Chapter 21

Public Perception

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Introduction

Public perception of genetic research and technology is a factor that could influence the rate of commercialization of biotechnology. This chapter considers the factors that may affect public ***perception*** of genetic research and technology. As it does not consider the many ways by which the public might express its perceptions, it does not describe various methods that have been or could be used for public ***participation*** in decisionmaking processes, nor does it consider the arguments advanced for each.

Most of the discussion in this chapter is centered on the United States. One of the final sections considers the relative influence of public perception on the commercialization of biotechnology in the United States and foreign countries. For issues and policy options, readers are referred to OTA'S April 1981 report ***Impacts of Applied Genetics: Microorganisms, Plants, and Animals (29).***

The discussion in this chapter goes beyond biotechnology as defined in the rest of this report, and, for that reason, uses the broader terms "genetic research" and "genetic technology These broader terms include directed manipulation of genes in human beings. Biotechnology, as defined in this report, does not include directed change of genes in human beings and is limited to industrial applications of new genetic technologies to produce useful substances, to improve the characteristics of economically significant plants and animals, and to act on the environment in useful ways. Because the public does not always make a clear distinction between industrial applications of novel genetic technologies and the manipulation of genes in humans, biotechnology can elicit public concerns that are based on incomplete knowledge and sometimes erroneous assumptions. Regardless of the ***accuracy*** of public perceptions about biotechnology, however, these perceptions could influence the rate of commercialization.

Public perception in the United States

The discussion that follows begins by considering the U.S. policymaker vis-a-vis the public on issues related to science and technology. It then describes various factors that influence public perception of biotechnology in the United States. It also reviews some arguments frequently raised in debates over genetic research and technology, considers difficulties in assessing risks and benefits of genetic research and technology, discusses the influence of the media on public perception of biotechnology, and provides some survey data.

The public and the policymaker

In a democratic society, where decisions are made by elected representatives, the public plays a vital role in the acceptance of new technology and the directions in which it will be applied (2). That public beliefs can significantly influence U.S. policymakers with respect to biotechnology is illustrated by the changing attitudes of policymakers in Massachusetts. In 1976, Boston Mayor Alfred Vellucci argued strongly for major controls on research and development (R&D) using recombinant DNA (rDNA) technology in Boston and Cambridge, As a result, the Cambridge Experimental Review Board was established to determine whether additional protection for citizens was needed beyond that provided by the National Institutes of Health (NIH) Guidelines for Research Involving Recombinant DNA Molecules (NIH Guidelines). * Mayor Vellucci's position may be con-

*The NIH Guidelines for Research Involving Recombinant DNA Molecules are discussed along with the rDNA research guidelines of other countries in *Chapter 15: Health, Safety, and Environmental Regulation* and *Appendix F: Recombinant DNA Research (guidelines, Environmental Lawrs, and Regulation of Worker Health and Safety.*

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trasted with that taken by then Massachusetts Governor King when he addressed Harvard University's symposium on "New Partnerships in Biotechnology" in 1982. Governor King pledged his assistance to the establishment of commercial biotechnology firms in the State. The different positions taken by Mayor Vellucci and Governor King reflect, in part, the changes in public concern over the risks posed by rDNA technology.

Although the level of U.S. public concern about R&D involving rDNA appears lower now than it was in the late 1970's, it is not nonexistent. As of June 1982, two States and nine municipalities had passed laws and resolutions relating to control of rDNA R&D. The two States are New York and Maryland. With the exception of Princeton, N.J., the municipalities are located in Massachusetts (Amherst, Boston, Cambridge, Newton, Somerville, and Waltham) and California (Berkeley and Emeryville). It is interesting to note that all local municipalities involved in formulating laws or resolutions are the sites of, or located near, major centers of corporate and university research activity in rDNA. Although most of this legislative activity took place in the late 1970's, several municipalities in Massachusetts either amended or originated ordinances or laws in 1981. At a minimum, the laws extend the NIH Guidelines from institutions receiving NIH funds to all public and private institutions conducting rDNA research. Some of them also establish additional occupational and environmental safety requirements (15).

