos develop into transgenic mice.' The others die or fail to incorporate the foreign gene.

Concerning TRAs, Church's lab superovulated a num ber of cows, then m ated them using traditional techniques. The embryos were then flushed, resulting in 1161 embry os, into wh ich were microinjected the foreign hGH gene coupled to a metallothionein regulatory sequence (MT-hGH). Of 126 calves bom, only 7 incorporated the MT-hGH fusion gene, and only one calf showed any signs of expressing the gene. [2] Assessing the state of the science in 1985, Church wrote that the lack of success with livestock compared to mice was probably not a function of species differences, but because rather by "our lack of knowledge of development at the m olecular level, the provision of inadequate culture conditions, and the use of inappropriate DNA constructs..."[3]

The few livestock animals that have s uccessfully devel oped from transgenic ova have not been healthy . A high frequency of sterility and other physiological problems plagues them. In another paper, I reported the results of the Beltsville hog experiment, in which:

> Nineteen transgenic swine lived through birth and into maturity. Several expressed elevated levels of growth gent, but none grew more quickly or to greater size than their counterparts in the control group. However, many suffered from "delet erious pleiotropic effects," me dical problems not afflicting the controls/ Those animals developed abnormally and exhi bited deformed bodies and skulls. Some had swollen legs; others had ulcers, crosse d eyes, renal disease, or arthritis. [3] Many seemed to suffer from decreased immune function and were susceptible to pneumonia/' All were sterile. Later, the researchers concluded that if transgenic swine were to be produced as s uccessfully as trans genic m ice, "better control of transgene expression, a different genetic background, or a modified husbandry regimen" would be required/ Further experiments are underway/

I draw four lessons from this history:

1. The science of producing transgenic farm animals is in its infancy.
2. The infant science of producing TFAs currently results in a high frequency of sickly, sterile, deformed animals.
3. In the course of this science' s maturation, many more gene rations of sickly , sterile, deformed animals should be expected.
4. The mature science of producing TFAs will be largely aimed at producing healthy animals for slaughter.

---

^Church, "Bio-Technology's Impact on the Livestock Industry," p. 17.

[2]Ibid

[3]Ibid.

^MichaelW .F ox, "Genetic Engineering and Anim alW elfare," *Applied Animal Behaviour Science* 22(1989), p. 107. Pleiotropism is a biological term meaning "multiple." In this context, it refers to the m any mechanisms involved in genes' control of the physical make-up of an animal.

[3]Of 29 founder pigs, 19 expressed either human growth hormone or bovine growth hormone. Among those exhibiting long-term elevated levels of bGH, health was gene rally poor: "the pigs had a high incidence of gastric ulcers, arthritis, cardiom egaly, dermatitis, and renal disease." Vernon G. Pu rsel, Carl A. Pinkert, Kurt F. Miller, D ouglas J. Bolt, Roger G. Cam pbell, Richard D. Palmiter, Ralph L. Brinster, Robert E. Hammer, "Genetic Engineering of Livestock," *Science* 244 (16 June 1989): 1281.

^Hammer, *et al., op. cit.* Cited in Fox, *op. cit.,* p. 107.

[2]Pursel, *etal., op. cit.,* p. 1281.

The Purpose

The primary purpose of making transgenic mice is to improve the state of medical knowledge. For example, by introducing an activated oncogene sequence taken from humans, scientists can produ ce transgenic mice with an increased propensity for developing neoplasms. The phy siology of the re sultant mouse makes an improved animal "model" of human diseases s uch as cancer. Cancer res earchers benefit from having TA m ice becaus e m ice are extens ively s tudied warm blooded mammals with many physiological and genetic similarities to humans. From the transgenic mouse research program, scientists have learned the location and function of mouse genes and hope to use th at information in identify ing the location and function of human genes. The TA research program is an undeniably important tool in the battle against diseases such as cancer, Alzheimer's, and diabetes. With GenPharm's immunodeficient m ouse, TA research may become a key part of the fight against AIDs as well. ^ TA mice are also being used to discover diagnos tic and therapeutic tools to treat genetic and developmental disorders.

Like TA research, TFA research promises to bring benefits to humans. For example, by improving the efficiency with which traditional farm products such as meat, eggs, milk, and wool are produced, scientists may be able to lower costs for the farmer and the consum er. Consider that the Beltsville research program was not aimed at producing hogs twice the size of their parents but at producing more cost effective swine, pigs that would convert grain into lean meat faster than their parents while eating proportionately less grain. Such animals would be a boon to certain sectors of the agricultural economy , including most of the pork industry , some hog farmers, and many meat consumers. The industry might cut costs by slaughtering fewer animals per pound of mea t; farmers might reduce expenditures on feedgrains while continuing to sell the same amount of pork; and consumers might benefit from industry and farm savings passed on to them at the meat counter. ^

In addition to aiming at more efficient production of traditional farm goods, scientists working with TFAs are aiming at production of nontraditional goods as well. One day , transgenic cows and goats m ay serve as protein factories, anim als capable of producing pharmaceutical drugs in their milk.

The moral justification of the TFA re search program, then, is utilitarian, base d on the consequences the research is expected to have. By causing a certain amount of pain to animals, scientists hope to bring about great benefits to humans. But may we use animals willy-nilly as means to our own ends? Do scientists owe their TAs nothing? When faced with new cases, moralists often proceed the way judges do, by reasoning from precedents, decisions reached about analogous cases, and then by trying to extend the relevant rule to the new cas e. Unfo rtunately we do no have m oral or legal precedents to guide reflection about TFA production. I propose to start with some intuitions about rules I think every one would agree to regarding the production of transgenic *humans* (THs). I will then use our intuitions about possible THs as a basis from which to reason about the present issue, actual TAs.

What Obligations; Have Scientists to Transgenic *Humans*?

Suppose that because of her genetic make-up, a woman is a high risk to develop cancer at an early age. So is her husband. Knowing full well that any children they bring into the world will almost certainly be saddled with a genetic predisposition to develop m alignant turn ors early in life, the couple still cannot overcome their desire to have a child of their own. Now suppose that science has progressed to the poi nt that medical researchers feel confiden t that they can insert a gene into the woman's ovum that will dram atically reduce the risks of cancer for the child. Suppose further that, due to a com bination of regulatory hurdles and technological shortcom ings, the researchers can only access the gene from another species, say, the ape. The baby we are now envisioning is the first transgenic human. What responsibilities would scientists have to her? What moral rules ought to guide us as we take the first tentative steps down the path of human germ cell therapy?

1 Comstock, "Should We Genetically Engineer Hogs?" p. 2.

^See Pursel, *etal., op. cit.,* p. 1281.

■^Comstock, "Should We Genetically Engineer Hogs?" p. 1.

I will not try to develop a com plete list of rules and regulations about this com plex subject here. The m edical community is now beginning to think about the more fundamental question, whether to allow th e insertion of foreign genes into human sex cells at all and, as Paul Thompson points out, there presently seems to be "a widely shared conviction that human eugenics is morally wrong."[1] But if the consensus on that issue turns out the way it has with regard to the insertion of foreign genes into anim al sex cells, then we shall soon ha ve to begin thinking about guidelines, because the option of foregoing all germ cell therapy will not be a live one. Presum ing that, one day , we will have transgenic human production, what basic rules ought to bind us? I have two very strong intuitions.

