



Genetic Engineering: A Challenge for Engineers

by Robert L. Manning, *New York Beta '49*

THE ENVIRONMENTAL ISSUE discussed in this article—transgenic biotechnology—is vitally important and very complex. It has generated heated controversy and some extreme reactions on both sides of the issue. The powerful biotechnology frequently referred to as “genetic engineering” deserves the attention of engineers; there are serious questions surrounding its widespread application, particularly in the case of products of transgenic biotechnology, the transfer of genes between species. Naming this process “engineering” is, in my view, entirely inappropriate and a misreading of the true nature of that profession.

Engineering, as I believe most engineers understand and practice it, involves the carefully calculated, responsible application of well-understood principles in accordance with established public and professional standards to produce results that are both safe and beneficial to society. It may be conventional or innovative, but the individual engineer is always accountable for the results of his or her work. None of these criteria seems to apply to biotechnology using direct genetic manipulation to create new life forms based on the discoveries of genetic science.

Anyone who has tried to introduce, almost anywhere in the United States, a new, better but unconventional building construction material, whether an improved fastener or an innovative structural panel system (my own experience), is aware of the extensive and rigorous testing and certification requirements that must be met before the new product can be used in buildings. While imposing such requirements arguably slows the pace of innovation, it is unquestionably a major reason why buildings in this country are among the safest in the world.

No such system of required testing and certification is in place for the introduction on farms and in markets of new food crops or meats from organisms modified by direct transfer of genetic material to express specific properties intended as improvements over the properties of the original food product.

The plant and animal products of modern biotechnology already introduced or being studied for introduction into foods and the natural environment are identifiably different from any previously existing organism. They could not have been produced using traditional breeding techniques developed by man (and evolutionary nature) over the centuries. Neither could they have been cre-

ated using more modern plant or animal hybridization methods.

The opposition to the introduction of genetically modified organisms into foods and the environment comes from diverse groups—from scientists with detailed technical knowledge and experience in this field who are concerned about the potential for ecological disaster, to parents worried about the possible effects of genetically modified foods on the health of their children.

The biotechnology industry has mobilized its considerable resources to defend the technology and its products. There seems, however, to be a striking inconsistency in the past and present positions of the industry. Pharmaceutical companies for years argued vehemently against the concept of “generic equivalence” of therapeutic products marketed by other companies—generic manufacturers—after an original patent had expired.

They took this position even when chemical and physical testing showed the patented and generic products to be essentially identical. The companies holding the original patents argued, with some logic it seemed then, that such testing was not adequate to demonstrate the safety or efficacy of the unpatented generic product and was much less rigorous than the testing required before the original patent holder could market the drug.

Today the same or related organizations appear to be devoting similar energy and resources to argue a contrary position. The producers and marketers of genetically modified, patented products claim that their products are “equivalent” to the original (unpatented, of course) plants or animals, and therefore extensive testing for long-term effects should not be required to demonstrate that they are safe for human consumption and introduction into the natural environment, or even that they are effective in doing what was intended.

The assumption seems to go something like this: “If it looks like corn, and we call it corn, it’s corn and will be safe and act like corn when released in the environment and ingested by humans” (even though no such plant ever existed). This article presents the dangers in such an assumption and offers ideas for needed regulation of biotechnology products.

During the past few years, I have asked questions of highly qualified people working in the field and exchanged with them ideas on the subject. Some of these people strongly favor the widespread application of this technology, but others believe that it presents unaccept-



able environmental and human health risks. I've also done considerable reading of the extensive material on the subject, particularly in relation to the potential for environmental damage.

The opinions offered here also reflect my chemical engineering education and my experience in management of pharmaceutical and chemical manufacturing operations and engineering projects in the United States and internationally. I believe that the ideas presented are reasonable and sound, but the reader must make that judgment.

THE ROLE OF THE ENGINEER

Most engineers consider themselves problem solvers, and genetic "engineering" can present serious problems; at best it raises important questions. Engineering itself will not directly provide the answers, but engineers can be influential in finding solutions. A great deal of information and opinion is available on both the technical and public-policy aspects of transgenic biotechnology. If engineers will inform themselves about the issue and bring their rigorous technical education, analytical skills, and problem-solving drive to the policy debate, they can make valuable contributions to the decision-making process.