In light of the developments noted above, U.S. policymakers probably can expect to be increasingly involved in biotechnology issues. one issue in biotechnology is the amount of consideration that should be given to the unanticipated consequences of deliberately releasing into the environment products of rDNA technology (e.g., modified plants or microbes with improved capability for mineral leaching or pollution control). But this is just the opening wedge to a wider range of societal concerns that are emerging as new knowledge leads to new capabilities, The potential capabilities of genetic research and technology include human gene therapy, gene surgery, and estimation of differential susceptibility to disease based on differences in genetic traits.

An accident or perceived negative consequence involving genetic research or technology could stir up public fears and have a sizable impact on biotechnology's further development. This observation is true especially in the United States, where public involvement in the debates surrounding rDNA technology in its early years was very strong compared with public involvement in other Western democracies.

Factors influencing public perception of genetic research and technology

The Organisation for Economic Co-Operation and Development identified the following characteristics of science and technology issues that distinguish these issues from other public controversies (18):

- rapidity of change;
- the raising of new issues;
- scale, complexity, and interdependence among technologies;
- irreversibility of effects;
- strong public sensibilities about real or imagined threats to human health; and
- challenging of deeply held social values.

OTA'S April 1981 report Impacts ***of Applied Ge***netics: Micro-Organisms, Plants, and ***Animals*** (29) noted that these factors were especially applicable to advances in genetics and that they helped to explain the public controversy over the safety of rDNA technology. The same factors remain applicable to advances in genetics today. Some are discussed below, along with other factors that may elicit positive, negative, or mixed public reactions to developments in genetic research and technology.

THE TECHNOLOGY IS PERCEIVED TO ENDANGER BASIC HUMAN NEEDS

Some new developments in science and technology are far more threatening to the societies in which they arise than are other developments. In an attempt to understand and predict which emerging technologies will be most threatening, and hence be most likely to raise issues for policymakers, E. W, Lawless makes the reasonable assumption that public concern with a new technology will vary in direct proportion to the degree that the technology is perceived to affect basic human needs (16). The greater the importance of an individual or societal need, and the greater the impact of the new technology on that need, the greater will be public concern.

At the top of the list of important individual needs developed by Lawless are the functions controlled by the nervous system, and particularly by the brain. Genetic technology has the potential to alter the functioning of the human brain, affecting attitudes, emotions, learning, and memory. Besides the concerns associated with the technology's potential to alter these characteristics per se, genetic technology may arouse deeper concerns that relate to an individual's sense of self. Aspects of self derive from each person's most basic characteristics—tendencies to elation or depression, ambition or sloth, and extroversion or introversion, to name a few. If these characteristics can be modified, what happens to an individual's unique, inviolate self?

The most fundamental ***societal*** need identified by Lawless is sexual activity, reproduction, and family organization. He notes (16):

> . . . any events or practices which portend a threat to man's reproduction or care of children cause immediate and serious alarm. Technologically related cases involving materials which are mutagenic (cause genetic damage) or teratogenic (cause congenital deformities) receive wide coverage by the news media and attention by the public—the announcement that LSD may cause chromosome breakage apparently caused much more concern to its users than other stated hazards, and the thalidomide case is almost classic.

The application of genetic technology to the production of useful industrial substances is not always clearly distinguished from the genetic manipulation-or "genetic engineering"-of higher organisms. Following Lawless, if biotechnology is associated with the capability to alter human reproductive cells, and hence future human generations, it is likely to be perceived as threatening.

TERMINOLOGY

As has been pointed out by various authors (20,21), some of the terminology of applied genetics has negative overtones. The phrase "genetic engineering," for example, may raise Frankenstein-like subconscious fears when associated with human application. "Cloning" of genes, a basic technique of rDNA technology, can be confused in the minds of those who are not expert in the field with the cloning of individual human beings. Because language is widely understood to influence perception, the problem of terminology is not a minor one. Terms that are widely used, however, even though inaccurate, misleading, or imprecise, are not easily changed.

