AGRICULTURAL BIOTECHNOLOGY: IMPLICATIONS FOR THE ENVIRONMENT AND THE FAMILY FARMER

by Joseph Yaffe

INTRODUCTION

Recombinant DNA research promises to change the face of American agriculture. The power that has been unleashed by innovations in the field of biotechnology over the last decade has led some to believe that the American agricultural industry is on the brink of "one of the major productivity revolutions" in its history.[1] The proposed benefits of agricultural biotechnology could dramatically increase crop yield and quality on American farms. At the same time, it could eliminate dependence on costly chemical inputs and ease the present burden on the rural environment caused by high levels of pesticide and fertilizer use. Through biotechnology, entire rural communities could be revitalized.

For every possible benefit of biotechnology, there is a hazard.

But for every possible benefit of biotechnology, there is a corresponding hazard. Biotechnology developments may result in environmental catastrophe and irreversible damage to the earth's ecology. Once allowed to escape the laboratory, genetically engineered organisms could upset the fragile balance of the environment in ways unforeseeable and possibly unpreventable. The dangers posed by the release of such powerful technology might very well outweigh any potential beneficial applications.

Even if fears of the risks posed by biotechnology prove to be groundless, a question remains regarding who is to benefit from the influx of biotechnology on the farm. For more than 250,000 small farms in the United States, biotechnology could mean ruin. After barely surviving the debt load of the 1970's and 1980's, America's family farms may be hard pressed to pay for a new technology which their larger industrialized competitors might afford. Congress has determined that the family farm structure in America must be maintained, but it is uncertain whether biotechnology and the small farm may peacefully coexist.

The biotechnology industry is still in an embryonic stage and its final acceptance will hinge on public awareness and understanding. This article will analyze the benefits and risks which biotechnology poses to the environment and examine its potential impact on the family farm.

I. AGRICULTURAL BIOTECHNOLOGY: A DEFINITION

Biotechnology is thousands of years old. Some early examples include the domestication of plants more than 8,000 years ago and the use of yeast in the fermentation and production of wine and beer in the 11th Century.[2] Modern biotechnology, has its roots in the research done on recombinant deoxy-ribonucleic acid (DNA) in the last half of this century. The double helical structure of DNA was discovered in 1953, enabling scientists to begin investigating the process by which genes coded information. Researchers discovered methods by which genetic information could be inserted, changed, or deleted within a host organism in order to create a different organism with new characteristics.[3] As opposed to traditional methods of breeding utilized in efforts to exert control over transmitted biological traits, gene transfer technology enables researchers to achieve results with greater speed, precision, reliability and scope. Particular genes that encode a desired trait in an organism are identified, isolated, and reintroduced into its natural host or a different organism.[4] Thus, desired traits can be retained or introduced into already existing organisms, resulting in novel

or "designer" organisms. Although encompassing a great array of specific applications, biotechnology can be defined most simply as the use of techniques intended to introduce change into the genetic material of plants or microorganisms in order to bring about specific results or applications.[5] Agricultural biotechnology is the collection of "modern genetic engineering technologies that are directly applicable to agriculture."[6]

Agriculture will most likely see the greatest impact of biotechnology in the genetic engineering of plants and microorganisms intended to increase crop yield or reduce dependence on chemical inputs.

II. BENEFITS OF AGRICULTURAL BIOTECHNOLOGY

Proponents of biotechnology are numerous and their arguments for continued pursuit of biotechnology research are persuasive. They cite a myriad of possible benefits to be provided by biotechnology. Through biotechnology, scientists may create new organic pesticides (biopesticides) which would be more selective than their chemical insecticide and herbicide counterparts, aiding in the elimination of groundwater contamination problems. After identifying genes in plants which produce chemicals that repel or attract insects or disrupt the feeding or breeding patterns of insects, scientists will be able to transfer these traits to other plants to create a "natural" pest control system.[7] Crops will be able to produce their own insect repellents and reduce the need for widespread usage of expensive and dangerous chemical inputs.[8] Biopesticides would have minimal impact on the environment and help to reduce the public health costs of traditional pesticide usage which currently amounts to almost $3 billion annually.

