Chapter 3

The Role of Public Perception and the Regulatory Regime

"In the realm of controlled release, it seems, we need sociology as well as ecology. But the qualifier "good" is essential in each case too."

Bernard Dixon
Bio/Technology 4:481, June 1986

"Public opinion, in today's democracies forms an archipelago, not a continent."

Jean-Francoise Revel
How Democracies Perish, p. 14
Harper & Row, New York, 1983

"The public does not have to understand what is going on in biotechnology. . . . But people need a perception that somebody is in charge and somebody is looking out for their best interests."

Warren Hyer
Bio/Technology 4:497, June 1986

"At this stage of its emergence, the biotechnology industry can learn from the painful experience of the chemical industry: That a public enthralled by technological advances can become quickly hostile if they are not honestly informed about both the benefits and potentially hazardous side effects and then given adequate opportunity to participate in regulatory decision making."

Jay D. Hair
Conservation Exchange 4(4):2, Winter 1986-87

Tables

Chapter 3

The Role of Public Perception and the Regulatory Regime

Field tests involving the deliberate release of genetically engineered organisms into the environment have resulted in increased public interest in and scrutiny of the developing biotechnology industry. The role of government has likewise increased. The United States has developed a Coordinated Framework for the Regulation of Biotechnology (10); the Organization for Economic Cooperation and Development (OECD), representing 24 nations, has developed proposals outlining safety considerations for applications of recombinant DNA organisms in industry, agriculture, and the environment (24); and several European countries have developed laws or regulations governing genetic engineering (7).

Activists opposed to environmental applications of genetically engineered organisms have increased their visibility at the Federal, State, and local levels. Perhaps best known is the Foundation on Economic Trends, led by Jeremy Rifkin, which has filed several biotechnology-related legal challenges. Local groups, some in concert with the Foundation, have become involved in debating the merits of several proposed field tests. Scientists and their constituent organizations have also participated in the public discussion. Public knowledge and opinion about issues concerning science and technology in general and genetic engineering and biotechnology in particular are likely to shape future debate.

This chapter reviews the general public's perceptions as measured by a national survey conducted by Louis Harris and Associates for OTA, the role of public perception in local communities where field tests have been proposed, and the existing governmental framework for the regulation of biotechnology.

ATTITUDES AMONG THE GENERAL PUBLIC

In addition to scientific considerations, public perceptions of the risks and benefits of biotechnology can play an important role in planned introductions of genetically engineered organisms. As one writer has stated, "the public is a mixed bag of people, each of whom interprets the information generated by a biotechnology company based on a set of personal biases" (20). This, combined with the general lack of scientific knowledge with respect to these introductions and the natural sense of unease with which the public views high technology, serves to highlight the need for sound information on public opinion.

Such information can provide a basis for understanding and anticipating public responses to risk factors. It can also identify the quality and sources of information the public draws upon, and provide a basis for improving the communication of risk information among lay people, technical experts, and decision makers (25).

As part of a broader survey, OTA commissioned Louis Harris & Associates to conduct a survey of public opinion on a number of issues related to planned introductions of genetically engineered organisms. The survey consisted of a national sample of 1,273 adults telephoned in November 1986. The variance for this survey is less than 3 percent for the total sample.

The results illustrate the complexities and contradictions characteristic of public attitudes in this area. As the complete data have been published separately (30), only a brief description of the points most germane to deliberate release is presented here.

The American public is interested in biotechnology and genetic engineering. Two-thirds of the public (66 percent) feel they understand the meaning of the term "genetic engineering." In a related question 35 percent say they have heard or read

a fair amount about the subject. However, only 19 percent has heard of any potential risks posed by products of genetic engineering. A much higher share (52 percent) believes it to be at least somewhat likely that these products will present some serious danger to humans or the environment. In spite of this, a clear majority (66 percent) thinks genetic engineering will bring changes that will improve their quality of life.

The American public is more positively and consistently inclined toward genetic manipulation of plants, animals, and microbes than toward human cell manipulation. This may in part reflect a sense that "we have no business meddling with nature"- a feeling strongly expressed by 26 percent of the population (table 3-7).

Not only is there some concern about the morality of genetically manipulating organisms, there is also concern about the potential risks that may be posed. Between 52 and 61 percent say they think it is at least somewhat likely that untoward consequences (antibiotic-resistant diseases, human birth defects, herbicide-resistant weeds, or endangered food supply) could follow. But fewer than one in five think any of these developments are very likely (table 3-l).

People seem willing to accept relatively high rates of environmental risk in exchange for the potential benefits that might be derived from deliberate release of genetically engineered organisms. A majority (55 percent) would approve an application that would significantly increase agricultural production even if the risk of losing some local species of plant or fish were as high as 1 in 1)OOO. With lower levels of risk, the degree of public acceptance increases. But despite a general public willingness to approve the use of genetically engineered organisms in the environment at relatively high levels of risk, a majority says it would not approve an application if the risk were unknown. Indeed, significantly fewer say they would approve if the risk were "unknown but very remote" than would approve if the risk were 1 in 1,000 (45 v. 55 percent) (table 3-2).

If there were no direct risk to humans and only very remote risks to the environment, a majority would approve the planned introduction of genetically engineered organisms to produce disease-resistant crops (73 percent), oil-eating bacteria to clean up spills (73 percent), frost-resistant crops (70 percent), more effective pesticides (56 percent), or larger game fish (53 percent) (table 3-3).

However, this approval is limited. Although a large majority of the public (82 percent) approves of small-scale experimental tests of genetically engineered organisms for environmental applications, 53 percent feel that large-scale experimental tests should not be permitted (table 3-4).

Most Americans also say they would favor or be indifferent to having genetically altered organisms tested in their community, assuming there was no direct risk to humans and a very remote potential risk to the local environment (table 3-4).

Thus, Americans seem to be pragmatic in judging genetic engineering. They are concerned about the morality and the safety of these new developments, but are willing to greet biotechnology with

Table 3-1 .—Likelihood of Specific Dangers From Use of Genetically Altered Organisms in the Environment[a]

Q.: From what you have heard or read, how likely do you think it is that the use of genetically engineered organisms in the environment will (READ ITEM) —very likely, somewhat likely, somewhat unlikely, very unlikely?

	Very likely	Somewhat likely	Somewhat unlikely	Very unlikely	Not sure
Create antibiotic-resistant diseases	180/0	43 "/0	21"!0	7%	11 "/0
Produce birth defects in humans	18	39	24	10	9
Create herbicide resistant weeds	15	41	22	11	11
Endanger the food supply	14	38	29	13	7
Mutate into a deadly disease	13	33	30	14	10
Change rainfall patterns	12	30	30	16	12
Increase the rate of plant or animal extinction	11	34	31	15	9

[a]Percentages are presented as weighted sample estimates. The unweighed base from which the sampling variance can be calculated is 1,273.

SOURCE: Office of Technology Assessment, 1987.

Table 3.2.-Acceptable Levels of Risk for an Environmental Application of Genetically Engineered Organisms[a]

Q.: Suppose that a new genetically engineered organism had been developed which would significantly increase farm production with no direct risk to humans. Would you approve the environmental use of that organism if the risk of losing some local species of plants or fish was (READ ITEM)?[b]

Risk level	Approve	Not approve	Not sure	No answer
Unknown	31%0	65%	3%	1 %
1 in 100	40	51	9	0
1 in 1000	55	37	3	5
1 in 10,000	65	27	3	5
1 in 100,000	71	21	3	5
1 in 1,000,000	74	18	2	5
Unknown, but very remote	45	46	9	5

[a]Percentages are presented as weighted sample estimates. The unweighed base from which the sampling variance can be calculated is 1,273.
[b]Approvals are cumulative. persons who approved at a risk level were not asked to approve at lower levels of risk.
CAs a result of a programming error, those who approved at "Unknown" risk level were not asked about specific risk levels. Those omitted Were recontacted to complete the risk section but we were unable to obtain responses from 5 percent of the sample, as a result. Although these are treated as "No answer, " most of them would be approvals at the first risk level specified.

SOURCE: Office of Technology Assessment, 1987.

Table 3-3.—Attitudes About Environmental Uses of Genetic Engineering Under Remote Risk Conditions[a]

Q.: If there was no direct risk to humans and only very remote risks to the environment, would you approve or disapprove the environmental use of genetically engineered organisms designed to produce (READ ITEM)?

	Approve	Disapprove	Not sure
Disease-resistant crops	73%	230/o	4%
Bacteria to clean oil spills	73	23	4
Frost resistant crops	70	27	3
More effective pesticides	56	40	4
Larger game fish	53	43	4

[a]Percentages are presented as weighted sample estimates. The unweighed base from which the sampling variance can be calculated is 1,273.

SOURCE: Office of Technology Assessment, 1987.

optimism if reasonable precautions are taken by those developing, applying, and approving the new technologies. Significant groups within the population do, however, depart from these feelings. Nevertheless, a large majority (82 percent) believes that research into genetic engineering should continue, and support for this research is found in all segments of the American public (table 3-5).

This research enjoys majority support even among those who believe human cell manipulations are morally wrong (7 I percent), that genetic engineering products will present serious risks (73 percent), or that it would be better if we did not know how to alter cells genetically (63 percent) (30).