PERCEPTION OF BENEFITS FROM BIOTECHNOLOGY

Biotechnology appears to offer potentially major positive contributions to diverse aspects of life. Economic benefits (e.g., cheaper chemicals and drugs), health benefits (e.g., cures for **cancer,** schistosomiasis, and herpes; improved diagnostic tools), agricultural benefits (e.g., saline-tolerant or pest-resistant plants, a vaccine for foot-and-mouth disease), and even decreased dependence on foreign oil (e.g., substitution of biomass for petroleum feedstocks, production of fuel alternatives) are envisioned. * To the extent that these benefits are perceived by the public, their perceptions of biotechnology are likely to be positive.

NIH GUIDELINES FOR RECOMBINANT DNA RESEARCH

Biological scientists were instrumental in bringing about the NIH Guidelines for Research Involving Recombinant DNA Molecules that established safety procedures for rDNA research conducted with NIH funds. The NIH Guidelines apply only to work supported by NIH funds, but other U.S. Government agencies have adopted them voluntarily. As far as is known, private industry observes them as well.

On the one hand, the history of the NIH Guidelines should produce a positive perception of responsible action with regard to genetic research and technology by the scientists concerned and the Federal Government. On the other hand, NIH is in a position of potentially conflicting interests. It serves both as a quasi-regulator of genetic research through the NIH Guidelines and as a promoter of genetic research through its sizable

*For a review of the state of the art in achieving these benefits, the reader is referred to chs. 5 through 10 of this report, funding of genetic research. The degree to which the public perceives a potential conflict of interest and its influence on public perception of biotechnology are unknown.

THE IMAGE OF THE SCIENTIST

Some members of the public appear to be dismayed by the fact that some scientific researchers have turned into entrepreneurs. The question of the appropriateness of private gain from research supported by public funds was aired as part of joint hearings in 1981 and again in 1982 by the Subcommittee on Investigations and oversight and the Subcommittee on Science, Research, and Technology of the U.S. House of Representatives (26,27).

There is no reason that scientists should not share in financial rewards that accompany application of the results of their research, but the deliberate pursuit of profits makes a scientist also a businessman. It can be argued that a major reason for supporting research with public funds is that such research leads to commercial products that benefit society and also generates more public funds through taxes levied on new businesses. However, the fact that some scientists have become millionaires through corporations they have helped to establish has disturbed some people. Simple envy is not the sole reason for unease; more important may be the public image of the scientist. Although U.S. cultural tradition has supported, and even encouraged, the entry of engineers and inventors into the business world (e.g., Edison), it has not done the same for individuals with established careers in pure science. *

COMMENT

A fundamental reason that rDNA technology may be "so inflammatory" is that it elicits a mixture of concerns from many categories (9). These concerns range from perceived positive benefits to fears associated with research on human subjects. The point for the policymaker is that, because of the wide range of concerns, genetic research and technology is a volatile area, one where the smallest incident may raise heated public emotions.

*For a discussion of university/industry relationships in biotechnology, see *Chapter 17: University/Industry Relationships.*

Arguments raised in debates over genetic research and technology

Five broad categories of arguments that are frequently raised in debates over genetic research and technology are briefly summarized below. It should be noted that the discussion that follows is in the simplest possible terms. The purpose is to indicate some topics of controversy rather than to describe the considerable subtlety of some of the positions that have been taken.