1. *No harvest THs.* Harvest animals are animals intentionally bred and raised for the purpose of being killed at a y oung age. In our culture, harvest animals fall la rgely into one of two groups. First, there are experimental animals, primarily mice and rats, which are killed so that researchers may do autopsies and learn scientific inform ation. Second, there are farm animals, primarily chickens, cows , and hogs, which are slaughtered for their meat. Harvest transgenic *humans* would be transgenic humans intentionally bred and raised for the purpos e of being harvested at a y oung age. I cannot imagine any one proposing to raise humans for meat, but it is not implausible to imagine someone in the future proposing to bring a handful of injected human ova to term in order to discover whether the injected genotypic change will be expressed phenotypically. The argument, of course, would be that hundreds of thousands of humans would eventually benefit from the harvest THs. But I have great trust in our intuition here, that we should allow the prohibition against producing harvest THs to be overturned only in the face of arguments so extraordinary that I cannot now imagine how they would go.

la. Protect innocent THs. This is an important corollary to the first intuition. Doctors and scientists should protect the basic interests of all human subjects used experimentally, but a special obligation ex ists to protect innocents. Not all writers are as uncompromising on this poi nt as Hans Jonas, but the vast majority would agree with the spirit of his remark on the morality of using an unconscious or subconscious patient in research: "Drafting him for non-therapeutic experim entsis simply and unqualifiedly impermissible; pr ogress or not, he must never be used, on the inflexible principle that utter helplessness demands utter protection." ^ Suppose that the happy parents of the low cancer risk TH infant agree to let their doctors conduct a certain number of nontherapeutic tests on their child. They understand that the baby will not be harmed by these tests and, indeed, the y oungster grows up to be health y and content. After fifteen y ears, however, the adolescent decides that enough is enough, and makes her wish known that the tests end. Her refusal to grant consent should be treated the same as any one's refusal to grant consent, just as any informed choice of a TH should be treated in the same way that we would treat the informed choice of a non-TH . The classic legal principle of informed consent was stated by Chief Justice Cardozo: "Every human being of adult y ears and sound mind has a right to determin e what shall be done with his own body; and a surgeon who performs an operation w ithout his patient's consent, commits an assault, for which he is liable in damages" *{Schloendorffv. New York Hospital,* 105 N.E. 92 (1914)). ^

The TH I have been imagining is one th at is well positioned to give consent. But if we want to protect her, how much more we should want to protect a TH who turns out not to be so well positioned. Suppose the experim ent, tragically, went awry, and the resultant child never developed the m ental capacities required to give inform ed consent. I believe we should not run any nontherapeutic tests on such a m isfortunate, simply because people who are least prepared to give inform ed consent, or who are utterly unable to give informed consent, should be most protect ed against experiments and tests that are not undertaken for *their* well being.

Ipaul Thompson, "Designing Animals: Et hical Issues for Genetic Engineers," p. 4, unpublished manuscript. Thompson is Director of the Center for Biotechnology Policy and Ethics, Texas A&M University, College Station, TX 77843-3455.

^Hans Jonas, "Philosophical Reflections on Experimenting with Human Subjects," *Daedalus* (Spring 1969), partially reprinted in Samuel Gorovitz, *et al., Moral Problems in Medicine,* 2nd ed. (Englewood Cliffs: Prentice-Hall, 1983), p. 114.

^Cited in Alan Donagan, "Informed Consent in Therapy and Experimentation," *The Journal of Medicine & Philosophy 2* (1977): 310-327; partially reprinted in Gorovitz, *etal., Moral Problems in Medicine,* 2nd ed., p. 162.

Which THs would we ideally use as experimental subjects? Those best able to understand and bear the risks to which they would be subm itting themselves, and who would be m ost disposed and prepared to care fo r their TH offspring in the event that something went wrong. Jonas' s way of talking about informed consent is apt, and here is how Samuel Gorovitz summarizes it:

> Morally permissible use of human beings in medical experimentation requires that they be those persons with a maximum of identification, understanding, and spontaneity — the most highly motivated, the most highly educated, and the least 'captive' members of the community. ^

Notice that nothing I have said prohibits the production of transgenic humans. If a transgenic procedure would make a future human being better off, and if sc ience could benefit from study ing the future individual, I see no obvious reason why that person might not also be the subject of future testing, providing that certain conditions were met. One condition would be that the testing itself would not harm the person. Another would be that the person's informed consent would be required. If, for exam pie, scientists sim ply wanted to observe the TH to find out if the in serted gene had been incorporated or expressed, and if they could make their observations without harming the subject or infrìnging on her informed consent, then doing so would not be impermissible according to either rule (1) or (la).

2. *No worse off THs.* My intuition is that it would be objectionable for scientists to experiment on THs, even with the informed consent of the TH, if the experiment would seriously undermine the well being of the TH. Claude Bernard, a leading nineteenth century phy sician, wrote that the very foundation of m edical morality is "never to carry out on a hum an being an experiment that cannot but be inju rious to him to some degree, even if th e outcome could be of great interest to science, that is to say, the health of other human beings." 2 Following Bernard's principle, we should not inject foreign genes into human ova if we have good reasons to suspect that the lif e of the prospective TH will be worse off than it would have been had it not been tampered with at the embryonic stage.

There are m any things y ou can do to m e without m aking me worse off, because m y well being is not m easured by a single criterion, such as the absence of physical disease. Because welfare is a composite measure of many different variables, and because welfare is ultim ately determined by a person's own feelings of well being, a slight setback in one area can be overcome by gains in another. For exampl e, a patient dy ing of lung cancer might f eel better off than an overworked single mother, depending upon how each person feels about her situation. If the single m other is under financial and em otional stress and constantly battles de pression, she m ay have lower feelings of well being than the elderly worn an who has spiritually and enthusiastically embraced her fate. Assessing welfare is a difficult chore.

But not an impossible one. There are many things I can do to you that will clearly make you worse off, and there are many things you can do to me that will clearly make me better off. To distinguish clear harms and benefits from the vast grey areas that he in between them, it is important to draw attention to our fundamental inte rests, things we must have. Some things are nice to have, but we do not *have* to have them. I would be worse off wit hout income sufficient to pay for violin lessons; I would be worse off without leis ure time to spend with my brothers-in-law going to movies; and I would be worse off without an indoor basketball court on which to practice m y fifteen footer. I take an interest in doing each of these things , and each of them is good for me. But if my violin money, my movie time, or my gym privileges were taken away , I would still be able to flourish by substituting different interests for those listed above. I could have m y wife teach me to play piano instead of paying someone else to teach me violin; I could watch movies at home on PBS instead of taking entire evenings for a night out with the boys; and I could begin jogging around the block instead of playing basketball.

---

^Gorovitz's explanation of Jonas' s position appears in a footnote in Gorovitz, *et al., Moral Problems in Medicine,* 2nd ed., p. 114.

^Quoted in Donagan, "Informed consent," p. 165. Donagan gives the following referen ces: Quoted in R. A. McCance, "The Practice of Experimental Medicine," *Proceedings of the Royal Society of Medicine* 44 (1950): 189-194, and in Irving Ladimer an Roger W. Newman, *Clinical Investigation in Medicine* (Boston: Law-Medicine Research Institute, Boston University , 1963), pp. 48-57.

Things we take a interest in, but to which we have no fundamental right, are nonbasic in terests (NBIs). A transgenic procedure that deprived m e of the ability to play the violin (in which I have an NBI) would not necessarily make me worse off. What would necessarily make me worse off was a transgenic procedure that deprived m e of my ears and, therefore, my ability to hear sounds. The reason is that I have a basic interest (BI) in bei ng able to hear sounds. Here are som e typical human Bis:

— to be able to ingest sufficient amounts of uncontaminated protein and water without undue pain; to be able to eliminate bodily wastes without wasting half the day doing it;

— to be able to maintain sufficient psychological equilibrium that we are able to fall asleep at night;

— to have access to sufficient open space that we can accelerate our heart rates to one hundred odd beats per minute for half an hour three times a week;

— to possess a backbone and neck muscles strong enough that our heads do not need external support;

— to have an immune system not vulnerable to common air borne viruses. ^

Things in a typical human's Bis include:

— clean water, clean air, and nutritious food;

— sufficient room in which to exercise;

— environments capable of stimulating and rewarding the imagination; and

— social conditions congenial to our gregarious, familial, instincts.

If we are deprived of something that is in one of our Bis, then we are by definition worse off. If I am deprived of the capacity to hear musical sounds, or if the genes responsible for gene rating bone cells are harmed so that my skeleton cannot support my body weight, or if my immune sy stem is genetically altered so that I cannot defend myself against common airborne viruses, then I am rendered unable to pursue things that are in m y Bis, and I am worse off for it.[2] To genefacture a TH who lacked the capacity to have these Bis met would violate fundamental human rights.