A plurality (40 percent) feels that government funding for biological research should be increased. Only 10 percent of the public thinks that government funding for biological research should be cut.

Table 3.4.—Environmental Release on an Experimental Basis[a]

Q.: Do you think that environmental applications of genetically altered organisms to increase agricultural productivity or clean up environmental pollutants should be permitted on a small scale, experimental basis, or not?

Yes	82°/0
No	13
Not sure	4

Q.: Do you think that commercial firms should be permitted to apply genetically altered organisms on a large scale basis, if the risks of environmental danger are judged to be very small, or not?

Yes	42°/0
No	53
Not sure	5

Q.: Suppose your community was selected as the site to **test a genetically altered organism—such as bacteria that protect strawberries from frost—where there was no direct risk to humans and a very remote potential risk to the local environment. Would you be strongly in favor, somewhat** in favor, somewhat opposed, very opposed, or really not care if **it was used** in your community?

Strongly in favor	14°/0
Somewhat in favor	39
Don't care	14
Somewhat opposed	21
Strongly opposed	11
Not sure	2

percentages are presented as weighted sample estimates. The unweighed base from which the sampling variance can be calculated is 1,273.

SOURCE: Office of Technology Assessment, 1987.

Table 3-5.—Opinions About Genetic Research and Funding

Q.: Do you think that research into genetic engineering should be continued or should be stopped?
Continued . . . . . 82°/0
Stopped 13
Not sure 5
Q: Do you believe that government funding for biologic research should be increased substantially, increased somewhat, remain about the same, decreased somewhat, or decreased substantially?
Increased substantially 11%
Increased somewhat 29
Remain about the same 43
Decreased somewhat 6
Decreased substantially 4
Not sure 7

[a]Percentages are presented as weighted sample estimates. The unweighted base from which the sampling variance can recalculated is 1,273.

SOURCE: Office of Technology Assessment, 19S7.

Aside from supporting research, the public recognizes another important government function associated with the development of biotechnology. A plurality (37 percent) says the government should decide whether commercial firms should be permitted to apply genetically engineered organisms on a large-scale, commercial basis. Twenty-nine percent claim this decision should be made by an external, scientific body, while only 5 percent feel voters, taxpayers, or other community-based groups should make the decision. Thirteen percent maintain the company involved should make the decision, and 4 percent find a role for industrial trade organizations (table 3-6).

Despite this relative ranking, which gives the highest degree of approval for decisionmaking to governmental agencies, the public has more confidence in university scientists than in the government. When asked whose statements they would be likely to believe about the safety of a particular application, the majority of Americans say university scientists (86 percent). Public health officials score second (82 percent), environmental groups third (71 percent), followed by governmental agencies (69 percent). In the case of conflicting statements from governmental agencies and environmental groups, 26 percent would favor the Federal agency, 63 percent place more trust in the environmental group, and 11 percent are undecided or say it would depend on the specific circumstances.

In summary, the survey found that while the public is concerned about genetic engineering in the abstract, most people approve nearly every specific environmental or therapeutic application explored in this poll. The public is sufficiently concerned about potential risks to say that strict regulation is necessary, yet a majority also agree strongly or somewhat that unjustified fears of these new technologies have seriously impeded the development of valuable new drugs and therapies, and that the risks have been exaggerated (table 3-7).

As in other areas of science and technology, the public favors the continued development and application of biotechnology because people believe the benefits will justify the risks. Strict regulation to avoid unnecessary risk is expected, but some risk is clearly acceptable if sufficient benefit is expected in return.

TabLe 3-6.—Who Should Decide?

Q.: Who should be responsible for deciding whether or not commercial firms should be permitted to apply genetically altered organisms on a large scale basis--the company that developed the product, an external scientific body, a government agency, an industrial trade association, or other group?

			Party affiliation		
	Total	Voters	Republican	Independent	Democrat
Government agency	37%	380/o	380/o	35%	380/o
External scientific body	29	31	32	34	25
Company **that developed product	**13**	**12**	**12**	**8**	**16**
**Public/voters/taxpayers community	**5**	**4**	**4**	**4**	**5**
**Industrial trade association.	**4**	**4**	**3**	**4**	**4**
**Not sure	**5**	**5**	**4**	**5**	**5**
**All other mentions	**8**				

[a]Percentages are presented as weighted sample estimates. The unweighed base for the total sample from which the sampling variance can be calculated is 1,273.

SOURCE: Office of Technology Assessment, ?9S7.

Table 3-7.—General Perceptions Concerning Biotechnology[a]

Q.: I will now read you a few statements. For each, please tell me whether you agree strongly, agree somewhat, disagree somewhat or disagree strongly. (READ EACH ITEM)

	Agree strongly	Agree somewhat	Disagree somewhat	Disagree strongly	Not sure
a. The potential danger from genetically altered cells and microbes is so great that strict regulations are necessary	43%	34%	14%	60/0	3%0
b. The risks of genetic engineering have been greatly exaggerated	15	40	27	10	8
c. It would be better if we did not know how to genetically alter cells at all	13	20	34	31	2
d. The unjustified fears of genetic engineering have seriously impeded the development of valuable new drugs and therapies	20	38	26	9	8
e. We have no business meddling with nature	26	20	31	21	2

[a]Percentages are presented as weighted sample estimates. The unweighed sample from which the sampling variance can be calculated is 1,273

SOURCE: Office of Technology Assessment, 1987

THE ROLE OF PUBLIC PERCEPTION IN LOCAL COMMUNITIES

Companies and researchers must be prepared to work with State and local officials and residents when a field test of a genetically altered plant, animal, or micro-organism is proposed. Without local support, proposed field tests may be delayed or canceled. To date, several proposed field tests have met with varying degrees of State and local support. Several States have or are currently considering legislation based on the perception that additional State protection or coordination is needed (see box 3-A).

The experiences of 11 communities described in this section illustrate varying degrees of local acceptance of proposed field tests, and varying degrees of State and local oversight of such experiments.

Monterey and Contra Costa Counties, California

"It was only local concern, generated in Monterey, that opened up the issue. As with events in the nuclear industry, public opinion only becomes focused when it is in your backyard, "

Roger Sherwood,
"The Monterey fallout continues,"
Trends in *Biotechnology, July 1986.*

Advanced Genetic Sciences, Inc. (AGS) of Oakland, California received the first experimental use permit issued by the Environmental Protection Agency (EPA) for the environmental release of a genetically altered organism. The AGS permit was also the first to be revoked by EPA.

In November 1985, EPA approved the issuance of an experimental use permit to release strains of *Pseudomonas syringae* and *P. fluorescent* from which the gene for the ice-nucleation protein had been deleted. The altered bacteria (also known as Frostban) was to be applied to 2,400 strawberry plants on an 0.2-acre plot surrounded by a 49-foot vegetation-free zone in northern Salinas Valley, California.

Various individuals and nonprofit environmental organizations sought injunctive relief against EPA's issuance of an experimental use permit to AGS. The suit was dismissed in March 1986 on the grounds that the plaintiffs (Foundation on Economic Trends et al.) failed to establish the likelihood of success in showing that EPA's issuance of a permit violated the requirements of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), the National Environmental Policy Act (NEpA) or the Administrative procedure Act (14).

In January 1986, the Monterey County Board of Supervisors held a hearing—receiving testimony

BOX 3-A.—State Legislative Activity

California

In 1984) the California Legislature passed Assembly Concurrent Resolution 170 ''to promote the biotechnology industry, while at the same time protecting public health and safety and the environment. " As a result, the Governor's Task Force on Biotechnology prepared a guide to clarify the regulatory procedures for biotechnology (26).

A bill (SB 844) introduced into the Senate on March 3, 1987, would require State regulations on the handling of biotechnologically novel organisms, making violators subject to civil and criminal penalties.

Illinois

Legislation was introduced (HB 1866) in 1987 establishing a 9-member committee to review existing Federal regulations and monitor the release of genetically engineered organisms. The bill was passed by the Legislature, but vetoed for budgetary reasons by Governor James Thompson on October 22, 1987.

New Jersey

New **Jersey State bill S. 1123 (introduced in the 1986 session) would find** that "the citizens of the state maintain legitimate concerns about the effect that the release of genetically engineered micro-organisms into the outdoor environment may have on the health, safety and welfare of the public, " and establish a 9-member commission to regulate the release of genetically engineered micro-organisms in the environment. The bill has been opposed by the Association of Biotechnology Companies (18), which is concerned that such legislation "would put New Jersey on the map as being antagonistic to the emerging biotechnology industry and thereby discouraging companies from locating their high-technology research and manufacturing jobs within the state" (19).

The bill was approved by the Senate but defeated by the State Assembly,

North Carolina

The North Carolina General Assembly approved the formation of a study commission approved by the Joint Appropriations Committee, in July 1986, to determine whether a State environmental protection agency should be formed.

Texas

HB 41, introduced during the 1987 legislative session, would have established a commission to review the adequacy of Federal and State laws governing biotechnology, and requiring State notification of releases of genetically engineered organisms. The bill was not acted upon.