FREEDOM OF INQUIRY

Some people argue that scientists should be free to pursue any inquiry they choose, and hence that genetic research should not be restricted in any way. Others disagree and feel that at least some forms of research are subject to restraint, H. Jonas takes the latter position and argues that unqualified free inquiry ceases as a preeminent right when science moves from contemplation to action (12). As soon as science involves action (e.g., conducting experiments with real apparatus and real subjects) rather than just thought, it is subject to legal and moral restraints, as all actions are,

RISK OF CATASTROPHIC CONSEQUENCES

Some people argue that genetic research should be banned unless the risk of catastrophic consequences can be shown to be zero. At the other extreme, some people argue that any level of risk is acceptable. Although either of these extreme positions may be taken by individuals, neither is likely to be taken by society. What constitutes an acceptable level of risk of catastrophic consequences, however, is a major societal issue, in part because of the difficulty of assessing both risks and benefits. The fundamental disagreement on both this and the preceding topic is where the line is to be drawn between two extreme positions that can be taken. The position of the line is a societal decision that is never permanent and that varies across cultures and over time.

THE TECHNOLOGICAL IMPERATIVE

Some people argue that what is technologically possible will eventually be done, regardless of moral and ethical guidelines. Others disagree. As S. P. Stich points out, successful animal breeding has been carried out for centuries, yet controlled breeding is not done in humans even though it has been known for a long time that it could be (24). Thus, people have differing views on whether society is capable of deciding when genetic manipulation of traits is and is not permissible.

"WE SHOULD NOT PLAY GOD"

Some opponents of genetic research argue that humans should not "play God" by manipulating the genes of other organisms or themselves. Despite its use of the term "playing God, " this argument is based on areligious as well as on religious grounds. Both types of arguments are briefly considered below.

To opponents of genetic research who argue on religious grounds that humans should not manipulate genes, proponents respond that humans have manipulated the genes of other organisms for thousands of years. Long before the laws of genetics were known, humans were successful in changing the characteristics of plants and animals by selectively breeding them for desired characteristics. In addition to altering the genes of other organisms, humans also have altered their own gene pool. Throughout history, because some persons are more desirable than others as mates, some genes have tended to increase in the gene pool while others have tended to decrease. More recently, medical advances have permitted persons with genetic diseases, such as hemophilia and phenylketonuria, to live and reproduce (17).

But, opponents argue, the genetic changes that have been brought about so far have been limited and ***did not involve crossing fundamental species barriers. So*** far, this argument is correct in that species are ***defined*** by the fact that fertile hybrids between them do not occur in nature. However, some opponents of research involving genetic manipulation further argue that the forces of evolution have led to separation of the species and that ***breaking down the separation will be deleterious or separation would not have occurred in the first place.*** The accuracy of this argument is not known.

As noted above, arguments for a prohibition against genetic research are sometimes based on religious grounds. Fundamentalist and religious objections have played a major role in U.S. debates over genetic research and technology in the past and are likely to continue to do so in the future. Recognizing the importance of religious views in such debates, the President's Commission for the Study of Ethical Problems in Medicine and Biomedical and Behavioral Research (hereafter referred to as the President's Commission) asked the General Secretaries of the National Council of Churches, the Synagogue Council of America, and the United States Catholic Conference to "elaborate on any uniquely theological considerations underlying their concern about gene splicing in humans" (2 I). The scholars concluded (21):

> . . . contemporary developments in molecular biology raise issues of responsibility rather than being matters to be prohibited because they usurp powers that human beings should not possess. The Biblical religions teach that humans beings are, in some sense, co-creators with the Supreme Creator.

Furthermore, Pope John Paul II, who has been critical of genetic manipulation, "recently told a convocation on biological experimentation of the Pontifical Academy of Science of his approval and support for gene splicing when its aim is to 'ameliorate the conditions of those who are affected by chromosomic diseases, because this offers hope for the great number of people affected by these maladies' " (21).

It should be noted, however, that the religious community's position is in a state of flux. As illustration, a resolution was issued on June 8, 1983, that urged the U.S. Congress to ban genetic changes affecting human reproductive cells. The resolution was signed by 64 religious leaders representing several faiths. The actual positions of the signatories of the resolution are difficult to decipher, because some church officials who signed the resolution appear to be in favor of genetic changes that would repair the effects of genetic diseases. Some forms of genetic defect, such as Tay Sachs disease, may be best eliminated through changes that affect the reproductive cells. Such changes would be banned by the resolution (3)11,14)19).

