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Sociology and Biotechnology: Challenges and Opportunities¹

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ABSTRACT Sociologists have traditionally been concerned with technological change. We now find renewed research interest in the social impacts and risks of biotechnology. Many public and key opinion leaders recognize that closer attention must be paid to tradeoffs, uncertainties, and negative consequences related to biotechnology. Sociologists have a number of important roles to play in ensuring that the benefits of biotechnology outweigh the potential risks. This paper examines several important issues about agricultural biotechnology that have not yet received adequate attention from sociologists. The nature of biotechnology as an innovation and as a risky technology is examined. Particular attention is paid to public perceptions of biotechnology. Research opportunities and challenges in the analysis of the biotechnology research and development system are presented. Implications of the complex nature of biotechnology for social impact assessment are described. Research opportunities in the area of risk management and perception are discussed.

Introduction

Rural sociologists are paying greater attention to biotechnology. Much of the writing to date, however, has been highly speculative and general. Inadequate understanding of the complex products and processes associated with biotechnology is evident. Most work has also been limited because it focuses only on potential socioeconomic impacts that biotechnology may have on agriculture. Little attention has been paid to risk assessment and perceptions of the nonfarm public.

This paper tries to inform future social science work in biotechnology by discussing several areas that need more attention from sociologists. First, the nature of biotechnology as perceived by farmers and the public will be described. Second, research needs in understanding the biotechnology research and development process will be explored. Finally, some conclusions about impact assessment and risk assessment will be presented.

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Social scientists have a unique opportunity to analyze the development, diffusion, and impacts of a host of new products developed through biotechnology. Once they become commercially available, most biotechnology products will be adopted more rapidly than previous agricultural innovations (Hueth and Just, 1987). Better channels of communication and technology transfer now exist. Farmers are becoming more progressive and interested in new technologies. Improved information on product performance is being developed and disseminated prior to release of the technologies. Farmers, researchers, and government leaders are increasingly concerned about the profitability and competitiveness of American agriculture. It is, therefore, important to understand what biotechnology is and how it will be perceived by farmers and the public.

Nature of biotechnology

Biotechnology is a general term that means different things to different people. Social scientists need to better understand the potential applications and scientific basis of biotechnology. Biotechnology refers to a diverse set of tools, rather than a particular kind of end product. Because its potential range of applications is so broad, we must acquire a basic appreciation for the biological and other processes involved. We have a lot to learn from the biotechnologists who are still trying to resolve a number of conceptual and scientific issues related to biotechnology. The Office of Technology Assessment (1986:31) provides the following definition:

Biotechnology, broadly defined, includes any technique that uses living organisms or processes to make or modify products, to improve plants or animals, or to develop microorganisms for specific purposes. . . . Such knowledge and skills will give scientists much greater control over biological systems, leading to significant improvements in the production of plants and animals.

Biotechnology, as defined above, is actually an ancient practice, and includes fermentation and selective breeding. Types of biotechnology receiving attention today include sophisticated molecular biology and genetic advances that allow scientists to have much greater control over living systems. These powerful new techniques include genetic engineering, tissue culture, and monoclonal-antibody technology. Genetic engineering is the most powerful and dramatic technique because it adds or removes genetic material from living organisms, allowing traits to be transferred between different species. It is also the most controversial because it involves manipulation of the fundamental basis of life. Detailed discussion of these techniques is beyond the scope of this paper, but other sources can provide social scientists with an introduction (Office of Technology Assessment, 1984; Office of Technology Assessment, 1986; Lacy and Busch, 1988).

We have the opportunity to study biotechnology from several different perspectives. As in previous innovation diffusion studies, we should analyze farmers' perceptions of biotechnology as an innovation,

including how the characteristics of biotechnology will influence adoption rates. An even more important challenge will be to systematically analyze public opinion toward biotechnology. Biotechnology will likely become controversial as products enter the market. Resistance is already mounting against biotechnology due to ethical and safety concerns. Sociologists with an interest in risk perception and management can make an important contribution by providing insight about risk perceptions and the dynamics of technological controversy (Freudenburg, 1988; Mazur, 1981).

Characteristics of biotechnology as an innovation

The fact that biotechnology is an innovation will affect its rate of diffusion and adoption. Six major characteristics of an innovation influence its adoption rate: relative advantage, complexity, compatibility, trialability, divisibility, and observability (Rogers, 1983). Different technologies will vary along each of these dimensions. One type of biotechnology may be as different from another type as it is from a traditional agricultural technology. Unfortunately, most writers have combined very different innovations under the generic term "biotechnology." This makes informed analysis and discussion difficult.

For purposes of discussion, it will be useful to compare two general products of biotechnology: synthetic animal growth hormones (e.g., bovine somatotropin) and genetically engineered plants (e.g., disease- or insect-resistant varieties). It is important to realize that other types of biotechnology will probably be received quite differently by farmers. This is not to suggest that all types of animal biotechnology will be negative. Some types, such as embryo transplants have been used successfully by some farmers for several years. Likewise, not all plant biotechnology will be positive. Some types of herbicide-resistant plants now under development may have adverse environmental effects due to greater dependence on herbicides. The following discussion serves to illustrate the types of distinctions that social scientists need to make when analyzing biotechnology.