Active participation by well-informed individuals in the debate on issues such as this, with potentially immense consequences for our own well being and that of future generations, is more than ever essential. I believe that such individual initiatives are indispensable if we are to maintain and strengthen our representative democracy as a viable system for ourselves and a beacon and model of hope for the rest of the world.

Perhaps this article will encourage some readers to extend their knowledge and understanding of the issue and draw their own conclusions about the global introduction of this powerful and, as it seems to me, extremely risky technology.

INTRODUCTION OF GENETICALLY MODIFIED ORGANISMS INTO THE ENVIRONMENT

Global introduction of organisms and products emerging from transgenic biotechnology is being strongly promoted in the U.S. and internationally by the biotech and feed industries. The previous and present administrations have seen this program as being in our national interest and have promoted it. We have applied considerable pressure in urging global acceptance, arguing that any attempt by other nations to limit or control importation of products resulting from application of the technology would be an unacceptable barrier to free international trade.

Transgenic biotechnology and its potential application not only to plants but to animals, including humans, raises extremely difficult and profound ethical, social, and economic questions that require extensive public airing and debate. The government's supportive policy seems to have been established without adequate public discussion, and to my knowledge there is no public

record of the deliberations leading to the decision to promote the use of this far-reaching new technology.

There is strong private industrial motivation to promote wide application of the technology. Large manufacturers and feed companies, in their search for growth and enhanced profits, are actively promoting dissemination of the technology and its products—at considerable expense and without malicious intent. The momentum has grown rapidly, with programs by multinational companies focusing their efforts particularly on the introduction of transgenic crops in the developing world.

They are joined in these efforts by some well-intentioned not-for-profit foundations and individuals who have been convinced that the technology is an effective way to deal with hunger in the poorest nations.

Experts familiar with all aspects of this serious and many-faceted problem or world hunger make a contrary argument—that introduction of genetically modified patented crops will destroy traditional agriculture and create even more suffering for the people of these impoverished lands. And they point to many other ways to attack the tragic problem of hungry families in the third world. A few of these alternatives are mentioned below.

The anticipated profitability of the technology, which underlies the push for its rapid dissemination, is based on genetic patents that the Supreme Court has ruled are allowable. This decision has generated some controversy, and there is a possibility that it may some day be reviewed by the court. For the present, it makes the field very attractive to private capital investment.

Both the private efforts and those of our government ignore the real possibility that widespread introduction of transgenic organisms will cause harm far greater than any benefits it may bring. Tradeoffs of costs and benefits are not unique to biotechnology; new technologies always carry risks. In this case the technology is far-reaching and powerful in its effects, which may well be irreversible.

The issue is too far-reaching and complex to allow the prospect of important gains to distract us from the need to understand the risks and potential costs, even if they are difficult to express in accounting terms. At this stage, the scientific knowledge is still rudimentary, the net gains in agricultural productivity and the potential profits are both uncertain, and the health and environmental risks are little understood. Testing to determine the long-term consequences for human health and environmental damage has been virtually non-existent.

It is likely that most Americans are not aware of the extent of the planting of genetically modified crops in the U.S. because it has happened with little fanfare, except in the cases where problems have made news. One widely reported case is the accidental contamination of flour used in tacos and other food products by Starlink corn, which had been approved only for animal feed. This resulted in a recall of the grain, flour, and food products and in payments both to farmers who had grown the modified corn and to others whose fields were contaminated, probably by pollen drift. The cost to



Aventis, the seed producer, apparently ran into the hundreds-of-millions of dollars, and the incident caused corn exports and U.S. corn prices to drop in the U.S. market.