Wisconsin

Two members of the Senate Agriculture, Health and Human Services Committee recommended the creation of a legislative council committee, that would consist of legislators and other interested parties, to study how the State should regulate biotechnology. This followed a 1987 report from the Department of Natural Resources that was critical of the Federal Coordinated Framework. In January 1988, a legislative subcommittee approved a proposal that would require experimenters to apply for a State permit prior to releasing any genetically altered organism into the environment.

SOURCE Office of Technology Assessment, 1988

from EPA, California State Departments of Health Services, Food and Agricuhure, AGS, scientists, the Foundation on Economic Trends, and concerned members of the public. An ordinance banning experiments in Monterey County for 45 days was passed by the Supervisors. In February 1986, it was learned that AGS had 1 year previously injected the test bacteria into approximately 50 fruit trees on the rooftop of its headquarters building without EPA approval. In March 1986, EPA suspended the AGS experimental use permit and fined the company $20,000 on the grounds that the organism had been released prior to EPA approval and that the company had deliberately made false

statements on its application. The fine was later reduced to $13,000 with an amended complaint that AGS had not provided adequate details about the testing method. In April 1986, the Monterey County supervisors, relying on their zoning authority, passed legislation banning experiments within the county for a year,

In December 1986, AGS applied to EPA and the California Department of Food and Agriculture for approval to conduct the field test in San Benito County or Contra Costa County (both in California). In February 1987, the EPA reissued an experimental use permit to AGS, and the State Department of Food and Agriculture gave its preliminary approval. In March, after receiving the approval of the Contra Costa County Board of Supervisors, AGS announced its intention to conduct the field test outside of Brentwood, a town with approximately 6,000 residents. Opponents filed a legal challenge in April, which was dismissed by a Sacramento County Superior Court judge. On April 24, 1987, the field test was carried out, even though many of the plants were uprooted by vandals just hours prior to the test. A second test on 17,500 strawberry plants commenced in December 1987.

Local reaction to the AGS proposed field test differs from the experience of other communities (described later) in several respects. The AGS proposed field test was the first to be approved by EPA, and the only one to be suspended by EPA. The proposed test site in Monterey County was also in a more populous area than the others (a situation remedied by the relocation of the proposed release site). Finally, disclosure in the media alleging that AGS had conducted a limited environmental release on its headquarters rooftop opened the company, and the environmental release issue generally, to closer public scrutiny.

Tulelake, California

"We object to using the Tulelake area as guinea pigs for an experiment that won't benefit the area and **could cause public refusal of local farm products. "**

Joe Victrene, master, Tulelake Grange, during public hearing, Jan. 10, 1987.

Tulelake, an agricultural town near the California/Oregon border, was the proposed test site for the release of genetically altered P. ***syringae*** bacteria on a small plot of potatoes. Designed by Steven Lindow and Nickolas Panopoulos, plant pathologists at the University of California at Berkeley, the experiment involved identifying the gene responsible for ice nucleation, deleting the gene, and applying the altered bacterium to the plants. If successful, the treated potato plants might resist frost damage from temperatures as low as 23 'F.

The proposed environmental release of the ice-minus bacteria was first approved by the National Institutes of Health (NIH) Recombinant DNA Advisory Committee (RAC) in April 1983. In September 1983, the Foundation on Economic Trends joined several other groups and individuals in filing suit to stop the experiment, The plaintiffs argued that NIH had violated the administrative requirements of the NEPA, which requires Federal officials to prepare an environmental impact statement before approving an action significantly affecting the environment. In May 1984, Judge John Sirica issued an injunction prohibiting the field test, and barring NIH from approving further experiments involving the release of engineered organisms until it assessed the environmental impacts of such tests, EPA began review of the experiment in 1984. In 1986, EPA and the U.S. Department of Agriculture (USDA) assumed regulatory authority, pursuant to the Federal Government's Coordinated Framework for the Regulation of Biotechnology.

Local opposition to the proposed field test received increased attention in 1986. In early May, field test opponents circulated a petition that garnered 450 signatures. The group, "Concerned Citizens of Tulelake," were present at a May 1986 public meeting, and then appeared before the Tulelake City Council and the Siskiyou and Modoc County Board of Supervisors seeking local gov-

ernmental action against the experiment. On June 2, 1986, the Modoc County Board of Supervisors passed a legally nonbinding resolution opposing the experiment on the grounds that "the questions and fears in the minds of the public could have a serious and immediate adverse effect on the market for crops from the area."

Despite the protest, on May 13, 1986, the EPA approved the experiment and issued an experimental use permit, saying that the environmental release posed "minimal risk to public health or the environment." In July, the scientists announced that they would proceed with the experiment in early August. On August 1, opponents of the test (Californians for Responsible Toxic Management and the Foundation on Economic Trends) filed suit in Sacramento Superior Court against the University of California-Berkeley Regents and the California Department of Food and Agriculture seeking an injunction against the experiment until environmental impact studies could be done at State level. On August 4, 1986,2 days prior to the proposed field test, Sacramento County Superior Court Judge A. Richard Backus granted an 18 day temporary restraining order. Two weeks later, the University of California agreed to halt the experiment for 1986.

Local opposition to the Tulelake field test continued at a public hearing in January 1987, when several residents, including the president of the Tulelake Growers Association and the master of Tulelake Grange, voiced opposition to the experiment, fearing crops may be boycotted by buyers. On April 29, 1987,3 days after Advanced Genetic Sciences, Inc. began its field test of Frostban in Contra Costa County, the University of California scientists planted potato tubers treated with the ice-minus bacterium on a half-acre site at a university field station near Tulelake. On May 26, 1987, vandals uprooted approximately half of the plants being studied. Earth First!, an environmental group, claimed responsibility for the raid, which disrupted attempts to study the yields from the plants, but not attempts to study how well the bacteria established themselves on the plants (1.

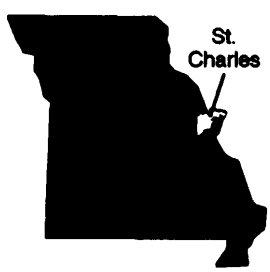
The Tulelake scenario is similar to that of Monterey County. Both experiments involved proposed releases of P. *syringae,* both followed similar regulatory approval processes, and both were linked together in many media stories. While both experiments elicited opposition in their respective communities, in Tulelake it focused to a significant degree on a fear that locally grown crops would be boycotted by buyers, damaging the local economy. Although opponents of the Monterey County and Tulelake field tests went to county authorities to stop the experiments, opponents of the Tulelake field test also relied on State environmental law as the basis for their suit in Sacramento County Superior Court. In both instances, experimental plants were vandalized.

St. Charles County Missouri

"The Monsanto case is the third product to move through regulatory agencies and is the most controversial because the bacterium produces a poison which will kill some living things, and which may remain for some time in the soil before dying."

Phillip **J. Hilts,** ***Washington Post,*** **Apr. 25, 1986.**

Monsanto proposed releasing an engineered microbial pesticide designed to protect the roots of corn plants against black cutworm. Although the company was prepared to proceed with the release in mid-1984, it held off until publication of proposed Federal guidelines late in the year. Monsanto then became the first company to seek EPA approval following publication of the Federal Government's Proposed Coordinated Framework for Regulation of Biotechnology. In April 1986, an EPA scientific committee recommended that the Monsanto field test should be allowed to proceed (5).



Local opposition to the Monsanto experiment became apparent when the St. Charles City Council passed a resolution in early 1986 opposing the procedure. This opposition ran counter to the test's endorsement by the 3-person St. Charles County Commission. In March 1986, the Foundation on Economic Trends petitioned EPA to deny Monsanto's permit application, citing "unresolved questions regarding the nature and magnitude of

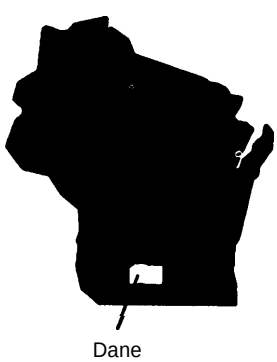
the risks and benefits involved in the Monsanto proposal." On May 8, 1986, St. Charles County officials delivered a letter to Monsanto threatening to sue if the company proceeded with the field test. The letter cited county code sections prohibiting storage or processing of anything considered harmful or potentially harmful to individuals or the environment and specifying that flood plains must be used for agricultural purposes.

Twelve days later, EPA requested additional information in support of Monsanto's application for an experimental use permit. Results of the additional tests are pending.

Middleton, Wisconsin

"The Agracetus project has not elicited much protest, however, even from the Foundation on Economic Trends, a frequent opponent of such tests. 'We looked at it and it didn't raise the kind of fundamental questions the other tests did, ' said Jeremy Rifkin, the foundation's president. Mr. Rifkin said that in general genetically modified plants pose less risk than micro-organisms because they can be contained more easily. ' "
—Andrew Pollock, New York Times, May 30, 1986.

The Agracetus Corp. (a joint venture of Cetus and W.R. Grace) proposed to insert an altered gene for disease resistance against crown gall tumors in 200 tobacco plant seedlings. The genetically modified plants were planted in a one-twentieth-acre plot in Middleton, WI. Tobacco was the experimental plant of choice because it is one of the easiest plants to engineer genetically. Agracetus received approval for the field test from the NIH's RAC, USDA, and the Wisconsin Department of Natural Resources.