Relative advantage is the degree to which an innovation is better than the technology it replaces. The greater its relative advantage, the more quickly an innovation will be adopted. From an economic standpoint, both synthetic animal growth hormones and new plant varieties should have a relative advantage for individual farmers if costs are not prohibitively high. However, if a particular company gains a monopoly on a biotechnology product, costs may rise so high as to negate any relative advantage. Considering the entire agricultural system, however, production-enhancing technologies will have lower relative advantage than those that reduce production costs (Office of Technology Assessment, 1986).

Complexity is the degree to which an innovation is relatively difficult to understand and use. The greater the complexity, the slower the adoption rate. Synthetic animal growth hormones will be relatively complex to use, requiring greater management skill and leaving more chance of error (Buttel, 1987b; Kalter and Tauer, 1987). On the other hand, new plant varieties should not be any more complex and may even

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be simpler to use if they reduce the need for chemicals (i.e., pesticides or fertilizers) and are less sensitive to environmental conditions.

Compatibility is the degree to which an innovation is consistent with existing values, practices, experience, and needs of the potential adopters. It also represents an innovation's overall acceptability. The more compatible an innovation, the more quickly adoption should occur. Synthetic animal growth hormones may be incompatible with existing management practices (Kalter, 1985). Increased milk production is not compatible with dairy producers' needs for higher prices. New plant varieties should be compatible with existing equipment and other practices. Major questions of compatibility relate more to social acceptability and ethical concerns.

Trialability refers to how much a potential adopter can experiment with an innovation. Product trials reduce risks of adopting inappropriate technology, and lower the learning costs associated with any new practice. Trialability of an innovation will be positively related to its rate of adoption. In theory, synthetic animal growth hormones should be relatively easy to try. However, if specialized knowledge or equipment are required, start-up costs of trial may be as great as the costs of full-scale adoption. New plant varieties should be relatively easy to try on a small scale for comparison with existing varieties.

Divisibility refers to the extent to which an innovation is part of a set of other technologies or ideas. A technology cluster consists of one or more interrelated elements that must be adopted as a package. In general, the more an innovation is divisible from a technology cluster, the more rapid will be its adoption. Producers who want to successfully use an animal growth hormone will also need better management practices (e.g., careful record keeping, more balanced nutrition programs). Effective use of certain types of biotechnology could even require the adoption of computers for record keeping and monitoring (Office of Technology Assessment, 1986). An improved seed variety, on the other hand, may be a stand-alone technology. Seed varieties developed with traditional plant breeding have been part of a technological cluster, requiring adoption of fertilizers and pesticides. Some varieties developed with biotechnology will have pest resistance engineered into the seed and, therefore, be divisible from some chemical inputs.

Observability is the degree to which the results of an innovation are visible to the adopter or others. Biotechnology, in general, may have very observable results (e.g., higher productivity), assuming the necessary management skills are furnished. Growth hormones should have quite visible results. Genetically engineered seed varieties will not appear that different from those produced through traditional selective breeding. Selective breeding has increased disease resistance and other desirable traits for years. In fact, farmers may not recognize or even care that familiar agricultural inputs (e.g., seeds) were produced through biotechnology. Biotechnology, in this respect, would be transparent to farmers.

Biotechnology's relative advantage, trialability, divisibility, and observability should encourage rapid diffusion. Some biotechnology products (e.g., animal growth hormones) may turn out to be relatively complex for some farmers. Some forms of biotechnology may be incompatible with certain farmers' operations or society's values. Based on these characteristics, soon-to-be-released synthetic animal growth

hormones may not be adopted as widely as new plant varieties which are further from commercial development.

Public perceptions of biotechnology

Since farmers are the potential users of new products generated from biotechnology, their perceptions of and attitudes toward biotechnology need to be investigated. Because most biotechnology products are not commercially available, farmers have not yet made actual adoption decisions. Some farmers are aware of biotechnology, but most are relatively uninformed about biotechnology (Bultena and Lasley, 1987). When asked about possible impacts, however, farmers are able to evaluate their desirability. Farmers supported improved production efficiency, reduced reliance on agricultural chemicals, new crop varieties, and new uses for agricultural commodities. On the other hand, most farmers rated structural impacts of biotechnology as undesirable, such as the decline in farm numbers, continued concentration of production on larger farms, and increased dependency on large corporations for production inputs. Proponents of biotechnology tended to be younger, better educated, and operated the largest units (i.e., farmed more acres and had higher gross farm sales). Smaller, less productive farmers were unenthusiastic about or even opposed to biotechnology.

In a study of dairy farmers' intentions to use bovine somatotropin (BST), Nowak (1987) found that those most likely to adopt the biotechnology were younger, better educated, had greater objective knowledge of BST, and were more likely to favor private industry and university research efforts aimed at developing BST. Those reporting intentions to adopt also had larger-scale operations, hired more labor, and were more efficient producers. He concluded that there will be clear winners and losers associated with the diffusion of BST and other biotechnologies.

Members of the nonfarm public are becoming increasingly concerned about new technologies. In particular, the public may perceive certain agricultural technologies as potentially dangerous because chemical residues and byproducts have been identified in the food supply. Biotechnology could elicit similar public concerns as are now being expressed about agricultural chemicals. In addition, other dimensions of biotechnology will also raise public concerns. Social science research needs to analyze the attitudes of public and key opinion leaders regarding biotechnology.