Another case that received media and public attention was a small laboratory study at the University of Michigan that indicated that corn containing the gene of the bacterium *Bacillus thuringiensis* (Bt) might produce pollen toxic to monarch butterflies feeding on milkweed receiving pollen from nearby corn fields. Subsequent studies by the USDA found monarchs are more sensitive to some Bt corn types than others and that, although there is a chance that while pollen from one of the early types of Bt corn might present a hazard to the butterflies under field conditions, this type was planted in only a small percentage of fields and would be entirely phased out by 2003.

If nothing else is clear about these cases, they do illustrate some of the difficulties in controlling the spread of genetically modified genes once they are released into the market or the natural environment, and they demonstrate the unintended consequences likely to accompany the introduction of new technologies.

By the year 2000, large areas were planted with transgenic crops. For three of our most important commercial crops, one-fifth of the corn, one-half of the soybean crop, and three-fourths of the country's cotton plantings used genetically modified seed.

Other crops that have been genetically modified and approved for planting include canola, potatoes, squash, sugarbeets and tomatoes. The intent of the insertion of genes from other plant species, bacteria, or viruses into the genomes of these plants has generally been to increase resistance to pests, raise tolerance to pesticides, or increase market value.

These goals are also the subject of controversy. One of the most serious issues is the strong likelihood that widespread use of transgenics will result in more rapid development of resistant strains of the pest that the modified plant is intended to resist. This would generate the need for greater pesticide use (not the goal!) or the need for more and/or multiple genetic modifications.

Widespread resistance to the Bt toxin produced by some approved strains of modified corn and potatoes would also deprive organic farmers of the most effective and widely used pesticide available to them for the few but critical times they have need to spray using the Bt bacterium itself. Organic farmers have a small, but growing, role in world agriculture and a growing customer base in the U.S.

For a concise listing of approved crops, see the following table prepared by the Union of Concerned Scientists and reprinted with permission from that organization.

Genetic modification of other food plant species is under study in biotech laboratories, and animal species are also being researched for genetic modification and possible future commercial introduction. A genetically modified and patented species of salmon with more

rapid growth to larger size is presently under review by the Food and Drug Administration.

In this case there have been serious questions raised by a diverse range of environmental scientists, activist groups, and some of those engaged in commercial fishing about the risks to the natural salmon population of accidental release into the ocean of such salmon, intended for aquaculture in confined "fish farms." Other species of fish—carp, trout, and tilapia—are being studied for useful genetic modification, raising similar questions of accidental release into the natural environment.

UNIQUE HEALTH AND ENVIRONMENTAL RISKS

Some concerns go far beyond international trade or other economic issues. Many competent scientists, who are not influenced by direct or indirect dependence on the industries promoting the technology, believe that its widespread introduction is premature and presents extremely serious and largely unquantifiable risks to both human health and the natural environment. They see it as a radical departure from the traditional agricultural breeding practices that have depended on hybridization of plants and domestic animals for improvement of productivity and the introduction of desirable traits.

Some biotechnology advocates claim that the results of direct introduction of genes from one species into the genome of another are predictable. They seem to be assuming full understanding of the function of the transplanted gene and conclude that the results of transgenic introduction are therefore predictable. The assumption of full understanding of gene function is contrary to the opinions of other scientists in the field.

These scientists argue that we have only limited understanding of the function of specific genes in the original organism and that, furthermore, individual genes transferred to another species and acting in concert with the other genes of the new genome can have unpredictable consequences, considering our present knowledge. It is also proving difficult, if not impossible, to prevent or control the spread of the genetically modified organisms after they are introduced into the field. As a result, ecologists are concerned about the effects of interaction of these new organisms with cultivated or wild species—food crops or weeds.

Perhaps the most serious of the risks from widespread application of transgenic biotechnology is irreversible disruption of the Earth's biosphere—the intricate web of interdependent life forms and processes on which human well being and all life depend. These ecological systems, including the genetic structures of all living organisms, have evolved and mutually adapted to slow changes in the planetary environment over three- to four-billion years. The biosphere today is the result of this unimaginably long and seemingly miraculous process. Its functioning is only minimally understood, even after the great scientific advances of recent years.