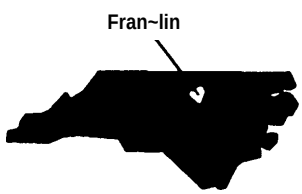
On May 30, 1986, Agracetus commenced the first authorized planting of a genetically altered crop. The Wisconsin *State Journal* noted its approval for the experiment, stating that "while it remains to be seen if the test will prove scientifically successful, it is already a winner from the regulatory point of view ." The editorial noted that regulatory approval was "by the book, " and that the release site was situated away from roads or people.

Unlike the proposed releases of genetically altered organisms in Monterey County, Tulelake, and St. Charles County, the Agracetus experiment involved the introduction of a genetically altered plant. Local newspaper accounts of the Agracetus experiment talked of the potential economic gain to be realized should crops be made resistant to crown gall tumors.

Franklin County, North Carolina

"Ciba-Geigy officials have informed state and local officials of their plans. 'I think they have done a responsible job, ' said Earl R. MacCormac, science advisor to Gov. James G. Martin. 'I feel real good about it, ' added Ronald W. Goswick, chairman of the Franklin County Board of Commissioners."
—Monte Basgall, Raleigh, N.C. News & *Observer,* **June** 18, 1986.

The Agricultural Division of Ciba-Geigy Corp., Greensboro, NC, proposed conducting a field test of a tobacco plant that had been genetically altered to resist atrazine, a herbicide used to control weeds in corn, sorghum, and other crops. Certain crops, including tobacco and soybeans, are susceptible to atrazinc. These crops can be injured when planted in some soil types the year after a tolerant crop treated with atrazine was grown there, since residual atrazine persists in the soil through the period of crop rotation.



Ciba-Geigy applied to USDA for approval of the field test. The North Carolina Department of Agriculture asked that USDA regulate the test because no State guidelines existed for handling such research.

USDA approved the field test in July 1986. The North Carolina legislature subsequently approved funding for a study commission to determine

whether control of State environmental responsibilities needed to be consolidated.

Mississippi and Florida

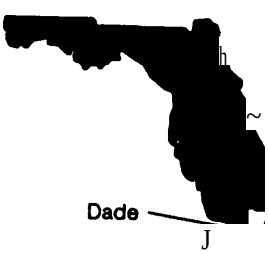
"The Rohm and Haas Company of Philadelphia, one of the world's largest producers of chemicals, announced Wednesday that the U.S. Agriculture Department had approved the world's first field test of genetically engineered caterpillar-resistant plants."

–Associated Press, **Aug. 28, 1986.**

Rohm and Haas developed tobacco plants altered by the addition of a single gene from the bacterium *Bacillus thuringiensis*. The altered plants, developed by a Belgian company for Rohm & Haas, were designed to be resistant to leaf-eating caterpillars.

In June 1986, Rohm and Haas announced that it had voluntarily applied to USDA for permission to field test the tobacco plants at company-owned research farms near Cleveland, MS and Homestead, FL. USDA issued an opinion letter in August 1986 stating that the "genetically engineered tobacco plants are not plant pests" (51 Fed. Reg. 32237).

Prior to publicly announcing its proposed field test, Rohm and Haas provided information to appropriate Federal, State, and local representatives for both test sites. This was followed up by two presentations for the local public and media on the day the proposed field tests were announced (22). Later, presentations were made to other interested groups, including the Central Mississippi Chapter of the Sierra Club. According to one member of the Sierra chapter, the presentation elicited no grave concerns, leaving the impression that the experiment seems valid and safe (3).

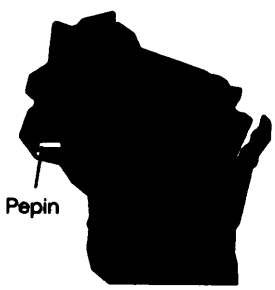


Pepin County, Wisconsin

"Does this test pose a high risk? No. EPA believes that this field test poses little or no risk for several reasons. The genetically engineered strains are expected to be no different than the naturally occurring strains, except for the enhancement of a preexisting trait (the ability to fix nitrogen from the air to the soil). This is significant because the naturally occurring strains have been the most extensively studied microorganisms in agriculture (they have been studied for nearly 100 years) and have shown no significant adverse effects."

—Environmental Protection Agency, "Note to correspondents" Fact Sheet, Apr. 29, 1987.

BioTechnica International, Inc. of Cambridge, MA, proposed a field test of genetically engineered strains of *Rhizobium meliloti,* a bacterium involved in nitrogen fixation in alfalfa. *Rhizobium* is a genus of bacteria commonly used in agriculture, with various strains being sold commercially to increase the yields of legume crops. In its proposal to EPA and USDA, filed on February 6, 1987, BioTechnica noted that about 80 percent of the U.S. alfalfa acreage and 15 to 25 percent of the soybean acreage are inoculated with nongenetically engineered rhizobia-based products. The genetically engineered *Rhizobium* converts atmospheric nitrogen at an increased level, resulting in increased alfalfa yields of up to 17 percent in greenhouse studies by BioTechnica.



The BioTechnica proposal was the first application under the Toxic Substances Control Act (TSCA) subject to the EPA biotechnology policy published in the Federal Register on June 26,1986. BioTechnica's application was filed with EPA in February 1987,

The proposed field test site is BioTechnica's Chippewa Agricultural Station near Arkansaw, WI, an unincorporated town in the Waterville Township of Pepin County. The area of the proposed test site is lightly populated and far from urban areas. The total population of Pepin County is approximately 7,000, of whom approximately

Photo credit: Kevin O'Connor

Pepin County, Wisconsin

1,000 reside in Waterville Township. The station, located about 30 miles from Eau Claire, WI, and 75 miles from St. Paul, MN, is a 360-acre farm, with less than 5 acres of the site designated for the field test.

The company produced a brochure designed to provide local residents with information regarding the proposed field test. The brochure addresses 21 questions that have been raised during the course of meetings between BioTechnica officials and local residents (see box 3-B). Another brochure, a nontechnical description of the field test, was also produced.

EPA gave tentative approval for the field test in May 1987, but delayed the experiment in order to extend the public comment period and to review how the test would be monitored. In July 1987, a hearing sponsored by the Wisconsin Senate Agriculture, Health, and Human Services Committee was held. Although little opposition was voiced regarding BioTechnica's proposed test, residents did express concerns about potential future tests (12). In August 1987, BioTechnica announced a postponement of the field test following EPA concerns regarding monitoring of the altered bacteria. BioTechnica concluded that the altered bacteria could not be distinguished from other common bacteria present in the soil. The company plans to develop an alternate monitoring plan, and expects to obtain final EPA approval in 1988 (15).

Box 3-B.—Pepin County and Biotechnology: **21** Questions and Answers

1. What is the Chippewa Agricultural Station? **The Chippewa Agricultural Station was established in January 1987 in Arkansaw (Waterville Township), Pepin County, Wisconsin. It is a wholly owned subsidiary of BioTechnica International, Inc. of Cambridge, Massachusetts. Formed in 1981, BTI is a biotechnology research and development company with commercial operations in agriculture and dental diagnostics. Its stock is traded on the national over-the-counter market. The new agricultural station is BTI's first expansion effort outside its home state and its first agricultural station. The station will be used for conventional farming operations, as well as for agricultural research.**

z. Why did BioTechnica International choose Wisconsin? Wisconsin is the Nation's leading dairy State, and it is also the number one producer of alfalfa. The State has been receptive to new advances in business and agriculture. Wisconsin has a sound policy for environmental protection which BTI supports. Field tests of biotechnology products have already been successfully conducted within the State. The University of Wisconsin offers outstanding research and academic expertise, and its Biotechnology Center in Madison is a highly effective channel for communications between the academic and industrial communities and public officials.

3. Why was Pepin County, one of the smallest counties in Wisconsin) chosen for BioTechnica International's research station? Pepin County was selected for BTI's first agricultural research station for several outstanding reasons:

- Wisconsin is the nation's top producer of alfalfa, the plant which will be field tested at the new site.
- The site is close to the University of Wisconsin's Marshfield Research Station, where BTI is currently conducting field tests of a new conventional silage additive. There is a possibility that this research effort will be moved to Pepin County.