GENETIC DIVERSITY

Another area of controversy is the potential effect directed genetic manipulation may have on genetic diversity, i.e., the total number of different kinds of genes available to a population. All members of a given species can mate with any other member of that species, so the total number of genes available to the species population is the sum of all the different kinds of genes in all members of the population. Nevertheless, certain combinations of genes may be perceived as particularly desirable. In agriculture, for example, most farmers in a given location often plant the same strain of a particular crop that they perceive as especially desirable; then all members of that crop in a given location are genetically identical. When a new pest threatens the crop, much of the crop will be lost, because the genetic similarity of the plants results in a similar susceptibility to disease. The corn blight of 1970 is a case in point (10).

Opponents of directed genetic manipulation fear that it may result in increased genetic uniformity with a consequent loss of a species' resistance to future threats. Whether such fears are justified depends, of course, on how the organisms resulting from genetic manipulation are used.

COMMENT

Genetic technology, particularly when direct applications to humans are considered, raises strong public concerns. The degree to which public concerns about direct human applications of genetic research and technology are likely to influence the commercial development of biotechnology as defined at the outset of this report is unclear. Some influence is likely, however, because of a failure on the part of the public to make a clear distinction between human and nonhuman applications of genetic technology, a problem that is exacerbated by multiple uses of terms such as cloning.

Difficulties in weighing the risks, costs, and benefits of genetic research and technology

The central question raised by genetic research and technology is how risks, costs, and benefits are to be weighed. This is a question surrounded by problems.

One problem is that of establishing the probabilities that various risks and benefits will occur. Some probabilities can be estimated more accurately than others because of differences in the assumptions that must be made and in the availability of data that are useful in making estimates. Estimating the probability that an organism will escape from a laboratory, for example, involves different assumptions than estimating the probability that an organism released to the environment (e.g., a genetically modified plant or a microbe designed to control oil spills) will adversely affect that environment.

Then, there is the problem of measuring benefits, risks, and costs, First, it is necessary to decide whether the measure should be in economic terms (i.e., dollars) or human terms (e.g., lives saved or lost, illnesses prevented, or some measure of quality of life). If a measure can be selected, then there is the problem of applying it. Furthermore, if different measures are appropriate for costs, benefits, and risks, how should they be compared? Although methods have been developed to deal with these questions, including cost-benefit and cost-ffectiveness analysis, they are always fraught with assumptions that become particularly acute with a new technology. *

Finally, like most new technologies, some applications of the new genetic technologies will have consequences that cannot be envisioned. These

"For a discussion of some of the limitations of techniques such as cost-benefit analysis and cost-effectiveness analysis, see OTA's 1980 report *The Implications of Cost-Effectiveness Analysis of Medical Technology* (28).

consequences may be high in benefit or high in cost, but some are certain to alter significantly any calculations that are made today.

In sum, assessment of benefits, risks, and costs, except where empirical data are available, is a subjective rather than an objective process, as is the assigning of relative value to various benefits, risks, and costs. Unfortunately, the most interesting and significant contributions of genetic research are those for which there are no empirical data. While risk assessment analysis was helpful several years ago when concern focused on the safety of laboratory research with rDNA, it may be of little use in considering many issues that may emerge as the technology matures, such as whether to release genetically modified organisms to the environment,

What, then, can be done? In a thoughtful analysis of gene splicing as applied to humans, the President's Commission recommends that an oversight group be established (21):

> . . . **through which the issues generated by genetic engineering can continue to receive appropriate attention. These issues are not matters for a single day, deserving of only occasional attention. They** will be of concern to the people of this country—and of the entire globe—for the foreseeable future; indeed, the results of research and development in gene splicing will be one of the major determinants of the shape of that future. Thus, it is important that this field, with its profound social and ethical consequences, retain a place at the very center of "the conversation of mankind."