When our Bis are not thwarted we have the opportunity to flourish, to be happy, to experience feelings of well being. Chances are good that all those reading this paper have access to conditions in which their Bis can be met. Nonetheless, we can imagine how it would feel not to have ears, to be sick all the tim e, or to ha ve immune sy stems that did not work. Our compassion for the victims of deprivation is all the reason we need to trust our intuition that it is wrong to deprive another human of something in theń basic interest unless you have a very good reason to do so. Why shouldn't we produce worse off THs? Because we can all imagine what it would be like to be the worse off TH, and we would not have *that* done to us. What we would not have done to ourselves we ought not to do to others.

I believe that the majority of rational people in western cultures would share these two intuitions about potential rules to guide the production of THs, assuming that they were prope rly informed about the purpose of the experimental science. Note that the rules are consistent with a long tradition of reflec tion in medical ethics, and may be seen as an extension of the time-honored injunctions of the Hippocratic Oath. All things being equal, doctors must not harm their patients, and scientists wanting to produce a harvest or worse off TH should be obligated to justify their position.

While I believe m ost will agree with these claim s, I do not believe that m ost will agree with the next one, so I will spend the rest of the paper defending it. That claim is: *The two rules about the production of THs should apply to the production ofTAs.* My argument for this claim has two parts. In the first, I discuss the powerful objection that "animals are obviously different from humans," and I examine the most common reasons offered in support of that claim. In the second, I

^Comstock, "Should We Genetically Engineer Hogs?" p. 4.

^As I have noted, welfare is diverse, and not all interests are basic; it is not unusua 1 to sacrifice one NBI in order to pursue another. On occasion, we can even live without things in our ba sic interests, but this is true only in the short term. For example, survivors of mine care ins have proven that individuals can live in extremely close quarters, sometimes for an extraordinarily long time. However, when our Bis are not met over the long term, we survive only through processes of compensation. Survivors of cave-ins who are confined too long may survive, but their psyches may be so scarred that th ey suffer psy chological disorder for the rest of their hves. Bis are truly *basic,* even if you can survive for some time with one or more of them going unsatisfied.

argue that the obligation not to thwart individuals' interests is m ore than *prima facie*; it is so weighty that it needs no justification. Killing for trivial reasons, the worst form of thwarting an individual's interests, needs to be justified by the person wanting to kill. Those opposed to killing need not assume the burden of proof.

"But Animals are Obviously Different From Humans"

This objection to my claim that the rule governing production of THs should also apply to the production of TAs is powerful because it is true. Anim als *are* obviously different from humans. The question we must answer, however, is whether the difference between us is great enough to jus tify us in believing that we should protect all of us while being free to kill any of them. After all, *we* are not all alike, yet morality enjoins us not to be unfair. Humans differ greatly from each other, yet we do not take that as an excuse to discrim inate against dum ber, less sensitive, or weaker people merely because they have a deficiency in intellectual capacity , aesthetic sensibility, or phy sical strength. In order to justify a difference in treatm ent of TAs and THs, we must be able to point not merely to differences between the s pecies, but to differences that are morally relevant. In order to justify the production of worse off TAs, the difference between us and them would have to be so great that it would serve to justify the act of undermining their welfare. In order to justify the production of harvest TAs, the difference between them and us will have to be so great that it will serve to justify the act of producing an animal in order to kill it at a young age.

The history of philosophy and theology knows several answ ers to the question of which differences between humans and animals are morally relevant. The strongest answers are: only humans have souls, only humans are rational, and only humans have m oral rights. Alan Donagan identifies each of th ese candidates in dis cussing the bas is of inform ed consent laws. According to Donagan, the main reasons usually offered as a basis for respecting humans are:

1. that in nature as it is known to us, human beings have a dignify and worth that is unique;
2. the Kantian principle that a human being is never to be us ed merely as a means, but alway s at the s ame time as an end; and
3. a principle laid down in the Declaration of Independen ce...that every human being is endowed with an inalienable right to life, liberty, and the pursuit of happiness. 1

Let us examine these reasons in turn.

The first reason holds that humans are unique, and have special "dignity and worth" simply because they are members of a particular species. This reason is attractive because many human beings do not m easure up to the high s tandard laid down in Donagan's second principle: a fetus in the ninth month, a neonate, the mentally enfeebled, the aged Alzheimer[1] s patient, and those in apparently irreversibly comatose stat es. These so-called "marginal humans" are not rational human beings, but they constitute a group that any system of morality ought to protect. However, they will not be protected if only the rational among us are legitim ate objects of m oral concern. D onagan's first principle is attr active, then, because of its inclusiveness; y ou can easily generate an obligation to protect neonates and mentally enfeebled humans if the only requirement for such protection is that they be human.

But there are two problem s with this way of justifying the protection of innocents. First, there may be other innocent beings that we should protect, and y et this principle offers us no basis on which to protect them. Suppose there are other beings in the universe of whom we do not presently know, beings that are at least as caring and rational as we are. Think of a science fiction example, of ET, the extraterrestrial. If ET la nded tomorrow, shouldn't we have in place a system of morality that would extend moral protection to him? But if we hold that membership in the human species is a necessary requirement in order to be protected morally , then we could not protect ET without radically changing our beliefs. Indeed, we would be justified in killing ET for the same sort of trivial reasons we kill stray ants in our kitchen; the creature "just bugs us," it's "out

1 Donagan, "Informed Consent," pp. 321-327.

of place," it "doesn't belong in the house." But it would be brutish to kill a being as sensitive and compassionate as ET simply because his unusual shape rubs you the wrong way, or because you want to look at his insides, or because y ou'd like to know how his cooked flesh might taste. The first problem with Donagan's first principle is that it fails to protect all innocents.

But why, you might respond, protect all innocents? Not everyone shares the intuition that we should protect them, not even among animal liberationists. Peter Singer, for example, denies that "gross mental defectives" have a right to life equal to an ordinary adult's right to life. He holds this view because of his anti-speciesist belief that "m erely being a m ember of the species *Homo sapiens* cannot carry with it any special moral status." ^ Singer's position is a radical one; he is unsure whether his position can protect the mentally enfeebled, and he seems in dined to believe that we must be ready to change our attitudes toward marginal humans:

> [My position] involves holding that mental defectives do not have a right to life, and therefore might be killed for food — if we should develop a taste for human flesh — or (and this really might appeal to some people) for the purpose of scientific experimentation.^

But insofar as a society has it within its resources to care for mental defectives , it ought to do so simply as a way of demonstrating its humanity . I do not disagree with Singer that" *gross* m ental defectives" m ay lack a m oral right to life, assuming that the individuals in question truly lack sentience, consciousness, and all conative live. It m ay be that gross mental defectives who lie in perpetual and irreversibly comatose states lack even the m ost basic of moral rights. But where Singer goes wrong is in thinking that m oral rights are the only fence protecting such individuals from being killed for trivial reasons. Even grossly defective humans may be morally valuab le for reasons that cannot be captured in the language of moral rights, so I disagree with Singer that the proper response to the marginal human problem is to revise common morality so as to exclude m arginal humans from the protections morality offers. The proper response is to figure out what all but the most grossly m arginal hum ans have that allows them to be included in m orality's protections, and then to extend those protections to all other beings that have what they have.

The second problem with holding that all and only human beings are unique is that it fails to tell us *why* being human is sufficient to m erit special protections not afforded to othe rs. In order to justify a differe nee in m oral treatment between species, there must be some relevant moral difference, some capacity , X, which only humans possess, which no nonhumans possess, and which succeeds in entitling us to preferential tr eatment. What might X be? Theologians have traditionally thought of X as "a soul," or "God[1] s image," and attributed our sacredness to that unique char acteristic. The problem here is that many religious people disagree that only humans have souls. Hindus, for exam pie, hold that animals have souls and within Judaism and Christianity, many agree. The Catholic saint, Francis of Assisi, held that animals have souls, and so do C.S. Lewis and Andrew Linzey , recent Anglican theologians. So there is not a consensus in Christianity , much less among the world's religions, that animals lack "X," where X is "a soul."