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There is the potential that biotechnology will enable farmers to eliminate their dependence on chemical fertilizers by creation of genetically engineered organisms which enable plants to enhance their absorption of nitrogen gases without petrochemical inputs harmful to the environment. An application of this type could result in substantial economic benefits for the farmer. The development of cheaper fertilizer systems would result in lower input costs to the farmer and a shift towards widespread adoption of low input sustainable systems of agriculture which would lead in turn to lower costs for the small to medium sized farmer.[9]

Crop yield may be dramatically altered by implementation of genetic engineering technology. Traditional plant breeding techniques have enabled plant scientists to develop specific commercially useful parts of plants. Some examples exist in the area of tubers (potatoes) and seeds (sunflowers).[10] Biotechnology innovations will never entirely replace traditional plant breeding techniques, but will enable scientists to accelerate current plant breeding experiments and programs to make them more efficient and useful. Stronger strains of plants may be genetically engineered to thrive in conditions previously considered untenable for crops.

Animal diseases currently cause about $14 billion in losses to American farmers annually.[11] Biotechnology can be a powerful tool for disease prevention in animals, particularly in livestock. Currently, emphasis is being placed on disease control rather than prevention, resulting in inefficiency and increased expense as farmers are forced to overcompensate in their application of traditional drugs to eliminate existing disease. Biotechnology is being used to develop diagnostic tests which will enable farmers to accurately diagnose animal diseases quickly. New vaccines are being created through gene manipulation techniques which are stronger and more effective than their traditional counterparts. Through genetic engineering, scientists are able to go right to the heart of the

problem of animal disease control by altering the immune systems of animals themselves and creating new organisms with enhanced disease resistance characteristics.[12] Genetic engineering could even go so far as to assist in altering the intestinal organisms inside agricultural animals to enable more efficient utilization of plant waste fibers and reducing feed costs to farmers.[13]

The end-user benefits of biotechnology could be substantial. As the great majority of biotechnology innovations are aimed towards increasing crop yields, there could be a reduction in retail cost of table food as farmers, especially small to mid-size farms, are able to cut input costs. How the biotechnology industry will transfer research and development costs of agricultural biotechnology products remains to be seen.

III. RISKS OF AGRICULTURAL BIOTECHNOLOGY

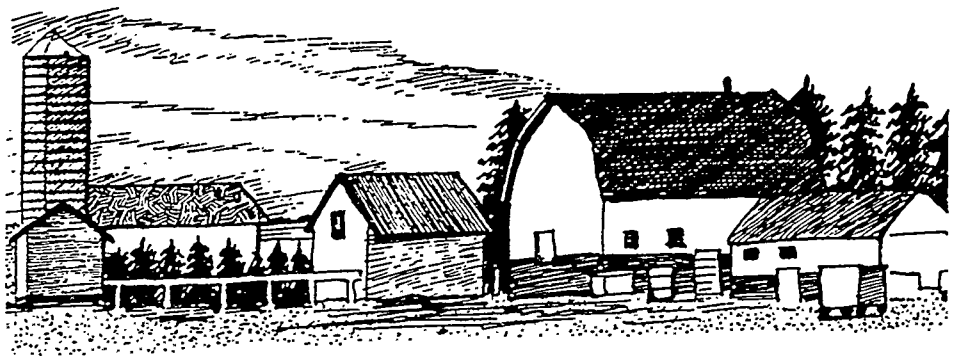
Current interest in biotechnology can be likened to the excitement that surrounded nuclear technology's early development.

The concept of tampering with the genetic makeup of organisms has not been met with great enthusiasm by a large segment of the population. A large segment of the general public is uncomfortable with the ethical implications of altering the building blocks of life and creating new life forms. Most of the current criticism of biotechnology research stems from public perception of the environmental risks biotechnology poses. .

To some, the current interest in biotechnology can be likened to the excitement that surrounded nuclear technology development and its subsequent failure to live up to its promised rewards without imposing severe environmental risks.[14] Like any powerful technology, genetic engineering research necessitates rational foresight and planning in order to minimize some of the risks that biotechnology entails.

Fears of biotechnology center around the threat of potentially dangerous or uncontrollable microorganisms leaking or escaping into the environment. The environment consists of a "web of highly synchronized relationships which have developed over millions of years."[15] It is feared that the release of genetically engineered organisms into the environment will disrupt the balance of this web, setting off a chain of reactions which once begun will be irreversible and possibly catastrophic. The genetically superior "supercow" might trample the dairy farmer.[16] Any possible environmental benefits that agricultural biotechnology could provide might be outweighed by the threat to the environment that the release of a not yet fully understood technology entails.