- **The area has excellent rainfall.**
- **BTI was able to buy the 360-acre site at a very reasonable price.**
- **An irrigation system was already in place on the farm.**
- **The soil at the farm is a sandy loam and is uniform throughout the 360 acres, almost unheard of benefits for an agricultural research station.**
- **The land is exceptionally flat, minimizing runoff.**
- **The site is 170 feet above the aquifer, making it virtually impossible for groundwater contamination from the field tests to take place.**
- **The site is protected by hills and trees, and is an infrequent host to severe winds and tornados.**
- **The site lies within the 110-day corn-maturity zone and Group 2 soybean zone which make it a very favorable crop-growing climate.**
- **The Chippewa Agricultural Station is less than 1 mile from the home of the farm's superintendent.**

4. Will the entire research farm be used for this field test? Absolutely not. Less than 5 acres, or slightly more than 1 percent, of the 360 acres will be **used in the field test this year. Conventional crops such as alfalfa, soybeans, corn, beans, tobacco, and rapeseed are being considered for planting in the spring and summer of *1987*.**

S. Why is your company planning field tests at the farm? Both laboratory and greenhouse tests have shown that BTI's genetically engineered ***Rhizobium meliloti*** **increases alfalfa yields by as much as** 20 **percent. Long before any agricultural product, conventional or genetically engineered, goes to market it must first be field tested to determine if it is effective under the actual growing conditions encountered in the field.**

6. What is ***Rhizobium meliloti*** anyway? Rhizobia are naturally occurring bacteria that exist in the soil. The rhizobia have a symbiotic relationship with legumes **such as alfalfa, soybeans, peas, and beans. Rhizobia attach themselves to the plant's roots and establish root nodules where they live. The plant gives the rhizobia a home and a food source; the rhizobia, in turn, convert atmospheric nitrogen into a form which the plant can use.** *Rhizobium meliloti* **is the species that naturally associates with alfalfa.**

7. How long have rhizobia been around? **Farmers have been aware of this unique relationship and have taken advantage of it in rotational farming for thousands of years. Rhizobia have been commercially available in the U.S. since the 1890s and are widely used today by farmers and home gardeners. The largest producer today of commercial rhizobia inoculants is located in Milwaukee.**

8. So what did you do to the rhizobia? **Very simply, our scientists "souped up" the bacteria's ability to supply nitrogen to alfalfa.**

9. How did they do that? **Through a laborious research process that took several years, our scientists identified the genes that are responsible for supplying nitrogen to plants. Using a surgically precise process called gene splicing, they were able to alter certain genes so that their nitrogen-fixing, or nitrogen-gathering ability was greatly increased.**

10. Is this some kind of "Super Bug"? **It definitely is an improvement of a naturally occurring bacterium, but by no means can it be considered a dangerous "Super Bug." Many of the strains now used commercially have been carefully selected by the USDA for improved performance. BTI's work is a natural outgrowth of such efforts to provide better products to farmers.**

11. How do you know it isn't dangerous? **Rhizobia are perhaps the best-studied bacteria in agriculture. They have a specific function in nature and that is to gather nitrogen for leguminous plants. In over 90 years of commercial use, they have never been found to be dangerous to plants, animals, or man, nor have they been known to be threats to the environment. Furthermore, BTI has tested its new strains in the laboratory and has shown them to behave the same as their natural counterparts.**

12. Couldn't a whole field of these new organisms deplete the nitrogen supply? **They couldn't even put a dentin it. First, the atmosphere is about 80 percent nitrogen, with over 33,000 tons of nitrogen above every acre of land and water on earth. Naturally occurring rhizobia in an acre of alfalfa gather from 100**

to 200 lbs. of nitrogen per year. BTI will be very pleased if its strains do twice as well. Secondly, Mother Nature is full of checks and balances as the nitrogen cycle proves: nitrogen taken from the atmosphere is ultimately returned to the atmosphere.

13. Won't higher yielding plants drain more nutrients from the soil? **Quite the opposite. Some of the gathered nitrogen will leak into the soil and will be available to crops grown in rotation with legumes, That's why farmers apply less nitrogen fertilizer to corn planted the year after alfalfa or soybeans. Since BTI's strains will gather more nitrogen, it is expected that they will leave more nitrogen behind, thus further enriching the soil.**

14. Can this improved version hurt cattle and eventually humans? Remember, the only alteration to the rhizobia will be to improve their natural nitrogen-gathering ability. Based on all scientific evidence we have, there is nothing to indicate that there could be any adverse effects on cattle or man. The nitrogen gathering process **occurs only in the roots which are not harvested. Cattle don't eat alfalfa roots.**

15. Can this new version affect other plants? No. Rhizobia function only in association with **leguminous plants. And, there are certain types of legumes for each rhizobial species. For instance, R. meliloti for alfalfa, R. *japonicum* for soybeans, etc. BTI's changes to R. rneliloti will not cause it to affect any other crop species.**

16. How far can these little creatures travel on their own? Not very far at all. Their entire range of motility is only about two-tenths of an inch per day, or, about 1 1/2 feet in a 100-day growing season.

17. **Can** they be blown away by the wind? They live under the soil, so it would take a pretty strong wind to blow them away. The test site is well shielded from the wind. But **the R. *meliloti* die without moisture and when exposed to the ultraviolet light of the sun. So, if they were blown away, their chances of survival would be nil.**

18. Suppose a hard rain came along and some of your topsoil washed away with your new strains and got into some streams and lakes. Could they cause a danger to fish and aquatic plants? It **is highly unlikely that the new strains could survive for any length of** time in the water, since water lacks many of the nutrients Rhizobia need to grow. They aren't toxic, and the levels of ammonia they produce could not possibly be high enough to have any adverse effect on aquatic plants.

l9. It **sounds safe, but has it been approved by the government? Before the field testing can begin, our application to field test must be approved by the United States Department of Agriculture and the Environmental Protection Agency. In addition, our application will have** undergone very close scrutiny by Wisconsin's Department of Agriculture, Trade and Consumer Protection, and by the Department of Natural Re***sources.* It goes without saying that BTI welcomes and appreciates the** approval of both the county leaders and the citizens of Pepin County.

20. **With so many crop surpluses being reported, why aim for yield increase? It is** true that there are many crop surpluses in the world today. With this particular field test, we are looking to achieve higher yield increases in the 15-20 percent range. But the value to farmers comes in gains in productivity. If our tests prove successful and we market this new product, farmers will be able to produce the same *or **more*** **alfalfa on less land at lower unit cost.**

21. Once **these tests have been ended, will your company pack its bags and move somewhere else? Not very likely. We have invested a good amount of money in the farm, its rehabilitation, its new buildings, and in its equipment. Chippewa employees are all residents** of Pepin County, and all of our farm purchases will be made through area merchants whenever possible. We have made the agricultural market a primary objective for BTI's growth and development as a leader in the biotechnology field. Pepin County and the Chippewa Agricultural Station will play a major part in the long range progress and growth of BioTechnica International, Inc.

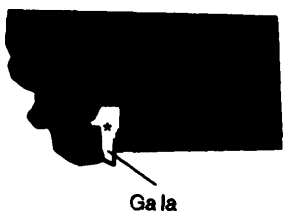
SOURCE BioTechnica International, 1987

Bozeman, Montana

"We can sit and talk elm disease, or we can do something about it. I choose to do something about it."

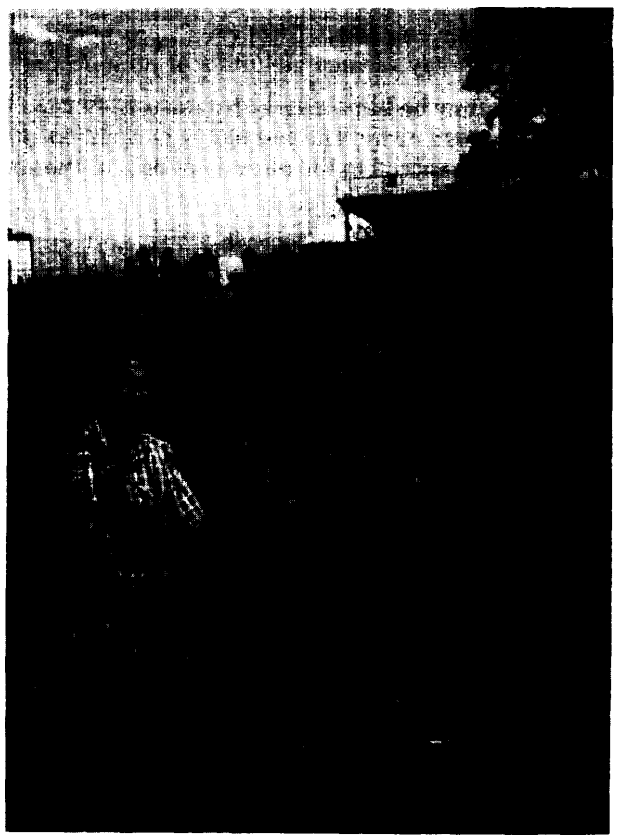
–Gary Strobe], Aug. 13, 1987.

Gary Strobel, a professor of plant pathology at Montana State University, injected 14 trees with a fungus that causes Dutch elm disease. Half of the trees had previously been injected with genetically altered bacteria designed to fight the disease. The experiment, carried out without Federal Government approval and without the knowledge of the university's biosafety committee, was initiated in June 1987. Two months later, the uninfected trees were dead; the injected trees were still alive. Overshadowing the scientific data, however, was the publicity aroused by Strobel's experiment as portrayed in headlines such as "Genetic Engineering Rules: The Making of a Monster" (34).



The 14 trees were located on the Montana State campus. Strobel initiated the field test in June in order to obtain results during the current year's growing season. When EPA contacted him in July 1987 requesting further information on the test, Strobel notified the agency that the experiment had already begun. In August 1987, Strobel notified his university's biosafety committee of the details of the field test. Shortly thereafter, the biosafety committee recommended that the trees be uprooted and burned. EPA and the university president reprimanded Strobel, and Strobel himself cut down the trees and terminated the experiment in early September.