There are secular way s of try ing to identify a unique hum an quality. Kantian and contractarian philosophers think of free will, or autonomy, as the X which entitles us to be treated as ends in ourselves. Autonom y is defined in various way s,

---

1 Peter Singer, "Animals and the Valu e of Life," in Tom Regan, ed. *Matters of Life and Death: New Introductory Essays in Moral Philosophy* (New York: Random House, 1980), p. 245.

^Ibid. Singer provides two other possible positions, but rejects the first one because he does not believe, as Tom Regan does, that all humans have an equal right to life. He is doubtful about the third position, that marginal humans and animals

> have some kind of serious claim to life - whether we call it a "right" doe s not matter much — in virtue of which, while we ought not to take their lives except for very weighty reasons, they do not have as strict a right to life as do persons. In accordan ce with this view, we m ight hold, for instance, that it is wrong to kill either mentally defective humans or animals for food if an alternative diet is available, but not wrong to do so if the only alternative is starvation, (p. 246)

Singer hesitates to adopt this view because he is not sure that the replaceability argument can be met. That argument holds that lives are replaceable, and the pleas ures that one hum an or animal may experience may be replaced by the pleasures of another human or anim al should the first individual be killed. I believe this argum ent can be m et by seeing that m odified form s of utilitarianism will not ultimately protect innocents, but I do not have room to make the case here. See Evelyn Pluhar, "Utilitarian Killing, Replacement, and Rights," *Journal of Agricultural Ethics* 3 (1990): 147-171.

but many of the following human characteristics play central roles in the arguments of Kantians: free will, our ability to make choices, to exercise our will so as to pursue our own conception of the good life without infringing on the ability of others freely to pursue their conception of the good life. The Kantian view is that all and only humans are autonomous agents, and on this basis we are uniquely entitled to be treated as ends and never as means only.

The marginal human problem plagues this response too, because this response does not protect those hum ans who are neither rational nor moral agents. Marginal humans do not have what it takes to think for them selves, make their own choices, or form and pursue their own conceptions of the good life. Yet they have desires, needs, and feelings. So a system of morality that not only fails to protect them, the most frail and weak among us, but which actually *excludes* them as objects of legitimate moral concern, hardly qualifies in m y mind as a "m oral" sy stem at all. Perhaps m orality should not protect the grossly marginal. But any one who is able to take an intere st in som ething is a m oral patient, and m orality should protect them, even if they are *not* autonomous or rational. ^ I conclude that the first two principles traditionally offered as reasons for denying nonhuman animals moral consideration are seriously flawed.

Donagan's third reason is not flawed in the way the firs t two are, and I want to defend the line of reasoning that innocent humans should be protected because they have rights. A coherent and widely adopted conceptual paradigm of moral rights ties the possession of such rights to the possession of interests. If we adopt th is paradigm, one way to try to justify differences between our treatment of humans and our treatment of animals goes as follows. Begin with the intuition that there are two kinds of things in the world: persons with basic mo ral rights, and nonliving things without basic moral rights. The paradigm case of something gin the first category is the adult human being, who po ssesses what I shall call the most basic moral right: *The most basic moral right (MBR) is the right not to be destroyed for trivial reasons.* We have strong objections to those who would lightly kill other hum ans. To riddle som eone's body with bullets simply because you saw it done in a movie is to violate the victim's MBR.

The paradigm case of something in th e second category is a worn out machine. We do not have, and should not have, strong objections to those who would destroy a rusted out Corvair in an auto graveyard simply because they had seen it done in a movie. We might object to their wantonly riddling the windshield with bullets on the grounds that it suggests weakness in their character, but we cannot object on the grounds that the action would violate the car[1] s MBR because cars, like m ost objects, have no moral rights at all.

Between the paradigmatic cases of things without the MBR and persons with it fall a vast range of problematic cases, including grossly and lightly marginal humans, fetuses, super smart computers, extraterrestrials, trees, plants, rivers and, of course, animals. Western cultures have traditionally put animal s into the category of machines, and denied them the MBR. But has the tradition been right to do this? To decide that question, we must figure out why it is that all but the most grossly defective humans have the MBR, while old Corvairs do not.

We have already seen that the old dividing lines fail b ecause they are drawn too high, and leave marginal humans unprotected. We need a lower line, perhaps sentience. Humans have feelings, whereas cars do not, so cars, incapable of *feeling* harmed, cannot be harm ed. This line is m ore prom ising than the old lines, but it still excludes too m any hum ans, humans who cannot feel harmed because, say, their sensory receptors have been damaged. A second line, and the line I ant to defend, may be drawn at "having interests. " All but the most grossly defective of humans can take an interest in things, and initiate actions, however humble, in order to acquire them. All but the most marginal of humans can *take* an interest in things they are feeling or thinking, and can be conscious of things they lack. When we want something, and try to think of way s to

---

1 Elsewhere I have argued that being autonom ous is not a n ecessary characteristic for having m oral standing because a good many *adults* turn out not to be autonom ous according to at least one philosophical definition. See Gary Comstock, "The Moral Irrelevance of Autonomy," *Between the Species* (forthcoming).

get it, we are exhibiting desire, "taking an interest." As G.E.M. Anscombe puts it, desiring is *"trying to get".*[1] Following Tom Regan, I will call these kinds of interests "preference-interests."[2]

To have preference-interes ts is to have the X needed to possess the MBR. To have preference-interests is to have projects, intentions, a future, and for someone to deprive y ou for trivial reasons of y our future is to violate y our most basic right. Now s ome preference-interests are bas ic, while s ome are not. An interest in getting water to drink is basic if you are dying of thirst, but not if y ou are uncomfortable at a dinner party and reach for a glass merely out of nervousness. An interest in moving my arm is basic if I am warding off an attacker, but not if I am stroking my son's hair as he falls asleep in my arms. Notice, however, that it does not matter whether the desire I am now pursing is fundamental or not. *Merely having* a preference-interest, no matter how humble, is sufficient to make me a possessor of the MBR so long as my current preference-interest does not conflict with someone else's BI.

What about plant life? A few y ears ago the actor Mr. T cu t down a stand of beautiful old oak trees on his property in suburban Chicago because they made his place "look cluttered. " Most of us believe that we can cut down trees for good reasons, such as to make desks and houses, but even Mr. T's trivial reason does not seem to infringe on the tree's moral rights because trees do not have m oral rights. Should they ? It is too quick to answer no, that trees lack interests and therefore should lack m oral rights, because there is a sense of "interest" in which trees clearly have them. It is *in* a tree's interest to exist in an environm ent in which it will receive sufficient s unlight, avoid prolonged drought, and not be subject to deadly pathogens. All of these things are good for trees; they contribute to a tree's welfare.^ So if trees have interests, then are they not proper candidates to posse ss mora 1 rights? ^ I think the answer must remain no, but my reasons cannot be clarified without distinguishing a second sense of the term.

Even though we talk about things that are *in* a tree's interests, we do not talk about things trees desire or prefer. There is a second sense of interest at work here , which Regan labels "welfare-interests," that is, interests the satisfaction of whic h contributes to some living thing's well being. There are things that are good or bad for living things with welfare-interests, but such living things do not necessarily have the MBR. To have the MBR a thing must have preference-interests because we get absurd results if we attribute the MBR to things that have welfare-interests only. If all living things had the MBR, then amoeba and viruses and weeds w ould possess a moral right to life and it would be morally impermissible to thin lettuces in our garden, kill cockleburs in our cornfields, or spray Ly sol on our toilet bowls. I take these consequences to be counterintuitive, and to indicate that something is wrong with attributing rights to things that lack preference-interests. There are good moral reasons to protect oak trees in suburban Chica go and even better reasons to protect seven hundred y ear old cedar trees along Opal Creek in Oregon, but the language of moral rights is not the language in which to do it.