The highest concern centers around deliberate release of genetically engineered organisms which differ from their laboratory-bound counterparts in that they are designed to



exist long enough to perform the task for which they are produced and therefore pose the possibility that they might exist long enough to reproduce and multiply beyond the control of researchers.[17] It is feared that biotechnology products which are freely released into the environment might evade the control of those conducting experiments and "exacerbate or facilitate the disease producing potential of naturally occurring organisms."[18] Ecologists sharing such concerns cite examples of exotic species' imported into new environments as analogous problems.[19]

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Concern over possible risks presented by biotechnology has resulted in a number of legal challenges to the development of the emerging industry. Primary responsibility for regulatory oversight of biotechnology is vested in the federal government, with states' regulatory involvement being relatively minimal. Most legal action has been undertaken under NEPA although the current regulatory framework assigns regulatory responsibility to a variety of federal agencies and statutes depending on the type of genetically engineered product to be regulated.[20] The Foundation on Economic Trends is a Washington, D.C. based non-profit organization concerned with the ethical and environmental dangers posed by biotechnological research and has filed several lawsuits to halt the field testing of genetically engineered products.[21] The gist of that organization's complaints are that the "release of unidentified novel and exotic microorganisms will result in significant risk of . . . harm unless more knowledgeable and effective federal controls of new genetic techniques are instituted."[22] In at least one instance the federal courts have been persuaded enough by the foundation's arguments to delay deliberate release experiments involving genetically engineered microorganisms.[23]

IV. AGRICULTURAL BIOTECHNOLOGY AND THE FAMILY FARM

Although criticism of agricultural biotechnology focuses mainly on its possible environmental impacts, little has been said about the impact of biotechnology on America's family farms. But just as public perception of the environmental implications of biotechnology is of great concern to those pushing for growth in the biotechnology industry, so should the possible effect of biotechnology on rural communities be carefully examined.

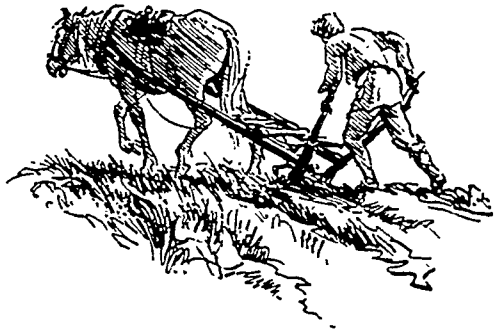
Congress has not addressed the issue of the relationship between agricultural biotechnology and the family farm at great length, but what it has said has been explicit. In recent findings, Congress

"[R]eaffirm[ed] the historical policy of the United States to foster and encourage the family farm system of agriculture in this country. Congress believes that the maintenance of the family farm system of agriculture is essential to the social well being of the Nation and the competitive production of adequate supplies of food and fiber. Congress further believes that any significant expansion of nonfamily owned large-scale corporate farming enterprises will be detrimental to the national welfare."[24]

Congress has demanded that the Secretary of Agriculture submit to Congress an annual report detailing the status and welfare of the family farm including:

"[I]dentification and analysis of new food and agricultural production and processing technological developments, especially in the area of biotechnology, and evaluation of the potential effect of such developments on--the economic structure of the family farm system."[25]

The clear implication being that any evidence that surfaces indicating a dramatic adverse relationship between biotechnology and the economic well-being of the family farm will be met with Congressional action to restrict biotechnology's impact.[26]



In the mid 1930's there were about 6.8 million farms in the United States and approximately 12.7 million annual farm workers. As a result of the wide scale introduction of mechanization into the agricultural sector after World War II and the rapid development and increased application of chemical inputs, such as fertilizers, U.S. farms saw dramatic increases in crop yields from 1947 to the beginning of the 1980's. The agricultural industry in the United States was transformed during those decades from a land and labor based sector to one with a "high degree of dependence on inputs purchased from off the farm. Farm production became much more specialized along commodity lines."[27]

The inevitable result was that in 1987 there were about 2.1 million farms and approximately 3 million farm workers. This number is not likely to change dramatically and "any future changes in farm numbers and farm employment resulting from biotechnology or other sources can never be as great as the changes of the last several decades."[28] Nevertheless, the economic disasters of the 1970's and 1980's illustrated the plight of the American family farmers. There is a legitimate concern on the small farm that the introduction of potentially radical technology into an already tenuous and conservative rural community structure will serve to further undermine the small farmer's position in America. Its impact could reduce labor opportunities for farmers and diminish the hopes carried by some that American farm policy will pursue a long term goal of widespread sustainable agricultural production systems.