The Montana State experience differed from the others in that the researcher had not obtained permission from either the Federal Government or the university prior to carrying out the experiment. At first, Strobel called his action "civil disobedience," a characterization he withdrew 2 weeks later. The EPA sent Strobel a notice of warning, telling Strobel that for a period of 1 year, any application for a proposed test would have to be "cosponsored by the university, a colleague or some other responsible party" (33). A written warning was the most stringent legal option available to EPA under FIFRA penalty provisions (7 U.S.C. 136(a)(2)). A Montana State University administrative review panel recommended that the university's administration issue a formal reprimand. In January 1988, NIH decided that Strobel violated no NIH Guidelines in his experiments.



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Unhappiness with the Federal regulatory framework was voiced by Strobel, and by Montana State University President William Teitz, who in reprimanding Strobel also complained of the "tangled interpretations, definitions, procedures, exceptions, inclusions, and classifications that dominate today's biotechnical research. "

Argentina

"There is a lesson to be drawn from this which I wish to pass on to my scientific colleagues: extreme caution is to be observed in conducting cooperative programs with organizations and scientists who have political motives which intrude upon even the most straightforward attempts to conduct scientific research for the benefit of huinanity. "

—Hilary Koprowski, Director, Wistar Institute

The Wistar Institute of Philadelphia produced a genetically engineered rabies vaccine, which it provided to the Pan American Health Organization (PAHO) for field testing in Argentina. In July 1986, 20 cattle were inoculated at a PAHO agri-

Argentina

culture station in Azul, Argentina (approximately 180 miles south of Buenos Aires). In September 1986, the Argentine government learned of the field test through a letter written by an Argentine trainee. The government barred further tests, claiming that the vaccine posed a health threat. On November 11, 1986, the New *York Times* reported that Wistar conducted tests the previous summer without obtaining approval from either the Argentine or United States governments. In December 1986, NIH sought written assurance from Wistar that no Federal funds were used to test the rabies vaccine in *Argentina*. Wistar replied that although the rabies vaccine research program received Federal funding, $100,000 for the Argentina field test came from private sources. In January 1987, NIH announced that the experiment did not violate NIH guidelines.

Criticism of the Wistar-PAHO experiment was voiced editorially by the New *York Times (29)* **and *Los Angeles Times (6)*** as well as by ***134*** Argentine scientists, who alleged violations of ethical, ecological, and safety rules (16). The director of the Wistar Institute maintained that media accounts ignored the results of the experiment and that the vaccine was both efficient and safe; that Wistar merely provided the vaccine to PAHO, anticipating that the health organization would obtain any necessary governmental approvals in Argentina; and that representatives of an Argentine scientific organization approached Wistar in 1984 proposing to conduct the same trial undertaken by PAHO.

New Zealand

Another overseas test of a genetically engineered vaccine (Bacteroides nodosus) involved researchers at Oregon State University, who, in May 1985, obtained permission from the New Zealand Ministry of Agriculture and Fisheries to import a vaccinia virus. The researchers inoculated 37 calves, 16 chickens, and 4 sheep near Wellington, New Zealand, beginning in April 1986.

A *Los Angeles Times* editorial noted that "unlike the Argentine affair . . . the Oregon State people told the government of New Zealand what they intended to do" (6). In November 1986, the Foundation on Economic Trends announced it would ask USDA and other Federal agencies to investigate the New Zealand experiment and determine whether any United States laws were broken.

Great Britain

"A cabbage patch somewhere in Britain is the unlikely venue for a world first. Since last month, the patch has been home for a collection of caterpillars that have been infected with a unique virus which does not occur naturally. The experiment may help virologist to engineer safe, artificial viruses that kill pests before they can destroy crops."

—Steve Conner, New *Scientist,* Oct. **16, 1986.**

Researchers at the Institute of Virology in Oxford conducted the world's first release of a genetically engineered virus when infected caterpillars were released in September 1986. The virus was engineered to contain a genetic marker so it could be tracked. The goal of the experiment was to evaluate survival and dispersal of the virus in the environment. If the experiment is successful, the researchers plan to introduce other properties into the organism, with along-term goal of developing custom-designed viral insecticides (2).

The Oxford researchers consulted with the United Kingdom Advisory Committee on Genetic Manipulation; the Nature Conservancy Council; the Ministry of Agriculture, Fisheries and Food; and the Department of the Environment prior to the environmental release. In the European Parliament, news of the U.K. experiment was met with disapproval by representatives of the Green Party, who have opposed environmental release of genetically altered organisms.

THE EXISTING REGULATORY FRAMEWORK

The development of recombinant DNA techniques during the 1970s raised concerns about potential hazards posed by the new technologies. Recognizing a need to establish consensus, scientists became involved in discussing recombinant DNA technology and its potential risks. The International Conference on Recombinant DNA Molecules (better known as the Asilomar Conference) convened 140 scientists in February 1975 to address self-regulation of research involving recombinant DNA technology until its safety could be assured. Recommendations were issued assigning risk categories to various recombinant DNA experiments and containment levels for each (28).

Federal regulation of genetically altered organisms began in 1976, when NIH adopted "Guidelines for Research Involving Recombinant DNA Molecules." These stringent guidelines established containment standards and review procedures to be applied by Institutional Biosafety Committees at each institution receiving Federal support for research (31). The guidelines were modified and relaxed several times as more became known about the safety of various organisms and technologies.

The NIH Recombinant DNA Advisory Committee was the primary Federal entity for reviewing and monitoring recombinant DNA research until 1984, when its oversight of field tests was challenged by a lawsuit alleging that NIH had violated provisions of the National Environmental Policy Act (13). This act requires all Federal agencies to prepare an analysis prior to any action that may significantly alter the environment.

In 1984, the White House Office of Science and Technology Policy (OSTP) published a Proposed Coordinated Framework for the Regulation of Biotechnology (11) in order to ensure the safety of biotechnology research and products. This document proposed policies for Federal agencies responsible for reviewing the research and products of biotechnology. It also proposed the establishment of a new, centralized advisory committee within the Department of Health and Human Services (DHHS) to coordinate responses to scientific questions raised by applications received by the various Federal agencies.

Following a period for public comment, OSTP decided against establishing a committee within

DHHS. Instead, a Biotechnology Science Coordinating Committee (BSCC) was formed "to monitor the changing scene of biotechnology and serve as a means of identifying potential gaps in regulation in a timely fashion, making appropriate recommendations for either administrative or legislative action." (50 Fed. Reg. 47174). In the same notice, OSTP published an index of laws conferring authority that could be used to ensure the safety of biotechnology-related products. Many elements of the Proposed Coordinated Framework were incorporated into the Coordinated Framework published by OSTP on June 26, 1986 (51 Fed. Reg. 23301).

Coordinated Framework for Regulation of Biotechnology

The Coordinated Framework includes separate descriptions of the **regulatory policies** of the FDA, EPA, Occupational Safety and Health Administration (OSHA), and USDA; and the **research policies** of NIH, the National Science Foundation (NSF), EPA, and USDA.

The Coordinated Framework mandates both the agencies responsible for approving commercial biotechnology products (table 3-8) and the jurisdiction for biotechnology research proposals (table 3-9). Where jurisdiction overlaps, a lead agency is designated. The goal is to operate in an integrated and coordinated fashion to cover the full range of plants, animals and micro-organisms derived by the new genetic engineering techniques.

FDA proposed no new procedures for regulating biotechnology products, instead relying on existing authority for approving drugs, human biologics, animal food additives and drugs, and medical devices. The FDA review relies on "scientific evaluation of products, and not . . . a *priori* assumptions about certain processes" and "is conducted in light of the intended use of the product on a case-by-case basis" (51 Fed. Reg. at 23309).

EPA addressed regulation of microbial products subject to two Federal statutes: the Federal Insecticide, Fungicide, and Rodenticide Act and the Toxic Substances Control Act. EPA's review under FIFRA places "particular emphasis on small-scale field testing of genetically engineered, nonindigenous, and pathogenic microbial pesticides" (5 I

Table 3-8.—Agencies Responsible for Approval of Commercial Biotechnology Products

Biotechnology products	Responsible agencies
Foods/food additives	FDA*, FSIS[a]
Human drugs, medical devices, and biologics	FDA
Animal drugs	FDA
Animal biologics	APHIS
Other contained uses	EPA
Plants and animals	APHIS,[b] FSIS,[=] FDA[c]
Pesticide micro-organisms released in the environment	
All	EPA,[d] APHIS[b]
Other uses (micro-organisms):	
Intergenetic combination	EPA,[d] APHIS[b]
Intrageneric combination:	
Pathogenic source organism	
1. Agricultural use	APHIS
2. Non-agricultural use	EPA,[d] APHIS[b]
No pathogenic source organisms	EPA Report
Nonengineered pathogens:	
1. Agricultural use	APHIS
2. Non-agricultural use	EPA,[d] APHIS[b]
Nonengineered nonpathogens	EPA Report

"Designates lead agency where jurisdictions may overlap; FDA, Food and Drug Administration.
[a]FSIS, Food Safety and Inspection Service, under the Assistant Secretary of Agricultural for Marketing and Inspection Services is responsible for food use
[b]APHIS, Animal and Plant Health Inspection Service, is involved when the micro-organism is plant pest, animal pathogen, or regulated article requiring a permit
[c]FDA is involved when in relation to a food use.
[d]EPA requirement will only apply to environmental release under a "Significant new use rule" that EPA intends to propose.