The Office of Technology Assessment (1984) summarized five main arguments frequently raised in public debates about genetic engineering and biotechnology. Little empirical research has been conducted on who supports which side of a particular argument and why. These controversies deserve more attention from social scientists. The first involves debate over what levels of health, environmental, or social risk should be considered acceptable. Benefits and risks are multidimensional and often difficult to systematically evaluate.

A second reason biotechnology will continue to be controversial is that scientists will be increasingly able to modify and manipulate living organisms. Some opponents of genetic engineering argue that humans should not "play God" by manipulating the genes of humans or other

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organisms. Proponents of genetic engineering argue that we have manipulated genes for thousands of years through selective breeding. Opponents respond that genetic changes have been limited and did not involve crossing fundamental species barriers. Moral and ethical issues associated with biotechnology will, therefore, deserve much greater attention.

A third area of controversy involves concerns over loss of genetic diversity. Opponents of biotechnology argue that genetic manipulation may result in decreased genetic diversity with a resulting loss of species' resistance to future threats. Others argue that biotechnology will, instead, increase the gene pool available, at least for human exploitation. Authors in Kloppenburg's (1988) edited volume describe this debate in considerable detail.

The fourth area of controversy involves freedom of scientific inquiry. Some argue that scientists should be able to pursue any line of inquiry they choose. Others feel that some forms of research should be subject to greater restraint. Views on this debate are related to risk perception and ethical issues. Most would agree, however, that as soon as science involves some form of action (rather than just thought), it becomes subject to legal and moral constraints like all types of action. The debate centers on who should regulate what kinds of scientific inquiry and technology development.

The final area of controversy described by the Office of Technology Assessment (OTA) involves the notion of a technological imperative. Some technologists argue that what is technologically possible will eventually be done, regardless of ethical or moral guidelines. A variety of factors, including the profit motive, influence the development of scientific knowledge and technology.

Considerable uncertainty and disagreement about biotechnology exists among scientists and among the public because it is new and complex. The public has become increasingly concerned about potential risks of new technologies. It is not yet clear how different segments of the public view these various controversies surrounding biotechnology. Social scientists have the opportunity to inform public debate by analyzing public understanding and perceptions of biotechnology. To date, little social science research has been done. During the past few years, several surveys have been conducted by public opinion organizations to determine public awareness of and attitudes toward genetic engineering.

The Office of Technology Assessment commissioned telephone interviews in 1986 with a random sample of 1273 adults from across the United States (Office of Technology Assessment, 1987). More than one-third had heard or read a fair amount about genetic engineering. About half thought that genetically engineered products were at least somewhat likely to represent a serious danger to people or the environment. However, a two-thirds majority of the public thought that genetic engineering would make life better for all people. Over 80 percent of the respondents believed that research in genetic engineering should be continued. While the public expressed concern about genetic engineering in the abstract, it approved nearly every specific application. Although they found the end products fairly attractive, they were sufficiently concerned about potential risks that a majority believed strict regulation is necessary.

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The Office of Technology Assessment (1984) summarized results of other surveys conducted in 1982 and 1983. Of those who had heard about genetic engineering, positive sentiments outweighed negative by almost two to one. Respondents with higher income levels or higher education levels were more likely to expect major benefits from genetic engineering. OTA concluded that although public concern over genetic engineering was low at the time, there was a significant latent level of public concern that could surface if adverse consequences associated with genetic engineering were reported. A relatively small fraction of the American public was fully informed about genetic engineering and biotechnology. More informed members of the public were more likely to view biotechnology favorably. However, there appear to be real and potential public concerns about genetic engineering.

It is not yet clear how different segments of the public will react to different applications of biotechnology. Many of the public's greatest concerns about biotechnology, particularly genetic engineering, will have little to do with the adverse impacts on farmers or rural communities upon which most rural sociologists have focused. The nonfarm public is increasingly worried about food safety and public health impacts of agricultural technology. Consumer and environmental interests are already alarmed about potential health effects or ecological effects of genetically engineered organisms (Mellon, 1988).

Moral issues and religious implications of biotechnology will also occupy a growing share of the public debate. If the animal rights movement is any indication of public concern over human manipulation of animals, public response to genetic engineering of livestock and poultry could draw an intense public outcry. On the other hand, nonfarm groups may be fairly tolerant or even supportive of plant genetic engineering if it results in reduced dependence on chemicals. Social scientists need to analyze the causes, dimensions, and consequences of these and other concerns, so we can feed that information into the public-policy arena.

The analysis of public opinion about biotechnology is still in its early stages. We will probably be able to analyze the rise of various social movements in response to various specific aspects of biotechnology. Social scientists have the opportunity to study how biotechnological controversies develop and are transformed by media attention, political climate, risk perception, and other factors. Jasper (1988) recently analyzed public opinion about nuclear power in France, Sweden, and the United States. Different factors were found to influence public opinion about technology during different historical periods. Political context was an important variable explaining major differences. He concluded that sustained, visible controversy over technologies may reflect serious debate over political and social goals rather than irrational fears of technology inspired by the mass media. Similar studies of biotechnology should be conducted over the life cycle of biotechnology research and development.