The Burden of Proof Is On the Killer

I have given my reasons for believing that nonliving objects lack the MBR, and that all but grossly defective humans possess the MBR. Thus, I have presented argum ents for my views. I have also said that I think it is plainly wrong to kill humans for trivial reasons. But, someone might ask, why do I think *that*? This might seem a difficult question, but I am convinced that it

---

1 G.E.M. Anscombe, *Intention,* second edition (Ithaca: Cornell University Press, 1963),__36, emphasis in original. Citation and reference taken with permission from Gary Varner, "Localizing Desire," chapter two of an unpublished manuscript, p. 52. Varner is an assistant professor in the Departm ent of Philosophy and Hum anities, and a research associate in the Center for Biotechnology Policy and Ethics, Texas A&M University, College Station, TX 77843-4237.

^Tom Regan, *The Case for Animal Rights* (Berkeley: University of California Press, 1983), p. 87.

%or clarification of this point, I am indebted to conversations with Ned Hettinger and Gary Varner. But I believe their views about the consequences of this claim, and particularly about whether plants have moral standing, differ from mine.

^Varner argues that "having desires cannot be a necessary condition for having m oral standing" because neonatal hum ans have moral standing but, even though they probably can feel pain, "they probably cannot desire to end it" (Varner, p. 89). I agree. Having desires, on my analysis, is a necessary condition for having moral rights. A 11 sorts of living individual beings may have the weaker status of possessing moral standing, including three month old fetuses and 700 y ear old trees, but probably not rivers neither has nor needs an answer. The claim that it is wrong to destroy human beings for trivial reasons needs no more justification than the claim that it is wrong to cause humans pain for trivial reasons. Pain hurts, and that is that. Death end s a life, and that is that. The burden of proof is on those who think inflicting pain or death for trivial reasons *is* m orally permissible. Steve Sapontzis quotes William James to this effect: "Take any demand, however slight, which and creature, however weak, may make. Ought it not, for its own sake, to be satisfied? If not, prove why not."l

The obligation not to thwart preference-interests, no matter how humble those preference-interests may be, is more than a prima facie obligation; it is so weighty that it needs no further argument.

> Ethical reflection means giving reasons for our judgments. When we say *X* is wrong, others are justified in asking us why we think that. When we give a reason, that reas on m ay be form ulated as a general moral principle. But our partners may want to know why that principle is true, and may justifiably ask us to ground our reasons for our decisions in some more basic, ultimately vindicating, reason. The work of ethics proceeds this way , with claim s being grounded in reasons; and reasons in principles, and principles in theories.
>
> But the dialectic of ethics does not go on forever, at s ome point we reach what is, for us, the true ultimately vindicating ground of our reasoning. When we reach this ground, others will ask us why we rest on *that* ground, and we may be tempted to try to provide a reason. We should resist this temptation, because, if we have truly reached bedrock, there is nothing further for us to say . W ittgenstein once remarked that the most difficult part of justifi cation in philosophy is to recognize a justification *as* a justification, and to stop.^

The wrongness of destroy ing desiring creatures for trivial r easons is such a stopping place. W e need offer no further justification for *why* we believe this to be a stopping place, for if we cannot assume that riddling someone with bullets merely because that person looks "out of place" is alway s and irre deemably evil, then we have no place to begin reasoning about tougher cases. The burden of proof is clearly on those who think that destruction of humans for trivial reasons *is* permissible.

We may, of course, destroy desiring creatures for non-trivial reasons. If other obligations conflict with the obligation not to des troy, then we s hall have to decide which obliga Hon takes precedence. M y obligation to feed m y family might conflict with m y obligation not to kill a buffalo, in which cas e the killing m ight be justified. My claim is not that the obligation not to kill anim als for food is unexceptionable, but rath er that it has the sam e status as the obligation not to kill human beings. It may be overridden by other obligations, but it may not be *lightly* overridden. A preference-interes t for the taste of meat, when other sources of nutr ition are available, is not a weighty enough preference-interest to justify depriving cows and hogs and chickens of their futures.

Some hold that killing for trivial reasons is not wrong if it involves killing a being that has only brief, short-term , desires. Ruth Cigman, for example, holds that killing is wrong onl y insofar as the victim is capable of having what she calls "categorical de sires," de sires in which the victim is not "blindly clinging on to life," but in which it also "possesses the related concepts of long-term future possibilities, of life itself as an object of value, of consciousness, agency and their

---

or mountains.

1 William James, "The Moral Philosopher and th e Moral Life." in Essay s in Pragm atism. edited by A. Castell (New York: Hafher, 1948), pp. 65-68, at p. 73; quoted in Vamer, "Localizing De sire," p. 50.1 agree with Varner, that "desireless organis ms nevertheless have interests," but not with his further claim that "it would not be necessary to show, as James asserts, that another creature's desires run the other way , but onl y that its interests run the other way , whether those interests are generated by i ts desires or something else." To attribute basic moral rights to plants, which, 1 agree, have welfare-interests, rather than only to animals, which have preference-interests, will lead to the count er-intuitive results mentioned in the text. Various organism s in my bodily fluids have welfare-interests, but no right not to be destroyed for trivial reasons.

^Comstock, "Should We Genetically Engineer Hogs?" p. 9.

annihilation, and of tragedy and similar misfortunes." ^ Humans are able to have these sophisticated concepts and desires, and death harms them by depriving them of their categorical desires.

I have argued that the mere having of de sires is sufficient to establish a moral right not to be blocked for trivial reasons from pursuing those desires. It does not matter whether the desire s in question are long-term, categorical, desires, such as wanting to write a book, or short-term, "humble" desires, such as wanting to con tinue stroking my son's hair. You have a basic moral right not to have others interfe re with y our preference-interests, whether they be basic or not basic, so long as their satisfaction does not conflict with the welfare of another desiring creature. The wrongness in killing a cow to eat it when your basic interest do not depend on y our killing it, then, is simply this: In killing it, y ou deprive it of the ability to pursue whatever is its current preference-interes t, which m ight be its desire to finish chewing the cud currently in its sy stem or, alternately, to relieve its present anxiety by getting out of the slaughter house confinement pen. In killing an ape, you deprive it of the ability to finish what it now wants to do, which m ight be stroking his son's hair as he falls asleep. The reason the Beltsville hogs were tampered with at the em bryonic stage was to produce brave new pigs that would grow more quickly to slaughter weight, and the purpose of much TFA research is to produce animals to be killed for meat. What is wrong with this research is not that it involves gene splicing but, rather, that it is aimed at morally objectionable goals.

What Obligations Have Scientists to Transgenic Animals?

This way of thinking suggests a criterion to use in deciding about the in-between cases of fetuses, neonates, the severely retarded, and anim als. The criterion is: *does an individual have preference-interests?* or, more simply, *does the individual have desires?* To answer this question requires separate empirical investigation of each of the ambiguous cases.

Do nonhuman animals have desires? Drawing on pioneering work by Gary Vamer, I want to suggest that the answer will differ from species to species. ^ The reason is that so-called lower species, which have welfare-interests, almost certainly do *not* have the phy siological equipment necessary to have preference-interests. On the other hand, so-called higher mammals almost certainly do have the physiological equipment necessary to have preference-interests.

Just what is it to have desires? Vamer recommends the following analysis:

A sentence of the form *"A* desires A"' is hue if and only if:

1)/l is disposed to pursue A?

2) *A* pursues *X* in the way he, s he or it does becaus e *A* previously engaged or concurrently engages in practical reasoning about how to achieve *X,* where engaging in practical reasoning includes both drawing inferences from beliefs of the form" *Y* is a m eans to A'," and the hy pothesis formation and testing by which such beliefs are acquired and revised; and

3) this practical reasoning is at least potentially conscious. ^

There are good reasons to accept Varner's analysis, including the one he mentions in his paper, namely that this analysis "has been widely accepted by the principals on either s ide of th e animal rights debate," including Tom Regan and R.G. F rey. Assuming that Varner's account is correct, it becomes important to determine which species engage in behaviors that suggest they are capable of engaging in practical reasoning. Conscious practical reasoning, Vamer suggests, is evidenced not so much by consciously entertaining beliefs and sy llogisms, as some opponents of animals rights have it, but rather by hypothesis formation and testing, activities not involved in things we or animals do routinely^ Conscious practical reasoning

1 Ruth Cigman, "Death, Misfortune and Species Inequality," *Philosophy and Public Affairs* 10 (1980): 59.

^For information on Varner's manuscript, see note 30 above.