Despite what can be described only as a state of deep and inevitable ignorance about the organisms and processes that constitute the ecology of our planet, we are



Genetically Engineered Crops Allowed in the U.S. Food Supply

PRODUCT/CROP

Institution(s)

• Engineered Trait(s)

• Sources of New Genes

NAME(S)

CANOLA

Aventis, Monsanto

- Resist glufosinate, glyphosate, herbicides to control weeds; altered for high lauric acid for soap and food products
- Bacteria, virus, Arabidopsis, Calif. bay, turnip rape

ROUNDUP READY 2000, LAURICAL 1995, UNNAMED 2000

CORN

Aventis, Dow-Mycogen, DuPont-Pioneer, Hi-Bred-Monsanto, DeKalb, Syngenta

- Resist glufosinate herbicide to control weeds; male sterile to facilitate hybridization; Bt toxin to control insect pests (European corn borer); male sterile to facilitate hybridization
- Corn, bacteria, virus, arabidopsis, potato

SEEDLINK, LIBERTYLINK, STARLINK 1998, NATUREGARD 1995, HERCULEX I 2001, BT-XTRA 1997, YIELDGARD 1996, ROUNDUP READY 1998, BT11 1996, KNOCK OUT 1998

COTTON

Monsanto-Aventis

- Resist bromoxynil herbicide to control weeds; Bt toxin to control insect pests (cotton bollworms and tobacco budworm); resist glyphosate herbicide to control weeds
- Arabidopsis, bacteria, virus

BXN COTTON 1995, BOLLGARD 1995, ROUNDUP READY 1996

POTATO

Monsanto

- Bt toxin to control insect pests (Colorado potato beetle); resist potato virus Y
- Bacteria, virus

NEWLEAF 1995, NEW LEAF PLUS 1998, NEWLEAF Y 1999

SOYBEAN

Aventis, DuPont, Monsanto

- Resist glufosinate herbicide to control weeds; altered oil (high oleic acid) to increase stability; reduce polyunsaturated fatty acids
- Soybean, bean, bacteria, virus

ROUNDUP READY AND OTHERS 1995-98

TOMATO (CHERRY)

Agritope, Calgene, DNA Plant Technology, Monsanto, PetoSeed, Zeneca

- Altered ripening to enhance fresh market value; thicker skin and altered pectin to enhance processing value
- Tomato, bacteria, virus

FLAVRSAVR 1994, ENDLESS SUMMER 1995, OTHERS

NOTES: All crops listed above required a determination from the U.S. Department of Agriculture that they were not plant pests under the Federal Plant Pest Act.

1. Bt crops, in addition to USDA regulation, were approved by the Environmental Protection Agency under the Federal Insecticide, Fungicide, and Rodenticide Act and the Federal Food, Drug, and Cosmetic Act.

2. Before most of the herbicide-resistant crops could enter the food supply, EPA registered the herbicide for use on the new crop. Sulfonylurea-resistant flax is the exception because the herbicide is not to be sprayed on the crop. Sulfonylurea-resistant flax is to be planted only in soils containing sulfonylurea residues.

3. Although not required, all products were the subject of voluntary consultations with the (FDA) about food safety. FDA required labeling of two products—canola and soybean with altered oils—because the agency considered the oils to be significantly different from nonengineered canola and soy oil. The required labels do not divulge that the oils were obtained from genetically engineered crops.

4. To the extent they are known, the chart lists trade names or company designations for crops at the time they finished the regulatory process. Once a crop is commercialized and licensed to other companies, it may be sold under many other names.

5. Not all crops allowed on the market are currently for sale. In some cases, engineered crops, such as the FlavrSavr tomato and StarLink corn, may no longer be available commercially.

SOURCES: Websites of USDA at www.aphis.usda.gov/bbep/bp/index.html; EPA at www.epa.gov/opppdpd1/biopesticides/; FDA at vm.cfsan.fda.gov/~lrd/biocon.html; communications with agency staff and company representatives; *Federal Register* notices; and agency documents on individual crops. Revised June 2001 (Table created by the Union of Concerned Scientists, and reprinted with permission after being condensed by author).



allowing optimism about potential benefits, anticipation of economic gain, and our limitations of imagination and will to put at risk this intricately balanced system. The long-term consequences for human life on Earth are unpredictable—and perhaps unimaginable.