Biotechnology research and development

Sociologists should be ready to analyze how and why biotechnology is used to develop new products. Because biotechnology is such a broad set of techniques, many alternative directions can be taken in product development (Hassebrook and Hegyes, 1988). Until the products of

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biotechnology actually enter the market, many opportunities exist to study and possibly influence the research and development process. It is important to analyze the major actors in the research and development system and to understand what factors influence their decisions. Theories and methods from the sociology of science will provide useful insights to such an inquiry (Ziman, 1984; Zuckerman, 1988). We also can benefit from the theory and methods developed in the areas of organizational theory and interorganizational relationships (Aldrich and Marsden, 1988; Mulford, 1984).

The agricultural research and development system is undergoing rapid change. Friedland et al. (1981) state that agriculture is now a highly technical and complex production process based on high levels of scientific knowledge and information distributions. Goodman et al. (1987) explain that the dominant tendency has been the convergence of mechanical, chemical, and genetic innovations to form a complementary, increasingly integrated technological package, which encompasses both the labor process and the natural production process.

Technology development and transfer system

We need to understand the nature of the technology development and transfer system. This system has evolved over the last century to become a complex network of organizations and private and public institutions. Feller et al. (1984) developed and tested an integrated conceptual model of the agricultural technology delivery system that encompasses the entire set of activities undertaken by organizations in the public and private sectors. Their model includes the following stages:

1. Delineation of research priorities (problem identification)
2. Performance of various types of basic and applied research
3. Conversion of research findings into economically useful production processes and technologies
4. Development of ancillary information on how to use the technologies in accord with site-specific production settings
5. Demonstration of new research findings and new technologies to an initial set of users
6. Subsequent spread of the new practices to a larger set of users
7. Iterative feedback of changes in research activities, adaptive modifications, and consequent use patterns that follow from the use of the technology.

Biotechnological products and processes are now generally in the early stages of this process. Sociologists can analyze specific biotechnology innovations as they move through this process. These stages do not constitute a linear, unidirectional set of sequences. The relationships between science and innovation are complex, reciprocal and rapidly changing. Central to the performance of the American agricultural innovation system are the systematic linkages among these various activities. Such linkages are reflected both in organizational and role specialization (e.g., researcher, extension specialist and county agent), as well as in intra- and inter-organizational coordination activities.

Genetic engineering is only one type of biotechnology. Biotechnology, in fact, includes two main types of scientific activity: basic science (e.g., molecular biology and genetics) and applied science (e.g., genetic

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engineering and tissue culture). Basic science is generally directed toward expanding the knowledge base of the biological science disciplines. Much of the academic biotechnology work is of this type. Applied science uses new knowledge to develop useful products. Industry is most concerned with applied science aimed at developing commercially viable innovations.

Just as social scientists work at different levels of analysis (e.g., individual, community, or societal), basic biological scientists also focus on different levels of biological systems. Molecular biologists study basic intracellular processes associated with DNA and RNA. At a higher level scientists focus on cell biology, reproductive physiology, and gene expression. At a more macro level, microbial ecologists study how bacteria and other microbes interact with their environment. Biotechnology incorporates knowledge from many levels of analysis.

This basic science is antecedent work that applied researchers use to modify and manipulate living systems. This is what most social scientists mean when they discuss biotechnology. Genetic engineering is still a fairly imprecise science that is largely characterized by trial and error. It is driven by basic scientific knowledge to the extent that such knowledge exists. Genetic material is inserted, deleted, or modified in various ways to determine if any useful changes result. Results are not always predictable. Such an understanding of the division of labor within biotechnology will provide social scientists with a better basis for understanding public-policy issues and potential risks.

Research priorities and decision making

Since many biotechnologies are in the early stages of research and development, sociologists should analyze how research priorities are determined. Because biotechnology opens up so many possibilities for innovative products and processes, corporate and university decisions will greatly determine what technologies are ultimately available. For example, Friedland et al. (1981) suggest that choice of new technologies will be greatly influenced by the economic organization of the industry and the relative power of the individual firms in the industry. Agricultural research and development has focused on reducing uncertainty and increasing productivity to serve the interests of the more powerful firms.

Private-sector goals and strategies represent a major determinant to biotechnology research and development. Private companies will develop technologies to make money. Those who promote a particular type of technology will likely have their own interests. These may vary significantly from farmers' and consumers' interests. The development and diffusion of specific biotechnological innovations will also depend on company priorities and policies. Products that are supported by large marketing budgets have the greatest possibility of diffusion. Technologies with greater market potential will receive more corporate attention than will other less profitable technologies even if the latter are more appropriate for farmers or less risky for the public. Implications of such private-sector decision making deserve more attention from sociologists.

Biotechnology will continue to receive a large share of private and public sector funds. In the private sector, two distinct types of groups are aggressively pursuing commercial applications of biotechnology (Lacy

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and Busch, 1989). The first includes large established companies that are generally process-oriented, and multiproduct companies in traditional industrial sectors (e.g., pharmaceutical, chemical, and food processing). The second group includes new biotechnology firms that are entrepreneurial ventures started to commercialize innovations in biotechnology. Industries are urging public-sector organizations (i.e., land-grant universities and the U.S. Department of Agriculture) to conduct basic research that will support efforts of the private sector. Sociologists can analyze the division of labor between different types of industrial firms, as well as between the public and private sectors.