^Varner, "Localizing Desire," p. 52.

^Several philosophers have attacked the view that we should a ttribute moral rights to animals by arguing as follows. T possess moral rights y ou must posse ss preference-interests, to posse ss preference-interests you must possess *beliefs* as well as desires, and to possess beliefs y ou m ust possess language; but anim als do not possess language because they are incapable of communicating verbally, because they cannot formulate propositions because they cannot distinguish hue and false beliefs, and requires a level of intellectual activity that goes bey ond habit and instinct, and is only found when a being turns its attenti on to the conditions and obstacles bearing on its desires. Here is Varner's explanation of conscious practical reasoning:

> Rarely do we consciously entertain the major and minor premises of an Aristotelian practical sy llogism, "cold beer would be good; there is cold beer for sale down the street at Ralph's," before acting out the conclusion: walking to Ralph's. But we do commonly devote conscious attention to the form ation and testing of hy potheses relevant to the fulfillm ent of our desires. A beer drinker in a new city devotes conscious attention to the formation and testing of th e minor premise, "there is cold beer for sale down the street at Ralph's," and, in ge neral, when one first seeks to fulfill a new desire, or when changing circumstances m ake it im possible to fulfill an exis ting desire by habitual m eans, one consciously entertains and tests hypotheses about what means are conducive to one's ends.

Conscious practical reasoning consists of entertaining and testing hypotheses as a way of overcoming obstacles and try ing to get what you want. Commenting on the importance of this matter to the animal rights question, Vamer adds that

> it is the special kind of learning involved in hy pothesis formation and testing th at separates desire from instinct and simple habit. And, as we shall shortly see, showing that an anim al is incapable of this kind of learning is the easiest way to show that it is incapable of having desires. ^

The empirical task, then, is to exam ine the behavioral and the phy siological evidence for different s pecies, and to try to determine which species are capable not simply of movement, which can be attributed to instinct and habit, but of the kind of learning involved in hy pothesis formation and testing. Varner's review of the availa ble empirical evidence leads him to this conclusion:

> Fish and lower animals almost certainly do not have desires. Mammals almost certainly have desires, and in them, the practical reas oning characteristic of desire is localized in the prefrontal cortex. Birds probably have desires (although the case for saying that they do is somewhat weaker than that for saying that mammals do), and in birds, practical reasoning is localized in the hyperstriatum. Reptiles may have desires (although the case for saying that they do is decisively weaker than that for saying that birds do), and if reptiles have desires, the related practical reasoning is lo calized som ewhere in the prim itive reptilian cerebrum.^

How does this line of reasoning apply to the question in the title of this paper? The moral obligations scientists have to TAs will depend on the level of sentience and consciousness possessed by the anim als with which they are working. It is wrong to cause pain for trivial reasons to any sentient animal, including fish. The r eason is simply that pain is bad and 10 units of pain are 10 units of pain whether I suffer them, or you suffer them, or a rainbow trout suffers them. Here it does not

---

because they cannot lie. For such argum ents, see R. G. Frey , *Interests and Rights: The Case Against Animals (Oxford'.* Clarendon Press, 1980); Michael P.T. Leahy , *Against Liberation: Putting Animals in Perspective* (Routledge, date unknown), Peter Carruthers, "Brute Experience," *Journal of Philosophy* 86 (May 1989): 258-269; and Donald Davidson, "Thought and Talk," in *Mind and Logic*, S. Gutterplan, ed. (Oxford: The University Press, 1975), pp. 7-23. There are two way s to respond to these arguments. The first is to deny that "language possession" consists of formulating propositions. As Vamer argues, a being can engage in practical reasoning simply by formulating and te sting hy potheses, even if it ca nnot articulate those hy potheses. The second is to point, as Singer does, to instances of animal behavior in which an imals are try ing out hy potheses, as when Figan, a y oung chimpanzee, waits fifteen m inutes for Goliath to move, then quietly moves in a nd retrieves a banana. Peter Singer, *Practical Ethics* (Cambridge University Press, 1979), p. 96; cited in Singer, "Bandit and Friends," *The New York Review of Books* 39 (9 April 1992), pp. 9-13, at p. 10. Singer refers both in his book and in his article to Jane Goodall, *In the Shadow of Man* (Boston, 1971), p. 107.

1 Vamer, "Localizing Desire," p. 55.

^Varner, "Localizing Desire," p. 76. Vamer refers in an end note to the work of M.E. Bitterman, "The Evolution of Intelligence," *Scientific American* 212 (January, 1965), pp. 92-100, and comments that "Bitterman did not do lesion studies to determine where in the reptilian cerebrum the ability for progressive adjustm ent is localized. But given that in both m ammals and birds, the ability is localized som ewhere in the cerebrum (rather than in, say , the midbrain), it is reasonable to assum e that the ability for progressive adjustment is localized somewhere in the cerebru m of the reptiles, from whom both the birds and the m ammals evolved" (p. 84, note 29).

matter that y ou and I can desire for the pain to cease, whereas the trout apparently cannot. Thus, all TA research on sentient animals should be bound by the worse off rule.

But research on animals that lack preference-interests n eed not be bound by the "No harvest TA" rule, even if the animals are sentient. Therefore, I presently see no valid objections to research that is aimed at the goal of producing harvest fish, assuming that the fish are killed painlessly . My reason is that fish appear incapable of conscious practical reasoning. Without conscious practical reasoning, fish cannot have desires or preference-interests. Fish clearly have welfare-interests, clearly feel pain and pleasure, and clearly will continue to live if the fisherman hovering over them does not kill them . But fish seem to survive off of instinct and ha bit alone and, so, apparently do not and cannot *want to get*.; they apparently do not and cannot *look* forward. Thus, while it is still wrong to cause them pain, it may not be wrong to kill them painlessly. Doing so would not deprive them of any of *their* basic interests.

If I am right, scientists producing transgenic fish and lower organisms should not make worse off TAs, but may make harvest TAs.

It is important to point out, however, that fish and lowe r organisms are not the target animals for those doing TA and TFA research. The mouse is the most popular animal, and mice, along with rats and apes and cows and horses and sheep and goats and s wine, clearly have preference-interes ts. S dentists working with thes e s pecies need not neces sarily call a moratorium on all of their research, but they do need to abide by both rules. The burden of proof is on them to show that their research does not involve making the TAs worse off, or killing them for trivial reasons.

What about scientists working with bi rds, reptiles, amphibians, and other in-between species? Our decisions on those species must wait on further empirical work. Meanwhile, we should err on the side of caution. Thus, I recommend: No harvest or worse off higher mammals, birds, or probably, reptiles. Fish and so-called lower organisms may be used as harvest TAs, but only if they can be killed painlessly, and only if they are not made worse off by the procedure.

Conclusion

The "Consultation on Life and the Environm ent" has apparently taken a position of unqualified opposition to TA research, while the U.S. government has apparently taken a position of unqualified endorsement. In contrast to both positions, I believe that some TA research is morally justified, and some is not. How y ou decide which is which depends on where y ou draw the line between animals with the most basic of moral rights and animals without it. I have argued that the line should be drawn at preference-interests, defined in term s of desires and conscious practical r easoning. Scientists producing transgenic creatures capable of practical reasoning should be bound by the "No harvest" and "No worse off" rules that apply to the production of transgenic humans. Scientists producing TAs that ar e sentient but lack the ability to have preference-interests may make harvest TA's, but should observe the "No worse off' rule.