The President's Commission suggests several objectives to guide the oversight group. Education, it states, should be a primary responsibility—education of the public about science and education of the scientific community about the social and ethical implications of emerging capabilities in genetic technology.

That Congress may perceive that the recommendation of the President's Commission for an oversight body reflects a broader public interest is suggested by the introduction of H.R. 2788 to the 98th Congress (Apr. 27, 1983) by Representative Albert Gore. H.R. 2788 would establish the President's Commission on the Human Applications of Genetic Engineering. The proposed Commission would review developments in "genetic engineering" that have implications for human application and examine the medical, legal, ethical, and social issues that might accompany such application. As of this writing, H.R. 2788 has been incorporated into the Health Research Education Act of 1983, H.R, 2350.

Influence of the media on pubIic perception of genetic research and technology

The media bring knowledge of new discoveries and applications of genetic research to the attention of the public and thereby play a role in public perception of biotechnology. The role of the media extends beyond simple reportage of facts, however, because television, radio, and print media have time or space limitations that result in selective coverage. In selecting items for coverage, the media impose value judgments on the relative worth of possible news items. The media also determine how the items they consider newsworthy will be covered and thus vary the amount of coverage and the tone of coverage. Thus, it is helpful to explore the role of the media in public perception of biotechnology further.

June Goodfield, in an essay entitled "Reflections on Science and the Media" (8), traces the shifting relationship between scientists and the media in American society and the reasons for present day dissatisfaction between these two groups. Goodfield's orientation is to the public, which, she believes, both professions serve. The media and scientists, Goodfield observes, share a common aim in their respective spheres, namely, "the public expression of truth." Different pressures, however, constrain achievement of this ideal for each profession. Constraints on the print media include the need to create interest, the basic structure of newspaper reports, and the constant need for newness. The problems are exaggerated for radio and television. Scientists, on the other hand, are constrained by the nature of their work and their methodology. No scientist likes to "go public" before being sure that his or her findings are reproducible. The tendency among scientists, therefore, is toward caution. There is also, for a variety of reasons, an aversion among scientists to popularization. Thus, the different forces acting on each profession tend to polarize scientists and the media rather than bring them together.

In considering the relationships among scientists, the public, and the media, Goodfield is particularly concerned with three aspects: 1) the obligation of science to inform, 2) the duty of the public to become informed, and 3) the appropriate role of the journalist relative to science and the public. The journalist, she believes, not only must help the public distinguish what is factual from what is speculative but also must help people judge between scientists who differ.

Some of Goodfield's observations are echoed by William Stockton, former Director of Science Times of the New ***York Times.*** At a recent New York Academy of Sciences meeting, Stockton cited an increasing number of science publications, such as Science 80 and the ***Science Times,*** as indicators that scientific journalism is moving into an era of scientific interpretation (25).

The possible roles for the media vis-a-vis genetic research and technology include:

- reporting the facts;
- separating facts from speculation;
- presenting issues;
- indicating which individuals or groups have a stake in each side of an issue and why;
- promoting, or downplaying, specific aspects of genetic technology; and
- educating the public in genetic science and technology, both their methods and their content.

Although many media people would probably claim that their role is limited to reporting the facts and separating these from speculation, their role is clearly larger. The media promote or downplay a technology, if only by virtue of the fact that some news items are selected for print or featured in a radio or television spot while others are rejected. Furthermore, the media's promotional role is sometimes far more active than simple selection.

Surveys of public perception

Given all the above, it is reasonable to ask for actual data on public perception of biotechnology, or at least of the broader area of genetic research and technology. Unfortunately, such data are extremely limited.

Two early surveys of the U.S. population were conducted in the 1970's with the following results (6):

- In 1977, the National Assessment of Educational Progress surveyed the attitudes of adults 26 to 35 years in age toward rDNA technology. About two-thirds of the respondents opposed its use on any life form.
- In 1979, the National Science Board conducted a survey of 1,635 adults. Sixty-five percent of the respondents believed that studies relating to creating new life forms should not be conducted.