Friedland et al. (1981) explain how the discovery of knowledge has social consequences. Scientists and research organizations are responsible for these consequences. Production and implementation of scientific knowledge constitutes social intervention. Science is a value-laden and structured activity that is often used to legitimate existing relations of power and control. We will need to pay greater attention to the motivations of the scientists and technologists who are developing new science and technology (Ziman, 1984). Many of the molecular biologists and geneticists who now work in the agricultural biotechnology arena may have little understanding of agriculture or appreciation for societal issues. Scientists and technologists may not have the motivation or the ability to adequately address some of the environmental and social risks inherent in technology (Schnaiberg, 1980).

Wenk (1986) argues that social management of technology is too important to be left only to the political, commercial, and scientific elite. Technology is itself a social system driven by specialized knowledge, involving all institutions of society. Technology deals with people, their values, and their political choices. It is a social process of generating and utilizing knowledge so deeply engrained in our culture that everyone is profoundly affected. Technological choice is not just a technical affair, but involves decisions of a number of organizations and institutions (Clarke, 1988).

Interorganizational relationships

Another major area for social science research involves the interrelationships among organizations involved in biotechnology development and transfer. Sociologists have studied interorganizational relationships for over 25 years and have developed a number of useful concepts, theories, and methodologies (Mulford, 1984). Although technology development and transfer is recognized as an interorganizational phenomenon, little attempt has been made to integrate these two areas of inquiry.

Numerous public and private organizations are involved in biotechnology. Wenk (1986) defines the technological delivery system as a symbolic network that incorporates all essential organizational components. It is internally differentiated and hierarchically interrelated. Communication networks form the nerves of the system. Information and resources flow through both well-defined and less formal channels. Those who control information and other resources in the system wield great influence by deciding what research is conducted and what products are developed.

Complex connections among basic research, applied research, and product development bring organizations closer together in the technology development and transfer process. Various types of relationships have been established between universities and industry (Kenney, 1986). Individual professors have historically worked with companies through consulting and research. Universities are now establishing a wider range of relationships with industries. Different types of relationships need to be analyzed in terms of the potential benefits and costs to universities and their clientele.

Lacy and Busch (1988) describe the changing division of labor between universities and industry in biotechnology research and development. The new types of relationships are more varied, aggressive and experimental than those that have been in place for decades. Basic conflicts may arise between universities and industry: restrictions on the communication of research results; the relatively short-term research orientation of the private firms versus the longer term orientation of universities toward basic research; different research agenda and priorities; different clientele groups; and concerns over patent protection and trade secrets (Kenney, 1986; Stallman and Schmid, 1987). As universities develop stronger ties with industry, social science research can help identify the most equitable and effective types of relationships.

Organizational research will also facilitate technology transfer during the later stages of the agricultural technology delivery system. The decentralized nature of this system involves linkages among farmers, county extension agents, extension specialists, researchers in land-grant universities, and the private sector. Additional research is needed on the role of technology transfer in facilitating the useful application of science. Private- and public-sector infrastructure and distribution systems must be better understood to encourage the development and diffusion of appropriate innovations. Technology transfer involves building linkages among a variety of organizations in the public and private sectors. Social science research can strengthen research and extension.

Potential impacts and risks of biotechnology

Sociologists' main interest in biotechnology to date has been in trying to anticipate the potential impacts of biotechnology on farmers and the structure of agriculture. Unfortunately, much writing has failed to distinguish among the various types of biotechnology products and processes. Most have focused only on biotechnology products that will increase production and require more sophisticated management (e.g., bovine somatotropin). Such products will probably be biased toward better farm managers who also tend to have larger-scale operations. Future analysis of biotechnology's impacts and risks will need to focus more on specific products that enter the marketplace. Two related types of analysis will be important: social impact assessment and risk assessment. Sociologists, to date, have focused mainly on the former, with less attention to the latter.

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Social impact assessment of biotechnology

Innovations can have both positive and negative impacts on individuals, organizations, communities, and larger systems. Economic and political institutions which generate and manage technology tend to neglect impacts on those people who are supposed to benefit from technology. Every technology has side effects, some benign and some dangerous (Wenk, 1986). Most research to date on innovation diffusion has largely failed to identify or assess the negative consequences of technology (Rogers, 1983). Like other technological developments, biotechnology will have short- and long-term consequences in a number of areas. Because most biotechnology products are still under development, social scientists have unique opportunities for impact analysis and risk assessment. Anticipating potential impacts will inform public debate and policy making, as well as minimize potentially disruptive effects (Hoiberg and Bultena, 1987).

Although some limitations exist, considerable progress has been made in social impact assessment (SIA) since the 1970s (Freudenburg, 1986). Effective SIA must be future-oriented to anticipate and mitigate adverse consequences before they occur. Explicit comparisons should be made between conditions as they are likely to be with and without the development and diffusion of specific-products biotechnology. All parties must be clear as to why SIA is being conducted (Dietz, 1986). As social scientists, we should maintain objectivity and avoid becoming advocates of one side.