REGULATORY FRAMEWORK AND PRECAUTIONS

In the absence of effective new legislation defining clear and coordinated responsibilities for regulating the introduction of products of this revolutionary technology, each regulatory agency—the Food and Drug Administration (FDA), Environmental Protection Agency (EPA), and Department of Agriculture (USDA)—tries to deal independently with the aspects identified as falling within its jurisdiction under existing legislation.

The FDA has been directed to develop labeling regulations for foods containing products of modern biotechnology. To date, the agency's approach has been to study the issue, and the studying continues. The agency has thus far been unwilling to require labeling of food products containing the products of transgenic biotechnology. The FDA assumes that direct genetic manipulation or insertion of foreign genes into a food crop plant does not generally and of itself create a new product. The agency has invited producers to take part in a voluntary labeling and safety consultation program. But, no proof of safety or efficacy is required from the developers of the technology. This approach contrasts sharply with the rigorous requirements placed on the testing and approval of pharmaceutical products.

The absence of labeling leaves consumers unaware of the presence of genetically modified products in the foods they buy. The voluntary program and the lack of testing requirements are dangerous deficiencies in the FDA's approach. As a result, there is no way to be certain that transgenic foods will not create serious health problems for Americans, who are dependent upon the agency to assure that their food is safe.

Until recently the EPA has provided no clear regulatory role, policy, or plan of action in relation to transgenic crop introductions, even though this is the agency charged with protection of the natural environment. And the USDA continues to approve genetically modified crops as though they were no different from the products of traditional breeding practices, with only ineffective requirements to isolate the modified strains to avoid contamination of neighboring crops or wild plants.

There is no required testing for long-term environmental impact. Given the complexity of the natural environment and our present state of scientific ignorance, there may indeed be no tests known at this time that can adequately ensure against disaster caused by widespread introduction of this radical new technology.

Even a small probability of irreversible damage to the interdependent systems and processes that make up the Earth's biosphere should be enough to demand extreme caution in the introduction of a new technology. This has not been the position of the present or previous

administration or the Congress. I believe that this amounts to a drastic failure of governance.

Our government's efforts to build cooperative and productive relationships with business organizations and to promote international trade are laudable and consistent with its responsibilities. This does not justify the abandonment of other even more fundamental responsibilities. The primary responsibility of the federal government is to safeguard the well being of the American people. In the case of this powerful technology, it means avoiding unnecessarily risking the safety and health not only of Americans, but of people all over the world now and in the future, and of the natural environment on which human well being ultimately depends.

Recently, apparently in recognition of the international importance of this issue, its complexity, and the controversy surrounding it and the U.S. position, the EPA and USDA sponsored a conference of the international Organization for Economic Cooperation and Development (OECD). This organization of 30 industrial democracies committed to a market economy met in Raleigh, NC, in December 2001. (A draft report of this meeting is available on the website listed in the *Sources* section below.)

The report reflects the wide diversity of views in the international community of industrial nations and makes clear how difficult it will be for the nations of the world to agree on a common policy. Ultimately, global agreement on at least the fundamental issues will be vital. The draft report lists many areas of general agreement and only three "outstanding issues," but when read carefully, it is clear that they are fundamental, especially the issues dealt with in paragraph 63.

"63. While there is general agreement that scientific knowledge is essential for risk assessment and management, debates continue on the necessary scope and detail of such knowledge and how the risk framework might best deal with uncertainty. Discussion also continues about whether a generic approach to risk assessment might be explored for certain applications.

64. One of the unresolved issues is whether concerns about uncertainty should be applied primarily to new technologies and LMOs [*living modified organisms*] or should also be applied to conventional crops.

65. Many of the safety principles that guide debate over LMOs have been developed in fields such as chemical and nuclear safety. While these areas are a major source of information and experience, it is not clear the extent to which the lessons are truly applicable to LMOs."