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Some believe that there is no room for consideration of social goals in the debate over regulation of biotechnology research. "It is often stated that such an approach interjects values and the emotions of nonprofessionals into decisions appropriately made on the basis of considerations such as free market signals."[29] But if the broad aims of national agricultural policy are to feed the nation cheaply and safely, there is arguably an inherent demand within that policy for the preservation of stable rural communities to assist in the maintenance of an abundant, safe food supply. "Producing healthy and sustainable communities is as desirable and important as producing more consumer goods for the short term and should be incorporated into the common understanding of efficiency."[30]

But support for family farms need not be interpreted as criticism of biotechnology development as long as the effects of biotechnology on the family farm remain unclear. "Biotechnology is not inherently detrimental to family farming. It will only accelerate the process by which the U.S. and other developed nations face fiscal choices about symbols of national heritage and the realities of resource endowments and comparative advantage in the world system."[31]

Despite the absence of a system by which the likely socio-economic impacts of biotechnology may be quantified, it is possible to gain "some general perspective of the likely magnitude of future effects" of biotechnology.[32] Implications of biotechnology on family farmers are highlighted by two main factors: (1) cost of application and (2) acceptance of application.

At present it is impossible to get an accurate fix on the likely cost of the many and varied proposed biotechnology applications. What is known, however, is that over $1 billion has been invested in the research and development of agricultural biotechnology by the many

start-up biotechnology firms across the country as well as other private investors.[33] This research cost must be transferred to either the farm supply industry, the farmer, or the consumer (through the food processing sector) in order to ensure profitability and sustained interest in research. Transfer to farm supply companies is likely for farm chemical and seed suppliers which may be able to integrate with large chemical manufacturers actively engaged in their own biotechnology programs. But the transfer of research and development costs to the farmer may result in a lack of acceptance of biotechnology on the small farm if proposed benefits are overridden by prohibitive costs.

Acceptance of biotechnology is a double-edged sword for the family farmer.

Acceptance of biotechnology is a double-edged sword for small farmers. To some degree, they control the extent to which biotechnology is utilized on the farm. But there is a risk that if costs of obtaining biotechnology are too great, or if reaction to innovation is too slow, small farms will be overwhelmed by their larger industrial counterparts' rapid assimilation and utilization of biotechnology innovations.[34]

Apart from the issue of cost and acceptance of biotechnology, family farmers' relationship with biotechnology is also affected by the delegation of the control of the new industry. At present, biotechnology research is almost exclusively in the hands of private corporations or land-grant universities, with small farmers left out of the development process. The role of the land-grant university and its relationship to federally funded agricultural research is its own issue worthy of debated, and in light of the Congressional determination that family farmers' interests should be protected, there is some argument that agricultural biotechnology research carried out at public universities should be conducted with the interests of the family farmer in mind. In California Agrarian Action Project v. University of California, a California appellate court ruled that the Regents of the University of California had no responsibility to ensure that federal agricultural research funds are used "so as to give primary consideration to the needs of the family farmer."[35] Thus, for the time being, it appears that there is no active representative of the family farmers' interests at the primary research level in agricultural biotechnology.

CONCLUSION

The family farm is facing an impending technology that is of indeterminate cost or value, the development of which it has no control over, and yet whose overwhelming socio-economic implications are fairly certain. The future is unclear, but as the tools of biotechnology are forged, family farmers hope that they will be fashioned for the hands of America's small farmers as well as for large industry.

This article has raised just a few of the issues relevant to the ongoing debate over biotechnology's role in American agriculture. That the introduction of a new technology into existing industry could stir controversy should come as no surprise to a nation built on technological revolution. But the relationship between the tremendous potential of biotechnology--whether disastrous or beneficial--and the general public must be weighed in light of our need to safeguard the environment and the interests of the family farm. The decision whether to spur rapid development of this new industry or to rein in its growing power

will affect millions of lives as it helps to determine the impact that scientific innovation will have on existing structures going into the next century. The larger question of public acceptance of controversial scientific research may be answered by whether agricultural biotechnology takes root on America's farms in the next decade.

Joe Yaffe is a 1L at King Hall with a strong interest in the legal implications of genetic engineering.

ENDNOTES

[1]Kimbrell, Andrew and Rifkin, Jeremy, Biotechnology: A Proposal for Regulatory Reform, 3 Notre Dame L. J. Ethics & Pub. Pol'y 117 (1987).

[2]Office of Technology Assessment, U.S. Congress, New Developments in Biotechnology--Field Testing Engineered Organisms: Genetic and Ecological Issues, at 34 (1988).

[3]Committee on a National Strategy for Biotechnology in Agriculture, National Research Council (NRC), Agricultural Biotechnology, Strategies for Competitiveness, at 23 (1987).

[4]Id.

[5]Thomas O. McGarity, Federal Regulation of Agricultural Biotechnologies, 20 U. Mich. J. L. Ref. 1089, 1091 (1987).

[6]Id.