Public participation and education must play an important role in SIA. As impacts are identified and evaluated, results should be clearly summarized and presented to the affected public and policymakers for final decision. Sociologists have an opportunity to improve the role of the public in biotechnology assessment. This will require a better understanding of public perceptions, as well as a knowledge of biotechnology. The public is concerned over possible impacts, but lacks accurate information on the relative benefits or risks of alternative technologies (Offutt and Kuchler, 1987). The public also voices concerns over the ethical and socioeconomic ramifications of biotechnology (Office of Technology Assessment, 1987). A recent nationwide survey found over 60 percent of the general public supported the notion that research on new farm technologies should always consider the social consequences of its use (Molnar and Patiyasikhan, 1987).

Technology assessment is a related area of inquiry that could complement SIA in the debate over biotechnology. It includes a class of policy-related studies that examine the effects on society that may occur when a technology is introduced, extended, or modified. It emphasizes the consequences that are unintended, indirect, and delayed (Porter and Rossini, 1983). Technology assessment is also future-oriented in its attempt to anticipate consequences of technological change rather than waiting for them to become evident. It is interdisciplinary in focus and tries to identify a wide range of social, political, economic, and environmental impacts of new technology. Like cost-benefit analysis, it weighs beneficial consequences against adverse impacts (Molnar et al., 1987).

Some types of biotechnology will affect agriculture in profound ways. Animal growth hormones, for example, will require sophisticated

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information, improved management skills, and financial resources. If larger, more commercially successful farmers are, in fact, first to adopt such biotechnologies, smaller-scale farmers will be at a competitive disadvantage. Other types of biotechnology (e.g., improved seed varieties), however, may be relatively scale neutral. All farmers are eventually compelled to adopt innovations to remain competitive (Kalter and Tauer, 1987). This phenomenon has been referred to as the "technological treadmill" and has occurred throughout the history of agricultural development (Cochrane, 1979). Given today's narrow profit margins, later adopters may pay a greater price for rapid technological change.

Biotechnology could have important implications for the changing structure of agriculture. Technological change is an important factor in the trend toward fewer and larger farm operations, with a disappearance of middle-sized operations (Office of Technology Assessment, 1986). Some types of biotechnology (e.g., bovine somatotropin) could accelerate the trend toward fewer and larger farms with more specialized and capital-intensive operations (Office of Technology Assessment, 1986). Other types of biotechnology products or processes will tend to be more scale and skill neutral.

Biotechnology also could affect rural communities already stressed by problems in the agricultural sector. Some rural areas will bear the costs, while others will reap the benefits (Buttel, 1987a). In terms of economic development, most rural communities will not benefit directly in the near future from biotechnology. During the current research and development stage, biotechnology firms have located almost entirely in urban areas on the east and west coasts (Buttel, 1986). Biotechnology will result in regional shifts in production, which will benefit some rural areas at the expense of others. For example, as frost tolerance is genetically engineered into high-value commodities, these crops could be grown in colder climates.

Agribusinesses (e.g., agricultural supply industries and processing facilities) will also be affected by biotechnology (Kalter, 1985). Firms that are able to rapidly develop and market new biotechnology products will achieve a competitive advantage. The agribusiness sector is becoming more concentrated (i.e., fewer firms control a greater share of the market). Large chemical companies have been acquiring seed companies and start-up biotechnology firms (Kenney, 1986; Hueth and Just, 1987). A small number of agribusiness corporations will gain even greater control over farmers' inputs. Without adequate competition, firms that hold exclusive rights to new technology will be able to charge premium prices.

Buttel (1987b) argues that some of the most far-reaching implications of biotechnology will include impacts on land-grant universities (LGUs). Greater emphasis on biotechnology may require reorientation of LGU research at the expense of traditional areas. To gain financial resources, many LGUs are becoming more closely connected with industry in the development of new technologies. Possible impacts of growing reliance on private-sector funding may include loss of LGU autonomy, reduction in public-sector support, and increased instability of program areas. In many cases, large biotechnology companies are bypassing LGUs, in favor of working more closely with non-LGU scientists. Possible impacts on the ability of LGUs to provide both quality

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education for students and the latest innovations to farmers need careful consideration.

Biotechnology will have important impacts on the Cooperative Extension Service. Farmers will need timely and accurate information to make well-informed decisions and to integrate biotechnology products into their operations. Extension will be expected to provide farmers and the public with accurate, neutral information on biotechnology. Farmers have historically turned to Extension when in doubt over the validity of information from other sources (Feller, 1986). Extension may be asked to expand its role in conducting adaptive field research to ensure that new technologies will be well-suited for local conditions (Moses and Hess, 1987). This will become particularly important as researchers at land-grant universities turn toward more basic research. Local field tests will become more difficult as innovations increasingly come from private firms with little LGU involvement in product development. Extension may not have access to information about innovations until they are marketed to farmers.

Biotechnology, therefore, involves potential impacts from the increasing privatization of formerly free knowledge and public-sector research (Buttel, 1987b; Kenney, 1986). Questions arise over who owns the fruits of public-sector research. The social impacts of biotechnology are in many ways similar to those raised by previous types of agricultural technology (Buttel, 1987b). With biotechnology society has a better chance of anticipating and mitigating negative impacts before the innovations are developed and diffused. Biotechnology raises other types of risks and ethical issues, however, that were not as common for other agricultural technologies.