In the 1980's, Cambridge Reports, Inc., included five questions on "genetic engineering" in its survey for the first quarter report of 1982 (5) and one question on behalf of the American Chemical Society in its survey for the firstquarter report of 1983 (1). The responses to the five questions in the 1982 survey showed (5):

- About half the people surveyed either hadn't heard the phrase "genetic engineering" or wouldn't guess what it meant.
- Of those who had heard of private corporations "getting into the field of 'genetic engineering' or biotechnology" (roughly 40 percent), and who were willing to take a position as to whether this was good or bad, positive sentiments (15 percent) outweighed negative (8 percent) by almost two to one.
- Of those expressing an opinion about "genetic engineering, " 25 percent believed it would bring major benefits to society; 11 percent believed it would endanger public health and safety; 44 percent didn't know; and 20 percent believed it would bring both benefits and dangers.

- Respondents with higher income levels and/or higher levels of education were more likely to expect major benefits from "genetic engineering" than those with lower incomes and/or less education.
- Of respondents able to choose between government regulation and self-regulation, 28 percent favored the former and 16 percent the latter. Combination of both government regulation and self-regulation and "don't know" made up the balance.

The single question in the 1983 survey by Cambridge Reports, Inc., asked what respondents thought of when the term "DNA" was mentioned. Sixty-three percent didn't know; 27 percent responded with relevant but incomplete answers; 2 percent gave an accurate definition; and 2 percent said it was "poison" (1).

In 1981 and 1982, Yankelovich, SkeIly, and White surveyed the general public with regard to "genetic engineering" (13). Their survey population is a nationwide stratified random sample of 2,500 persons aged 16 and over. Results are considered predictive of the U.S. population as a whole at a confidence level of 98 percent. The results showed the following:

- The percentage of the general public believing that the benefits of "genetic engineering" outweigh the risks increased from 31 percent in 1981 to 39 percent in 1982.
- Seventy percent of the public had heard of "genetic engineering" in 1982.
- Sixty-two percent of the public were very or somewhat concerned about '(genetic engineering" in 1982.
- In 1982, those who had heard of "genetic engineering" were asked how it would be applied (by responding to a list of possible application areas). Health was selected most frequently (61 percent), followed closely by test tube babies (58 percent), and farming (57 percent), Responses to other application areas were: food processing (33 percent), forestry (31 percent), waste management (30 percent), chemical research (28 percent), pollution control (20 percent), and energy (19 percent).

Yankelovich, Skelly, and White believe that, although the intensity of public concern with "genetic engineering" is low at present, there is a significant latent level of public concern that could surface if adverse consequences associated with applied genetics were reported (13).

The survey data just cited suggest several things:

- A relatively small fraction of the American public is fully informed about genetics in general and, undoubtedly, about biotechnology in particular.
- The more informed public is more likely to view applied genetics favorably than unfavorably.
- There are real concerns about applied genetics.

Implications of public perception for competitiveness in biotechnology

As a factor influencing competitiveness in biotechnology, the importance of public perception varies greatly both across and within countries. Considering first democratic v. nondemocratic countries, public perception as a factor influencing competitiveness will be more important in the democracies than in those countries without such forms of government, simply because of the greater public input permitted by democratic, representative forms of government and the independence of the media.

Among democratic nations, variability in the importance of public perception as a factor influencing the commercialization of biotechnology is a function of many cultural characteristics. of these characteristics, the traditions of the media, the degree to which the public participates in deci -

sionmaking on scientific and technological issues, and the level of public education in science and technology are particularly important.

Of the six countries examined in this assessment—the United States, Japan, the Federal Republic of Germany, the United Kingdom, Switzerland, and France—public perception appears to have the greatest importance in the United States. The basis for this statement is that public debate over the establishment of rDNA R&D laboratories in the late 1970's was much greater in the United States than in the other countries. The behavior of the public and the media in the United States and other countries in the years since has changed little, and thus, public involvement as a factor in competitiveness currently remains of greatest importance in the United States.