We cannot wait for 30 countries to agree; America should initiate effective action now to reduce the likelihood of health and environmental damage from invasive and little-understood transgenic biotechnology. At the same time, we need to develop alternative policies and programs to deal with third-world hunger and its underlying causes.



HUNGER IN THE DEVELOPING COUNTRIES

Our intensive campaign to convince other nations that free-trade principles require them to accept our genetically modified crops and seed seems improper and dangerous. Many, including some leaders of developing nations who are almost certainly influenced by the promotional campaigns of the biotech industry and our government, have come to believe that this technology offers the only solution to hunger in the third world. This conclusion is unwarranted, even if modern biotechnology were not such a serious health and environmental risk. There are many underused and far less risky approaches to solving the critical global problem of hunger—among them:

- Further development and global dissemination of conventional and sustainable agricultural practices.
- Economic aid, including direct emergency shipments of food when and where needed, as well as economic incentive programs and technical and scientific support to developing countries from the wealthy nations. These steps would include improvement of food-distribution channels in third-world countries where hunger is endemic. This would be combined with:
- Increased support by the industrial democracies for democratic institutions, public education, and human and civil rights in countries where they are not firmly established. Political development of this kind is essential to achieve stability and ultimately eliminate the root causes of poverty and hunger. It is clear that nations without stable democratic institutions have great difficulty resolving their own economic, social, and political problems and are a source of international instability. In these conditions, the heaviest burden of hunger and suffering almost always falls on those most impoverished.

Actions along these lines could begin immediately to alleviate the problem of third-world hunger and in time to eliminate it. They present none of the huge health and environmental risks that in our present state of knowledge inevitably accompany the widespread and growing introduction of genetically modified organisms.

We need to end the present rush to the radical, dangerous, and unnecessary deployment of transgenic biotechnology. It is unrealistic and dangerous to rely, as we seem to have done thus far, on untested claims of long-term benefits from this technology and assurances of its safety from both the same industries that profit from the technology and from scientists who may be influenced by dependence on those industries.

AN EFFECTIVE REGULATORY POLICY FOR TRANSGENICS

On this vital issue, as with so many others in today's world, this most powerful and wealthy country must lead the way. What seems to be urgently needed is a comprehensive, government-sponsored review of the issue. This could be initiated by naming a broad-based panel of highly competent scientists, including leading experts from other countries, who have no direct or indirect personal connection to the biotech and feed industries or other conflict of interest.

During the review period, I believe that there should be a global moratorium on any introduction of new products of transgenic biotechnology—and withdrawal to the extent possible of products already introduced. The scientific panel would be charged with developing and presenting to the Congress and the Administration, as expeditiously as is possible for such a complex matter:

- 1) A comprehensive analysis and assessment of the technology and its potential benefits and risks; and
- 2) A program of safety testing to protect the environment and human health from possible long-term negative effects of the new technology. This testing would presumably be required *before* introduction of genetically modified organisms or products of such organisms into the marketplace and the environment. If scientific knowledge at this time is inadequate to develop a detailed program, the panel would define the purpose, principles, and criteria for an adequate testing program.

The initial panel could then be expanded into one or more working groups charged with recommending the substantive content of new legislation. The expanded group(s) would include other major stakeholders, including individuals involved in the industrial production and marketing of the transgenic foods and products containing them. The groups would also include consumers, large-scale and family-farm operators, large- and small-scale food manufacturers, and others in the food production and distribution chain.

In view of the far-ranging implications of this technology, the group(s) might invite the participation of ethicists, religious leaders, academics, and practitioners in other disciplines who would ensure deep and broad consideration of this extremely complex issue. Building on the findings of the scientific panel, these broader groups would develop guidelines for future use of the technology.

I believe that with scientifically sound recommendations in hand the government must then act promptly and vigorously to establish an effective legislative framework. This cannot be dealt with as a partisan issue. If the Administration and the Congress would act together, using the best available scientific knowledge and their own good and conscientious individual judgment, they would have the support of the vast majority of Americans. They would accomplish a great service for the American people and human beings everywhere.