Risk assessment research

Technology assessment involves the difficult task of evaluating uncertainties and risks. Close attention must be paid to uncertain consequences and tradeoffs inherent in biotechnology. Wenk (1986) explains that the intended role of technology is to reduce risk, but technology is also a source of risk. Technology has reduced some risks while generating new dangers of greater scale, complexity, speed, and ubiquity. There is no such thing as zero risk. Acceptable risk is a social judgement based on the probabilities of occurrence and severity of harm, as well as cultural and ethical values. Risk decisions have often been made by the companies that produce hazardous technologies with little concern for those who have to bear the risks. The public has an obligation and a right to understand the nature of the risk and to determine how much risk is acceptable. This implies opportunities and challenges for social scientists.

Biotechnology products could represent serious new risks if they are not properly managed (Mellon, 1988). Some of the most important potential risks involve ecological disruptions that are difficult to anticipate or mitigate. Perrow (1984:294) explains the implications of evaluating tradeoffs between benefits and risks under conditions of uncertainty:

Unfortunately with these fantastic potentials go some fantastic risks. These industries will produce new, *living* technologies; life forms that are unique, unprecedented, and in some respects very poorly understood. In many of the proposed applications, new organisms will be introduced into the environment in massive quantities. Such quantities may produce totally unexpected interactions; there is nothing in our experience to go by. . . . (Biotechnology) creates interactions among systems that were not previously linked at all and perhaps could not be foreseen to be linked. Once the linkage is made, it cannot be controlled by the operators.

Christenson (1988) explains that social risks represent the probable outcomes from involuntary exposure of people to conditions that may adversely affect their life chances and well-being. Social risk assessment explores what is, what could be, and what happens if nothing is done. It should address the following: factors that underlie public risk perceptions; distributional and fairness issues; and trust and legitimacy of institutions. Social risk assessment will require unique theoretical perspectives, innovative methodologies, and realistic policy orientations.

Sociologists need a better understanding of how risks are understood and managed. Risk is perceived differently by different people. Heimer (1988) provides a good overview of recent psychological research that will be of importance to sociologists interested in risk assessment. These include the heuristics that people use in thinking about risk, the resulting biases in their perceptions, the preferences people exhibit for avoiding risk in some cases and seeking it in others, and the effects of variations in how choices are framed. She cites four opportunities and challenges for building a more sociological theory of risk. First is the fact that people sometimes see risk in situations where psychological theory predicts they would not. Second, many risks are difficult to compare and reduce to a common metric. Third, many of the choices about risks are made by or mediated through organizations and interorganizational networks. Finally, people are often active decision makers because they often alter risks rather than simply choosing among them.

Freudenburg (1988) explains that social scientists offer at least three major contributions to risk assessment. First, we can provide tools and a set of relevant findings to help clarify the differences between the scientific community and the general public in the assessment of technological risks. Second, we can contribute to risk assessments, including calculation of probabilities and consequences of undesired outcomes. Third, social science offers insight into the processes by which risk assessments are carried out. Christenson (1988) encourages us to raise the right questions to identify probable outcomes and improve knowledge about the probable occurrence of alternatives. We also are in a position to assess the values underlying the alternatives.

Conclusions

Biotechnology presents significant opportunities and challenges for sociologists. From a theoretical perspective, biotechnology presents a unique opportunity to study innovation diffusion from the basic scientific

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discoveries, through technology development, to the ultimate impacts. From a research perspective we have the opportunity to test our models of innovation diffusion, public opinion, social impact assessment, and risk management. From a public-policy perspective, we can help ensure that a broader range of information, values, and goals is considered in forming decisions on research and policy (Buttel, 1987b).

We also face challenges because of the complex and diverse nature of biotechnology. Sociologists have not addressed questions about the risks of biotechnology, but the need for thoughtful evaluation has never been greater (Offutt and Kuchler, 1987). As we found with chemical pesticides, it is very difficult to recall products once released, even when scientific evidence clearly shows environmental or human health risks. After innovations become standard management practices, both users and manufacturers have vested interests in maintaining their availability (Offutt and Kuchler, 1987). No simple answers exist to the complex questions about risks and negative impacts, but the tradeoffs should be evaluated. Evaluating the potential impacts of biotechnology will require close cooperation between biological and social scientists.

Disagreements exist over the relative impacts of biotechnology. On one extreme, many writers claim that biotechnology represents another revolution in agriculture that will have more profound impacts than any previous technological development (Kalter and Tauer, 1987; Office of Technology Assessment, 1986). On the other hand, Tweeten and Welsh (1987) argue that biotechnology does not promise to revolutionize the structure of agriculture as much as the tractor. They further claim that the impact of biotechnology on rural communities will be less than that of modern transportation and communication.

Buttel (1987b) agrees that productivity increases made possible by biotechnology over the next two to four decades will not be "revolutionary," compared to those gains achieved during the post-World War II period. What sets biotechnology apart is its rapid rate of development and transfer (Kalter, 1985). Unlike earlier technologies, biotechnologies have become controversial, and strong critics have arisen well before the introduction of commercial products (Buttel, 1987b). Such disagreements result, in part, from inadequate understanding and appreciation of the diverse nature of biotechnology. We need to carefully examine and compare specific agricultural innovations produced with biotechnology, rather than referring to the general set of tools known as "biotechnology."