The Beltsville hog experim ent was undertaken in order to produce more efficient slaughter anim als. The experiment produced transgenic hogs that were deprived of the capacity to pursue things in which they had a BI. On my view, scientists pursuing lines of TA research have the opportunity to st rengthen and enrich the 10,000 y ear old bond that has evolved between us and the s pecies we have we have dom esticated, a nd they are m orally justified in their res earch. But thos e pursuing TA research that involves the production of "Beltsville " animals, animals that wind up worse off than the anim als they would have been had they not been tampered with at the cellular s tage, are not m orally justified in their research. Neither are those pursuing research in which the target animals are creatures with fu tures who, nonetheless, are being raised only to be slaughtered at a young age.

And, finally, what about the living egg machine? Assuming that the new birds could be created with a snap of the fingers, scientists would have no obligations to them, since "the birds" have neither feelings nor a future. Moreover, to snap our fingers and have living egg machines would be good insofar as it would provide humans with excellent sources of protein with removing the need for factory farm real chickens . F actory farm lay ers are blocked from pursuing their preference-interests for trivial reasons, and instant living egg machines would remove from the moral universe these utiles of disvalue without, presumably, introducing new utiles of disvalue.

But let us come back to reality. As any molecular biologist can tell you, genetic engineering is not done with a snap of the fingers. So agbiotech researchers should adopt the living egg machine as a goal only if they think they can go from a chicken to an egg machine in a single generation, without bringing into the world even one generation of "Beltsville" chickens. And any biotechnologist who genuinely thinks that that can be done should either be given a new lab, more research assistants, and lots of money, or, lots of sedatives.

The most prominent lines of TA medical research require the production of worse off animals who are sentient, while the most prominent lines of TFA research require the production of harvest animals who have futures. If my arguments are valid, scientists pursuing transgenic animal research are not obliged to give up TA research. They are obliged to give up its currently most prominent lines.

Biotechnology and Sustainable Agriculture*

Martha Crouch

Associate Professor, Department of Biology
Indiana University
Bloomington, IN 47405

"This is an edited version provided by the author. The full text appeared in *Ag Bioethics Forum* 4, June 1992, pp. 5-6.

What is sustainable agriculture? *Sustainable* means capable of being repeated over and over without diminution. *Agri* means land. *Culture* is an active way of living, a set of behaviors that allows a group of people to live in a unique place. Therefore, sustainable agriculture allows people to make a living from the land without diminishing cycles that characterize it: nutrient and water cycles, disturbance and restabilization cycles (e.g., fire and regeneration, gap and enclosure), predator and prey, symbiont and host, life and death relationships. Note that sustainability does allow impact and change. What it means is that the activities of humans become part of the cycles of a place in a way that allows the whole system to continue to function and exist. Integrity is preserved.

Our species began to experiment with agriculture as a way of life about ten thousand y ears ago, and now most of us obtain the bulk of our food from agriculture. Compared to gathering a nd hunting, the impact of agriculture on ecosy stems has been great. However, there are examples of agricultures that have functioned well fo r at least hundreds of y ears. Given the arrogance of industrial culture, we don't know as much about how other agricultures function as we should. Since industrial modes of growing food have not proven to be sustainable, it seems reasonable to learn as much as possible about how others have done it. Examples include traditional Hawaiian poly culture (Cuddihy and Stone, 1990), Mexican Zapotec maize culture (Flannery and Marcus, 1976), shifting poly culture in the Am azon (Clay, 1988), and Peruvian terrace farm ing (Sandor and Eash, 1991). Although each system is unique, there are some generalizations that can be drawn.

1. The culture is finely attuned to the cy cles of the place. People put great value on intim ate knowledge of the place where they live.
2. The people who use the land for gathering or grow ing food depend for their lives on wise use of the land. They have a direct and perceivable stake in sustainability.
3. Agricultural technologies are developed by the people themselves, and thus can be adjusted relatively quickly in response to success or failure.
4. The community uses many types of food to provide security. This is a co mmon strategy: if one crop fails the community still has many other sources of food on which to rely.
5. The culture guides individual behavior with rituals, distinctions between sacred and profane, and careful teaching. This is how the community ensures intelligent action by individuals.

A recent description of rice growing in Liberia illustra tes some of these points (Thom asson, 1991). Around 400 y ears ago, Kpelle people moved into Liberia' s rainforests and began to grow newly introduced Asian rice. They developed a sophisticated agricultural technology based on rainforest swidden fields which, until recent export-oriented plantations and wars intervened, had sustained them without destruction of the rainforest ecosystem. One of the hallmarks is genetic diversity of rice, with m ore than 100 varieties m aintained in each villa ge. Each variety is adapted to very specific local conditions: slope, rainfall, soil ty pe. No external inputs of fertilizer or pest-control chemicals are used. The diversity ensures som e harvest in the face of unpredictable weather, pests, and so on. Breeding, selection and m aintenance of the gene pool is a conscious process carried on by the women and carefully taught to the girls. Men produce steel tools capable of working the tough rainforest fields via an alloy process developed by themselves. Kpelle steel production becam e a source of regional trade income. Both the genoty pes and tools are developed by the people who use them , for their own com munities, and the ability of the Kpelle to survive depends on the success of these activities.

The importance of culture guiding individual behavior is central. In the Zapotec system in Mexico, for example, early rainfall patterns are good predictors of total rainfall in the co ming year. "When May - June rainfall indicates a wet year, the

Zapotec response is not what a Western ag ronomist might expect, but it is consiste nt with their "harmonizing" ethic. Predicting that yields will be higher than average, the Indian actually reduces his maize planting in the...m ain agricultural zone..." The goal is to produce enough but not too much com. "Indeed, the traditional Zapotec farmer seeks not to maximize his annual crop but...(to grow) enough to m eet the subsistence a nd ceremonial needs of his family, but no more." (Flannery and Marcus, 1976). The rehgion and cosmology of the Zapotec support this practice.

In all of these cases, people have direct incentive to us e the land wisely, they have the power to do so, and they have the knowledge to be able to participate in feedback loops.

What underlying rituals and cosmologi es guide technological agriculture, and who has the power and knowledge to respond to feedback? In technological societies such as ours, the world revolves around global industrialism. Our view of the world does not im bue the land with sacred qualities; all things are profane (for sale). Healthy economies are m easured by their expansion, and progress is a linear rather than cy clical process, most food production in our societies can be described as agribusiness. In agribusiness, profit is the main product, a nd food is the means to get profit. Culture has been uprooted as the sense of place has been taken out of the picture: the varieties and techniques are deemed successful to the extent that they can be applied to vast areas, rather than specific locales. Less than 5% of the population is involved directly in growing food, so very few people have the opportunity to see what happens on the land. Thus the knowledge to response to changes is in the hands of a small fraction of the comm unity. The rural people who see the water, soil, and organisms on a daily basis are often not the same ones who have the power to respond, because urban-generated global market forces drive the adoption of genotypes and practices. Researchers who ha ve often never seen a field produce technologies which are then used by people who do not understand them, and cannot easily modify them. Also, since the consumers of food are not the same people who produce food, the urgency of agricultural crises is not apparent to most members of society.

Monocultures are a logical outcome of the business worldvi ew. The best producers are those who are most efficient. Farmers purchase high yield seed varieties and then apply fertilizers, herbicides, and pesticides to realize the promised yield. Individuals have little knowledge of the consequences of their actions. They simply look at the size of the yield and then follow directions provided by agribusiness. The feedback 1 oop is long — sometimes it must wind through five levels from farmer, salesman, distributor, corporati on, and research division — creating a slow response time. A nd the incentives are divorced from the needs of a specific place.

I contend that sustainable agriculture cannot be attained as long as the primary purpose of growing food is to make a profit. In order to sustain profits, busin ess requires expansion, excess production, and increasing consumption. Sustainability requires an emphasis on subsistence and lo cal m arkets, and a com mitment to livi ng within limits. Given this vision of sustainable agriculture, what can be predicted about the role of biotechnology? Biotechnology as a whole is not likely to help us shift the focus of our agriculture from making profits in a global market to supply ing the local economy and feeding people as the main incentive.