SOURCE: 51 Fed. Reg. 23339.

Fed. Reg. 23313), while TSCA provides EPA authority to regulate any organic or inorganic substance of a particular molecular identity, including any combination of such substances occurring in whole or in part as a result of a chemical reaction or occurring in nature. Under FIFRA, all field tests of genetically altered organisms require an experimental use permit. TSCA requires a manufacturer to adhere to premanufacturing notice requirements (see box 3-C).

USDA stated that '(agriculture and forestry products developed by biotechnology will not differ fundamentally from conventional products and the existing regulatory framework is adequate to regulate biotechnology" (51 Fed. Reg. at 23336). The USDA policy statement listed nine statutes considered most relevant to biotechnology applications (table 3-10).

Of primary interest is USDA's regulation of "plant pests''-any living stage of any insects, mites, nematodes, slugs, snails, protozoa, or other inver-

Table 3-9.—Jurisdiction for Biotechnology Research Proposals

Proposed research	Responsible agencies
Contained research, no release in environment:	
1. Federally funded.	Funding agency[a]
2. Non-federally funded	NIH or S&E voluntary review, APHIS[b]
Foods/food additives, human drugs, medical devices biologics, animal drugs:	
1. Federally funded.	FDA,[c] NIH guidelines and review
2. Non-federally funded	FDA,[c] NIH voluntary review
Plants, animals and animal biologics:	
1. Federally funded.	Funding agency,[a] APHIS[b]
2. Non-federally funded	APHIS,[b] S&E voluntary review
Pesticide micro-organisms:	
Genetically engineered:	
Intergeneric	EPA,[d] APHIS,[b] S&E voluntary review
Pathogenic intrageneric	EPA,[d] APHIS,[b] S&E voluntary review
Intrageneric nonpathogen	EPA,[d] S&E voluntary review
Nonengineered:	
Nonindigenous pathogens	EPA,[d] APHIS
Indigenous pathogens	EPA,[d] APHIS
Nonindigenous nonpathogen . . .	EPA
Other uses (micro-organisms) released in the environment:	
Genetically engineered:	
Intergeneric organisms:	
1. Federally funded.	Funding agency,[a] APHIS,[b] EPA[d]
2. Commercially funded.	EPA, APHIS, S&E voluntary review
Intrageneric organisms:	
Pathogenic source organism:	
1. Federally funded.	Funding agency,[a] APHIS,[b] EPA[d]
2. Commercially funding	APHIS,[b] EPA[d] (if non-agricultural use)
Intrageneric combination:	
No pathogenic source organisms	EPA report
Nonengineered	EPA report, * APHIS[b]

"Designates lead agency where jurisdictions may overlap.
[a]Review and approval of research protocols conducted by NIH, S&E, or NSF.
[b]EPA jurisdiction for research on a plot greater than 10 acres.
[c]APHIS issues permits for the importation and domestic shipment of certain plants and animals, plant pests and animal pathogens, and for the shipment or release in the environment of regulated articles.
[d]EPA reviews federally funded environmental research only when it is for commercial purposes.
KEY: APHIS: Animal and Plant Health Inspection Service; EPA: Environmental Protection Agency; NIH: National Institutes of Health; S&E: United States Department of Agriculture Science and Education.

SOURCE: 51 Fed. Reg. 23305.

tebrate animals, bacteria, fungi, or parasitic plants or reproductive parts thereof, viruses, or any organisms similar to or allied with any of the forgoing, or any infectious substances, which can directly or indirectly injure or cause disease or damage in any plants or parts thereof, or any processed, manufactured, or other products of plants" (7 U.S.C. 150aa(c)).

USDA subsequently issued a final rule on the "introduction of organisms and products altered or produced through genetic engineering which are plant pests or which there is reason to believe are plant pests" (52 Fed. Reg. 22891). The rule sets forth procedures for obtaining a permit prior to the introduction of organisms and products that present actual or potential plant pest risks. The final rule also mandates State notification and review of permits in addition to Federal review.

Because many applications of genetically engineered organisms in the environment will be agricultural, USDA is placed in a dual role of regulating the technology while attempting to fulfill its statutory mandate "to procure, propagate, and distribute among the people new and valuable seeds and plants" (7 U.S.C. 2201). In addition, instances are likely to arise where microorganisms that are not intended for agricultural purposes could still represent a plant pest. The Coordinated Framework addresses this issue, laying out USDA and EPA jurisdictional agreements whereby both agencies will "perform independent reviews, focusing on independent objectives" (51 Fed. Reg. 233.59). EPA will review pursuant to TSCA or FIFRA, while USDA will review pursuant to the plant pest statute.

Table 3-10.–Statutes Applicable to USDA-Regulated Biotechnology

Virus-Serum Toxic Act (21 U.S.C. 151-158)
Federal Plant Pest Act (7 U.S.C. 150aa-150jj)
Plant Quarantine Act (7 U.S.C. 151-164, 166, 167)
Organic Act (7 U.S.C. 147a)
Federal Noxious Weed Act (7 U.S.C. 2801 et seq.)
Federal Seed Act (7 U.S.C. 551 et seq.)
Plant Variety Protection Act (7 U.S.C. 2321 et seq.)
Federal Meat Inspection Act (21 U.S.C. 601 et seq.)
Poultry Products Information Act (21 U.S.C. 451 et seq.)

SOURCE: 51 Fed. Reg. 23339.

Box 3-C.— EPA's Statutory Mandate: FIFRA and TSCA

Under the Coordinated Framework for Regulation **of Biotechnology, the Environmental Protection Agency is addressing certain microbial products under two statutes: the Federal Insecticide, Fungicide, and Rodenticide Act; and the Toxic Substances Control Act.**

Federal Insecticide, Fungicide, and Rodenticide Act

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) was enacted in 1972 (PL 92-516), **bringing under one statute various Federal initiatives that had been in effect as far back as 1910. FIFRA regulates the use and safety of approximately 1 billion pounds of pesticide products produced and sold annually in the United States. Approximately 70 percent of the $6 billion worth of such products are herbicides and agricultural chemicals (4).**

FIFRA mandates the registration of pest control products and defined "economic poisons" with the EPA prior to the production or sale of such product. In order to register a product, an applicant must submit complete data on the product as provided in the statute (7 USC 136a). Any person may apply for an experimental use permit for a pesticide. Such a permit can be issued only if it is determined "that the applicant needs such permit in order to accumulate information necessary to register a pesticide. . ."(7 USC 136c)

Civil penalties for violations of FIFRA vary, depending on whether or not the violator is considered to be a private applicator. A private applicator must receive a written warning for a first offense. Subsequent violations can result in a fine of $1,000 for each violation. Other registrants can be assessed $5,000 for each offense, including the first offense.

Toxic Substances Control Act

The Toxic Substances Control Act (TSCA) (PL 94-469) was enacted by Congress in 1976. In contrast to other environmental statutes specifically regulating the quality of water, air, or natural resources, TSCA gave EPA broad authority to regulate "chemical substances and mixtures." Such substances and mixtures include "any organic or inorganic substance of a particular molecular identity, including any combination of such substances occurring in whole or in part as a result of a chemical reaction, or occurring in nature, and any element or uncombined element; statutory exceptions to this definition include pesticides (as defined in FIFRA, above), tobacco, special nuclear material, food, food additive, or drug. TSCA, therefore, is not designed only to regulate toxics, but also the large number of chemical substances and mixtures to which human beings and the environment are exposed each year.

Under TSCA, the manufacturer of a new chemical must submit to EPA a premanufacture notice (PMN) that describes test data relating to the identity, use, amount, chemical identity, disposal, etc. EPA then has 90 days to consider the notice and decide whether to approve production. TSCA allows EPA to ask for additional data, and to limit or ban production.

TSCA's civil penalties are harsher than those under FIFRA: up to $25,000 for each violation, with each day a violation continues constituting a separate violation.

BioTechnica's proposed field test in Pepin County, Wisconsin (see **page 54) represents the first time TSCA has been used to regulate the release of a genetically engineered organism in the environment. Proponents of EPA use of TSCA contend that the statute is well-suited for evaluating the risks of field tests on a case-by-case basis. Critics contend that the 90 day review period is too short to determine the risks of a particular experiment, and that the decision-making process within EPA could prevent meaningful, accountable, pre-release screening (17).**

OSHA stated that its authority under the Occupational Safety and Health Act of 1970 (29 U.S.C. et seq.) **is** sufficient to protect employees in the field of biotechnology, and that no further regulation is necessary.