Public perception will be a factor in determining competitiveness of the United States in the commercialization of biotechnology primarily in the event that genetic research or technology results in actual or perceived adverse consequences. In the case of an accident or perceived negative consequence, several factors would operate to make public perception of genetic research and technology of particular importance in the United States compared to other countries: the role of the media, traditions regarding public participation in scientific and technological issues, and the public's level of education in such issues. In this context, "level of education" requires further elaboration.

A technologically literate public can discriminate between different uses of genetic research and technology; this is important because different uses are associated with different issues. Some uses do not raise any new issues; others do. Thus, use of rDNA technology to produce drugs and biologics that replace similar products produced by chemical synthesis or extraction is simply an alternate means of production and in itself raises no ethical issues (17). An ethical issue for the pharmaceutical industry may be allocation of resources to produce drugs using biotechnology with markets that are potentially large and profitable v. drugs for treating rare diseases or diseases endemic to the Third World, where profits are more limited. Ethical issues are also raised if rDNA technology permits the manufacture of drugs that influence learning, memory, and personality traits, for decisions will be needed on whether such substances should be produced and perhaps on how their distribution should be handled and controlled.

Use of normal DNA to treat the body cells of patients with genetic diseases such as sickle cell anemia is another area where rDNA raises no new ethical issues beyond those associated with other treatment of sick persons. As geneticist A. G. Motulsky points out, this therapy is (17):

> . . . conceptually no different from any therapy in medicine that attempts to improve the health of a sick patient. The only difference is that DNA, rather than other biological, drugs, or surgery, is used as the therapeutic modality.

An application of genetic research and technology that does involve new ethical issues is use of genetic markers for diagnosis of susceptibility to disease. This application raises questions pertaining to private v. societal goals and confidentiality. Similarly, any genetic manipulation that alters the reproductive cells is "a qualitative departure from previous therapies since this would affect future generations" (17).

Rational consideration of issues raised by genetic research and technology is often confounded by failure to discriminate between different types of applications. The problem is compounded, because, as pointed out in ***Chapter 14: Personnel Availability and Training,*** scientific education in the United States is falling behind that of many industrialized nations. These factors could act to the disadvantage of the United States in the worldwide commercial development of biotechnology should an accident or other adverse consequence occur.

Findings

Public perception of the risks and benefits of biotechnology is of greater importance in countries with representative, democratic forms of government than it is in countries with other forms of government, simply because of the greater attention paid to public opinion in the democracies, and the independence of the media. As a factor influencing competitiveness, public perception is probably of greater importance in the United States than it is in Japan, the Federal Republic of Germany, the United Kingdom, Switzerland, or France.

A number of factors influence the relative importance of public perception as a factor influencing competitiveness. In all countries, the importance of public perception will be greatly increased in the event of an accident or perceived negative consequence of biotechnology. In such a case, the level of scientific and technological literacy in the various competitor countries becomes important, as judgments must be made concerning complex issues. Unfortunately, at least in the United States, survey data show that only a small fraction of the public is fully informed concerning genetics in general and therefore, undoubtedly, about biotechnology in particular. Survey data also suggest that there are real concerns in the public mind concerning applied genetics.

Given the lack of public knowledge, it is particularly important that the media play a responsible role with respect to biotechnology. The role of the media extends beyond mere reporting of the facts. How far the media should go beyond such reportage deserves consideration.

Issues and policy options

OTA'S first assessment in the field of genetics, ***Impacts of Applied Genetics: MicroOrganisms, Plants, and Animals (29),*** was published in April 1981 and contained a chapter titled "Genetics and Society. " The issues that arise from the material presented in the preceding pages are similar to the ones developed in the chapter on genetics and society. Since the issues in this report and OTA's earlier report are similar, the reader is referred to that earlier report for issues, options, and arguments relevant to them.

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