[7]Committee on a National Strategy for Biotechnology in Agriculture, NRC, supra note 3, at 31.

[8]Id.

[9]See generally C. Hassebrook & G. Hegyes, Choices for the Heartland: Alternative Directions in Biotechnology and Implications for Family Farming, Rural Communities and the Environment, Report for the Center for Rural Affairs (1989) (urging need for compatibility between family farming and biotechnology research).

[10]McGarity, supra note 5, at 1093.

[11]Committee on a National Strategy for Biotechnology in Agriculture, NRC, supra note 3, at 37.

[12]See James Mason, Biotechnology and Disease Control in Animals: Social and Ethical Issues, in NABC Report 1, Biotechnology and Sustainable Agriculture: Policy Alternatives 150 (June Fessenden MacDonald ed., 1989).

[13]Committee on a National Strategy for Biotechnology in Agriculture, NRC, supra note 3, at 40-41.

[14]Gore, Senator Al, Federal Biotechnology Policy: The Perils of Progress and the Risks of Uncertainty, 20 U. Mich. J. L. Ref. 965, 967 (1987).

[15]Kimbrell & Rifkin, supra note 1, at 119.

[16]See Gore, supra note 14, at 969. Senator Gore's vision of the cantankerous "supercow" has already been played upon by movies such as *Revenge of the Killer Tomatoes* and its sequels.

[17]Diane Hoffman, The Biotechnology Revolution and its Regulatory Evolution, 38 Drake L. Rev. 471, 477 (1988); Sidney A. Shapiro, Biotechnology and the Design of Regulation, 12 Ecology L. Q. 1, 9 (1980).

[18]Hoffman, Id. at 478.

[19]See Office of Technology Assessment, Impacts of Applied Genetics: Micro-Organisms, Plants, and Animals 200, 201 (1984) (regarding the introduction of Brazilian water hyacinth into U.S. waterways and importation of English sparrows to control insects and their subsequent uncontrollable spread).

[20]Hoffman, supra note 17 at 533; See generally Coordinated Framework for Regulation of Biotechnology, 51 Fed. Reg. 23, 302 (1986) (assigning federal regulatory responsibilities for biotechnology under existing federal statutes).

[21]Foundation on Economic Trends v. Heckler, 756 F.2d 143 (D.C. Cir. 1985); Foundation on Economic Trends v. Richard G. Johnson, 661 F.Supp. 107 (D.D.C. 1986); Foundation on Economic Trends v. Otis R. Bowen, 722 F.Supp. 787 (D.D.C. 1989); Foundation on Economic Trends v. Richard Lyng, 943 F.2d 79 (D.C. Cir. 1991).

[22]Foundation on Economic Trends v. Richard G. Johnson, 661 F.Supp. 107 (D.D.C. 1986).

[23]Foundation on Economic Trends v. Heckler, 756 F.2d 143 (D.C. Cir 1985) (court upheld an injunction against a deliberate release experiment involving genetically engineered "ice minus" bacteria).

[24]7 U.S.C. at 2266 (1991).

[25]Id. (emphasis added).

[26]There is a great deal of legislation at the state level aimed at protecting small farms as well. Several states (Oklahoma, Kansas, Wisconsin, North Dakota, South Dakota, Iowa, Minnesota, Missouri and Nebraska) have adopted laws barring the purchase of farms or ranches by non-family owned farm corporations. See, e.g., MSM Farms, Inc. v. Robert M. Spire, 927 F.2d 330 (8th Cir. 1991) (upholding constitutionality of Nebraska law barring such purchases).

[27]Burt W. Sundquist & Joseph J. Molnar, Agricultural Biotechnology-Issues and Choices (Bill R. Baumgart & Marshall A. Martin eds. 1989).

[28]Id.

[29]Hassebrook & Hegyes, supra note 9, at 5.

[30]Id., at 6.

[31]Joseph J. Molnar & Henry Kinnucan, Biotechnology and the New Agricultural Revolution, at 36 (1989).

[32]W. Burt Sundquist, Economic Impacts and the Implication of Emerging Biotechnologies, in Biotechnology and Agricultural Cooperatives: Opportunities and Challenges, at 71 (William B. Lacey & Lawrence Busch, eds., 1988).

[33]Luther H. Smithson, Remarks at an Industrial Biotechnology Association conference, Food for the World through Biotechnology (May 1989), in 9 Biotechnology Newswatch 1 (June 5, 1989).

[34]Molnar & Kinnucan, supra note 31, at 42.

[35]258 Cal. Rptr. 769 (Ct. App. 1989), review denied, (Sept. 1989).