ENVIRONMENTAL ACTION BEYOND TRANSGENICS

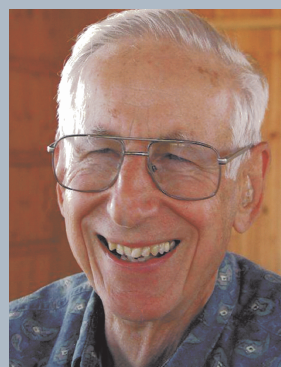
We need to recognize that some of our own personal attitudes and national policies seem environmentally reckless and irresponsible. Our waste of nonrenewable natural resources and our grossly inefficient use of energy are practices more deeply entrenched than the use of transgenic biotechnology, and they pose equally fundamental environmental threats. In recent years we've become increasingly aware of the dangers inherent in these practices and better informed on those dangers, but we are far from translating that knowledge into effective action.

America has amply demonstrated the strength and vitality of our form of representative democracy as it has evolved over more than two centuries. It has long been a model and a beacon of hope for ordinary people everywhere. It still is. But the power of modern technology to upset the Earth's ecology means that we have to go beyond the promise of liberty and justice and economic opportunity for all. To be a viable model for the rest of the world, *we must be sure that our actions as a nation are environmentally sustainable*. Today they almost certainly are not.

It is even more urgent to acknowledge the looming risk of environmental catastrophe when developing nations, or even the two-billion citizens of China and India together, seriously begin to emulate American patterns of consumption. That process is already well underway. We must ensure that our political leaders

face this problem and move now to deal with this global reality. Environmental sustainability must be a clear and primary goal of American policy—and be reflected in all of our actions. Today it certainly is not.

The attacks of September 11 have understandably diverted the attention of Americans and our government from many important issues. But we must find the will and the means to deal effectively with every serious environmental challenge. If we do not, who will bear responsibility for the global health and environmental disasters resulting from our inaction and our ill-considered and mistaken decisions?



Robert L. Manning, New York Beta '49, received his degree in chemical engineering from Syracuse University in 1949. He worked for more than 20 years in various manufacturing and engineering management positions in the pharmaceutical industry with Merck and Pfizer International, as well as with Shawinigan Resins Corporation in the manufacture of vinyl polymers. The assignments included 10 years of in-residence work in Brazil, Mexico, and Japan. Bob retired as senior vice president of Stetson Harza, an architectural/engineering firm in Utica, NY, in 1991, after an 18-year second career.

He now devotes a considerable amount of his energy to an issue he considers vitally important, the environmental sustainability of our national and public policies. Other, more immediately rewarding activities include working with family members to try to bring their family farm in upstate New York back into sustainable production and following, with his wife Betty, the diverse activities and interests of their children and grandchildren.

REFERENCES

Many of the issues discussed in this article are covered in the publications and websites of environmental organizations in which I have considerable confidence. Two that have focused significant attention on biotechnology are:

- Union of Concerned Scientists (www.ucsusa.org/index.html) and
- Sierra Club (www.sierraclub.org/biotech/—the July/August issue of its publication *Sierra* highlighted “genetic engineering”).

Biotechnology developments reported in publications such as *Nature* and *Scientific American* are often well covered, along with other biotechnology news, in a few U.S. newspapers, among them *The Wall Street Journal* and *The New York Times*. There is frequent press coverage on this subject in other countries, including Canada, England, India, and New Zealand.

An interesting forum for the exchange of ideas on biotechnology is conducted by Harvard University at: www.cid.harvard.edu/cidbiotech/comments.

Other sites that tend to reflect primarily the positions of the biotechnology industry or environmental or GM-free food advocates can be found easily by interested Internet surfers.

Worldwatch Institute, an environmental research and publishing organization based in Washington, DC, is a valuable source of reliable information and data on a wide range of environmental issues. There have been short items on developments in agricultural biotechnology as recently as the Jan./Feb. 2002 issue of its publication, *Worldwatch Magazine*.

OECD conducted an international conference on this issue in December 2001. *The Rapporteur's Report* is at www1.oecd.org/ehs/raleigh/report0412.htm.