Challenges Facing Regulators

The Coordinated Framework noted "that future scientific developments will lead to further refinements" of the regulations (51 Fed. Reg. at 23303). Several challenges face regulators as they work with the new Framework:

- **Definitions:** The Coordinated Framework provided definitions for "intergeneric organism" (i.e. anew organism) and for "pathogen." The OSTP notice makes clear that "[t]hese definitions are critical . . . for the regulation of biotechnology because they establish the types of the organisms subject to certain kinds of review" (51 Fed. Reg. 23302). NSF, FDA, and USDA announced that certain definitions "may be ambiguous" (51 Fed. Reg 44397). In addition, the BSCC "is attempting to define what constitutes 'release into the environment'." Release into the environment, "for the time being, will have somewhat varying definitions for the regulatory and research review of the different agencies" (51 Fed. Reg. 23307). In October 1986, an NIH Committee reviewing allegations surrounding an alleged field test of a pseudorabies vaccine noted that "we found ambiguities in the NIH Guidelines, both in regard to whether the pseudorabies vaccine used in the field test consisted of 'recombinant DNA molecules,' and whether the field test constituted 'deliberate release into the environment'" (32).
- Risk Assessment and Management: The continuing need to protect the environment and public health requires a balancing of the known risks of existing technologies and the potential risks of new technologies against the benefits derived from these technologies. Because the risks involved inmost proposed releases of genetically engineered organisms into the environment cannot be measured precisely, there will be some uncertainty in determining the safety of proposed fieldtests.
- The Need To Promote a Favorable Economic Climate for Research and Product Development. Excessive **regulation will make it difficult for biotechnology-related research projects to move from the controlled environment of the laboratory to the field. Initially strict regulation of recombinant DNA research, through NIH** guidelines, was revised and relaxed as increased scientific knowledge revealed the safety of various applications. Decreased regulation of genetically engineered organisms in the environment may also be possible if warranted by scientific developments. If proposed field tests are severely restricted, curtailed, or delayed, researchers may conduct research and product development in other countries that are more hospitable to such technology.
- Assurance That Regulation of One Type of product Does Not Hinder Development of other products: The new Framework provides several Federal agencies with jurisdiction over a wide range of research and products (e.g., food, drugs, pesticides, vaccines, and medical technologies). Some agencies may regulate this new technology better than others. Mistakes made in regulating research or products could erode public confidence in the entire Coordinated Framework, which could in turn lead to inconsistent regulatory review of proposed planned introductions of genetically engineered organisms.
- Jurisdiction of Federal Agencies Regulating Biotechnology Agencies need to adjust to the integrated Framework, which establishes a lead agency for those instances where regulatory oversight or review is to be performed by more than one agency (see tables 3-8 and 3-9). Environmental concerns, for example, fall under the direct mandate of EPA. All Federal agencies, however, must prepare an environmental analysis for major actions significantly affecting the quality of the human environment.
- The Legality Applicability and Scope of Current Statutes To Regulate the Release of Genetically Engineered Organisms: The Coordinated Framework is predicated on the use of existing statutes (e.g., TSCA and FIFRA) to handle emerging issues in the regulation of biotechnology. The applicability (e.g., use

of a conventional chemical statute to regulate genetically engineered organisms) of such statutes may be challenged in court, as may the scope and legality of other statutes. In addition, each statute relied upon presents administrative law issues that could result in court cases.

- Promotion v. Regulation: Two Federal agencies–NIH and USDA—are charged with regulating biotechnology research and development while at the same time having statutory mandates to promote research and product development. NIH promotes and funds much of the nation's biomedical research pursuant to the Public Health Act, while at the same time regulating that research, including biotechnology research. USDA is mandated to procure, propagate, and distribute new and valuable seeds and plants; at the same time, it must regulate and potentially curtail new products through the application of several statutes designed to eradicate potential problems (e.g., plant pests).
- Consistent Penalties for Violators: Because existing statutes are being used to regulate biotechnology, varying penalties can result. For example, the two statutes relied upon by EPA (TSCA and FIFRA) carry different penalties. As a result, penalties could merely reflect the statute employed, not the actual severity of the civil or criminal act.
- The Role of State and Local Governments in Regulating Biotechnology and Environmental Release of Genetically Engineered Organisms: State environmental, authority and county zoning and land use ordinances have played an important role in several proposed field tests and could play an increasing role in future tests. Several States are considering regulations governing the release of genetically engineered organisms in the environment. Where Federal and State Governments claim subject matter authority over such releases, the issue of Federal preemption of State action could arise.
- Public perceptions: The environmental applications of genetically engineered organisms will be affected considerably by public opinion, particularly in communities that host the early field tests. Ultimately, any applications approved for general use will feel the weight of public opinion. Regardless of the scientific judgments by experts who will develop and consider these applications, a hostile public or one unconvinced of the value of these developments will give the biotechnology industry a difficult time in the marketplace. Several proposed field tests have already been the targets of protest in some communities, although other proposed field tests have met with little or no local opposition.

European and Japanese Regulation

In addition to action in the United States, several European nations have begun to assess the need for regulatory review of genetically engineered organisms in the environment. Both the European Economic Community (EEC) and several member nations have considered regulatory issues over the last few years.

The EEC established a biotechnology steering committee in February 1984 to coordinate biotechnology policies. In 1986, a meeting was held by member-state officials to discuss the regulation of releases of genetically engineered organisms in the environment (35). In November 1986, a commission report highlighted the need for collective action, and announced that proposals would be developed for Community action on "a) levels of physical and biological containment, accident control, and waste management in industrial applications, and, b) authorization of planned release of genetically engineered organisms in the environment" (8). This initiative occurred as several member states were taking steps to regulate biotechnology:

- **Denmark enacted legislation in 1986 preventing the deliberate release of any organism that is the product of recombinant DNA technology as well as any organism resulting from gene deletion or cell hybridization (23). The Danish law forbids such experiments unless approval is obtained from the environment minister.**
- **France in 1987, established a 15-member panel of scientists, under the jurisdiction of the Ministry of Agriculture, to review proposed deliberate release experiments on a**

case-by-case basis and to consider the need for future regulation. Notification of any intent to use recombinant DNA technology must be made to the Ministry of Research and Higher Education (23). Field tests involving the nitrogen-fixing bacteria Rhizobium began in March 1987.

- The Netherlands established an advisory committee on recombinant DNA activities to regulate such research.
- The United Kingdom developed voluntary guidelines published in April 1986 that encourage any person planning a deliberate release of an engineered organism to contact the Health and Safety Executive (9). Proposed regulations would require scientists to notify the Executive of any general intention to conduct experiments involving genetic manipulation as well as individual notification forcertain high risk experiments (27).
- Sweden established a special commission in 1984 to study whether tighter regulations were needed for recombinant DNA research. The advisory committee recommended that existing occupational health and environmental protection oversight is adequate, and that stricter regulations are not needed.
- The Federal Republic of Germany classifies experiments in four categories; releases of organisms into the environment fall into the prohibited category, although researchers may apply for an exception. A parliamentary commission was formed in 1984 to study the potential scientific, social, and legal implications of gene technology. The report recommended a 5-year moratorium on environmental releases of genetically altered viruses (except for those used as vaccines in human and veterinary medicine) and of micro-organisms into which genetically foreign genes have been inserted (8).
- Japan regulates biotechnology through several ministries. Pharmaceutical production has developed under guidelines developed by the Ministry of Health and Welfare. Regulation of agricultural biotechnology is expected to become more important as the number of permits for research and production increase (21).

SUMMARY AND CONCLUSIONS

A recent poll indicates that a large majority of Americans (82 percent) approve of small-scale experimental tests of genetically engineered organisms for environmental applications. Most people approve of such applications for a variety of purposes, and a majority appear willing to accept relatively high levels of risk to the environment in exchange for the potential benefits that might be derived from environmental applications of genetically engineered organisms.

The experiences of local communities illustrate the varying degrees of local support for fieldtests of genetically altered plants, animals, and microorganisms. In several instances, local opposition thwarted or delayed proposed field tests. In other communities opposition was minimal. Opponents of proposed field tests have relied on State environmental laws, local laws (e.g., zoning laws, county ordinances), political pressure (e.g., petition drives, public meetings), and even physical sabotage of test sites to achieve their objectives. Where opposition has been minimal, companies and individual researchers have generally informed governmental and citizens' groups about their scientific goals and objectives, the degree of regulatory review of the experiment, safety considerations, and the economic impact of such experiments on the local economy.

Factors specific to individual cases may affect the degree of public support or opposition to a proposed field test. Genetically altered microorganisms, for example, have elicited more public concern than proposed field tests of plants. The extent of local support or opposition may also depend on the degree to which a proposed field test is perceived as a first (e.g., the first release of a microorganism, first application under TSCA, first release in a particular State).

The development of recombinant DNA techniques during the 1970s led to self-regulation by scientists and, later, regulation by the Federal Gov-

ernment, The Coordinated Framework for Regulation of Biotechnology, published by the White House Office of Science and Technology in 1986, describes a comprehensive Federal regulatory policy to ensure the safety of biotechnology research and products. Several challenges face regulators as they adjust to the new Framework: defining key terms; balancing risks and benefits of the new technology; maintaining a favorable economic climate for research and product development; assuring that regulation of one type of product does not hinder development of other products; determining jurisdiction when regulatory oversight or review is to be performed by more than one Federal agency; balancing technology promotion and regulation; establishing consistent penalties for violators; resolving potential challenges to the legality, applicability, and scope of current statutes; balancing technology promotion and regulation; establishing consistent penalties for violatons; resolving potential jurisdictional conflicts between Federal, State, and local governments; and assessing public opinion.

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