First, biotechnology requires a large, complex industrial infrastructure. Purifi ed enzy mes require rapid, refrigerated transport; information about genes is stored and manipulated in computer networks; chemicals and machines used in isolating DNA, maintaining constant temperatures for tissue growth, and so on, all rely on chemical companies, centralized and inexpensive energy sources, and efficient marketing. To maintain and expand the infrastructure required to do biotechnology research and then to im plement the results will be easier for people already well established in that network Their interests are to maintain the *status quo*, not to shift the balance.

It also requires special expertise to develop and use biotechnologies. People have to be trained for y ears in Western science. For rural people, this usually means that they have to go to universities in urban areas or foreign countries. There they are trained to be urban industrial c onsumers. Talent is removed from the local level, with a concomitant loss of respect for the local knowledge of how to do things. Thus the gap between people developing technol ogies and those using them widens. The feedback loop gets bigger.

By turning everything it touches into commodities, biotechnology also has the effect of making products and processes that fit more easily into the global m arket. Seeds that used to be saved by the farmer now must be purchased each year, for example. Genotypes that used to be specific to a slope, soil type, and rainfall amount in a particular valley are replaced with a genotype that will grow in a whole region. Markets that res pond to short term increases in production replace subsistence or local markets that respond to the need for a secure food supply in unpredictable conditions. Diversity is lost.

Finally, biotechnologists are not dependent for their own i mmediate survival on the success of their craft. They get their food from some distant place. If the crop fails in Ca lifomia, the supplier buy s from Florida instead, and the biotechnologist buys it from wherever he can get it. There is no direct accountability or urgent stake in the sustainability for the developer of the technology.

It seems clear to me that our economic system, of which agribusiness is a part, cannot be sustainable. My solution is a radically conservative one: more people need to be directly involved in sustaining their own lives, and they need to have control of the technologies used to grow food. Land refo rm, support for regional autonomy and democracy, policies that strengthen local markets, removal of subsidies that favor global markets, and a willingness to learn from nonindustrial people would all do more to promote sustainable agriculture than any specific technological change I can think of.

References

Flannery, K. V. and J. Marcus. 1976. Formative Oaxaca and the Zapotec Cosmos. *American Scientist* 64:374-383.

Cuddihy, L.W. andC.P. Stone. 1990. *Alteration of Native Hawaiian Vegetation: Effects of Humans,Their Activities and Introductions.* University of Hawaii Press, Honolulu.

Clay, J.W. 1988. *Indigenous Peoples and the Tropical Forests: Models of Land Use and Management from Latin America.* Cultural Survival, Inc., Cambridge, MA.

Sandor, J.A. andN.S. Eash. 1991. "Significance of Ancient Agricultural Soils for Longterm Agronomic Studies and Sustainable Agriculture Research." *Agronomy Journal.* 83:29-37

.

List of Participants

Don Albrecht
Dept, of Rural Sociology
Special Services Bldg.
Texas A&M University
College Station, TX 77843-2125

Fuller Bazer
Animal Science Dept.
University of Florida
Gainesville, FL 32611-0691

David Berkowitz
FDA HF-6
5600 Fishers Lane, Rm 11-64
Rockville, MD 20857

Patel Bharat
USDA/APfflS
14th & Independence Ave. SW
Room 4911, S Building
Washington, DC 20250

Frans W. A. Brom
A. Schelfhoutstraat 29hs
1058 HR Amsterdam
NETHERLANDS

Linda Bullard
Coordinator for Genetic
Engineering Policy
The European Parliament
Rue Belliard
B-1047 Brussels, Belgium

Bruce Bullock
2-44 Agriculture
University of Missouri
Columbia, MO 65211

Aubrey Cartwright
Dept, of Poultry Science
Texas A&M University
College Station, TX 77843-2472

Andres de la Concha
Ag. Research & Ext. Svc.
Texas A&M University
7887 N Highway 87
San Angelo, TX 76901

Kate Clancy
CHD 34 Slocum Hall
Syracuse University
Syracuse, NY 13244

Gary Comstock
Dept, of Philosophy
Iowa State University
403 Ross Hall
Ames, IA 50011

Martha Crouch
Dept, of Biology
Indiana University
142 Jordan Hall
Bloomington, IN 47405

Peter Dunn
1158 Entomology Hall
Purdue University
West Lafayette, IN 47907-1158

Lee Ellis
Dept, of Sociology
Minot State University
Minot, ND 58701

Antonio Fernandez
Oklahoma State University/
EMBRAPA
104-6 N. University Place, #6
Stillwater, OK 74075

Neal First
Dept, of Meat & Animal Science
752 Animal Sciences Bldg.
Madison, WI 53706

Ted Friend
Animal Science
Texas A&M University
College Station, TX 77843-2471

Jeff Goodwin
TAEX
Texas A&M University
College Station, TX 77843-2124

Ralph W.F. Hardy, President
Boyce Thompson Institute
Tower Road
Ithaca, NY 14853

Holly Hazard
Doris Day Animal League
900 Second Street
Washington, DC 20002

Edwin Hettinger
Dept, of Philosophy
College of Charleston
Charleston, SC 29424

Lawrence Busch
Dept, of Sociology
Michigan State University
East Lansing, MI 48824-1 111

Dermis Erpelding
Elanco Animal Health
1901 L Street, Suite 705
Washington, DC 20036

Lisa Hummler
501 Nagle Street 101
College Station, TX 77840

Bees Butler
Dept, of Ag. Economics
University of California
Davis, CA 95616

Frank Fair
Division of Psychology & Philosophy
Sam Houston State University
Huntsville, TX 77341

Dale Jamieson
Dept, of Philosophy
University of Colorado
Campus Box 232, Helems 182
Boulder, CO 80309

Daniel Jones
Vet Medicine, Physiology and Pharmacology
Texas A&M University
College Station, TX 77843

George Murphy
Taraval Associates
1220 University Dr., Ste. 204
Menlo Park, CA 94025

Patricia Swan
Vice President, Research and Advanced Studies
Iowa State University
Ames, LA 50011

Tom Kasari
Vet Medicine, Large Animal Medicine
Texas A&M University
College Station, TX 77843

Robert Oltjen
Asst. Deputy Administrator
Animal Sciences National Program Staff
Rm 134, Bldg 005-BARC-W
Beltsville, MD 20705

Paul B. Thompson
Biotech Policy Center
Texas A&M University
329 Bell Bldg.
College Station, TX 77843H355

Brewster Kneen
125 Highfield Road
Toronto, Ontario
M4L 2V4

Bernard E. Rollin
Dept, of Philosophy
Colorado State University
Fort Collins, CO 80523

Frits van Vugt
Min. Landb. Beh. & Viss.
Directie Fez AFD. FA
Postbus 20401
2500 ED Den HAAG
NETHERLANDS

Michael Linskins
Dutch Society for the Protection of Animals
P.O. Box 85g80
2508 CR. The Hague
Netherlands

Koushik Seetharaman
Soil & Crop Sciences
Texas A&M University
College Station, TX 77843-2474

Gary Vamer
Biotech Policy Center
Texas A&M University
329 Bell Bldg.
College Station, TX 77843-4355

June Fessenden MacDonald
Deputy Director, NABC
159 Biotechnology Bldg.
Cornell University
Ithaca, NY 14853-2703

Martin McGregor, Esq.
Botts and Baker
910 Louisiana
Houston, TX 70002-4995

Margaret Mellon
Nat'l. Biotech Policy Center
Nat'l. Wildlife Federation
1400 Sixteenth St., NW
Washington, DC 20036

Robert Merrifield
Directors Office
Texas A&M University
College Station, TX 77843-2147

George J. Seidel
Dept. of Physiology
Colorado State University
Fort Collins, CO 80523

Scott Shore
NC Dept. of Agriculture
216 West Jones Street
P.O. Box 27647
Raleigh, NC 27611

Doreen Stabinsky
Dept. of Plant Pathology
University of California
Davis, CA 95616

John J. Sullivan
American Breeders Service
6908 River Road
De Forest, WI 53532

Curt Youngs
Iowa State University
Ames, IA 50011

Robert Zimbelman
American Society of Animal
Sciences
9650 Rockville Pike
Bethesda, MD 20814