As a society we need to resist the technological imperative. Biotechnology should be seen as a means rather than an end in itself. The public should have real opportunities to shape both the means and ends. This will require a more highly educated public, which in turn depends on a better understanding of public perceptions of technology and risk. Public and private decision makers need timely and unbiased information to weigh the relative benefits and costs of particular technologies. Whether the benefits justify the costs is a political and ethical decision, not a scientific one. This requires careful assessment of consequences and open debate among policy makers and affected groups. Sociologists can provide considerable insight to improve the quality of that debate.

References

- Aldrich, Howard E. and Peter V. Marsden
 1988 "Environments and organizations." Pp. 361-392 in Neil J. Smelser (ed.), *Handbook of Sociology*. Beverly Hills, Calif.: Sage Publications.
- Bultena, Gordon and Paul Lasley
 1987 "The dark side of biotechnology: farmers' appraisals of the benefits and costs of technological innovation." Paper presented at the Iowa State University Agricultural Bioethics Symposium, Ames, Iowa.
- Buttel, Frederick H.
 1986 "Biotechnology and the Future of Rural America." Pp. 234-243 in Joint Economic Committee of the Congress of the United States *New Dimensions in Rural Policy: Building upon our Heritage*. Washington, D.C.: U.S. Government Printing Office.
 1987a "Biotech tradeoffs in the rural economy." *Rural Development Perspectives* (June):11-15.
 1987b "Biotechnology, agriculture, and rural America: socioeconomic and ethical issues." Paper presented at the Iowa State University Agricultural Bioethics Symposium, Ames, Iowa.
- Christenson, James A.
 1988 "Social risk and rural sociology." *Rural Sociology* 53(1):1-24.
- Clarke, Lee
 1988 "Explaining choices among technological risks." *Social Problems* 35(1):22-35.
- Cochrane, Willard W.
 1979 *The Development of American Agriculture: A Historical Analysis*. Minneapolis, Minn.: University of Minnesota Press.
- Dietz, Thomas
 1986 "Theory and method in social impact assessment." *Sociological Inquiry*:54-69.
- Feller, Irwin
 1986 "Research and technology transfer linkages in American agriculture." In Lawrence Busch and William Lacy (eds.), *The Agricultural Scientific Enterprise: A System in Transition*. Boulder, Colo.: Westview Press.
- Feller, Irwin, Lynne Kaltreider, Patrick Madden, Dan Moore, and Laura Sims
 1984 *The Agricultural Technology Delivery System* (five volumes). University Park, Penn.: Institute for Policy Research and Evaluation, The Pennsylvania State University.
- Freudenburg, William R.
 1986 "Social impact assessment." *Annual Review of Sociology* 12:451-478.
 1988 "Perceived risk, real risk: social science and the art of probabilistic risk assessment." *Science* 242:44-49.
- Friedland, William H., Amy E. Barton, and Robert J. Thomas
 1981 *Manufacturing Green Gold: Capital, Labor, and Technology in the Lettuce Industry*. Cambridge: Cambridge University Press.
- Goodman, David, Bernardo Sorj, and John Wilkinson
 1987 *From Farming to Biotechnology: A Theory of Agro-Industrial Development*. New York, N.Y.: Basil Blackwood.
- Hassebrook, Chuck and Gabriel Hegyes
 1988 *Choices for the Heartland: Alternative Directions in Biotechnology and Implications for Family Farming, Rural Communities, and the Environment*. Walthill, Nebr.: Center for Rural Affairs.
- Heimer, Carol A.
 1988 "Social structure, psychology, and the estimation of risk." *Annual Review of Sociology* 14:491-519.

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- Hoiberg, Eric O. and Gordon L. Bultena
1987 "Towards an assessment of the socioeconomic impacts of farmers' adoption of porcine growth hormone." Paper presented at the Iowa State University Agricultural Bioethics Symposium, Ames, Iowa.
- Hueth, Darrell L. and Robert E. Just
1987 "Policy impacts of agricultural biotechnology." *American Journal of Agricultural Economics* (May) 69:426-431.
- Jasper, James M.
1988 "The political life cycle of technological controversies." *Social Forces* 67(2):357-377.
- Kalter, Robert J.
1985 "The new biotech agriculture: unforeseen economic consequences." *Issues in Science and Technology* 2(1):125-133.
- Kalter, Robert J. and Loren W. Tauer
1987 "Potential economic impacts of agricultural biotechnology." *American Journal of Agricultural Economics* (May) 69:420-425.
- Kenney, Martin
1986 *Biotechnology: The University-Industrial Complex*. New Haven: Yale University Press.
- Kloppenburg, Jack R. (ed.)
1988 *Seeds and Sovereignty: The Use and Control of Plant Genetic Resources*. Durham, N.C.: Duke University Press.
- Lacy, William B. and Lawrence Busch (eds.)
1988 *Biotechnology and Agricultural Cooperatives: Opportunities and Challenges*. Lexington, Ky.: Kentucky Agricultural Experiment Station.
- Lacy, William B. and Lawrence Busch
1989 "The changing division of labor between the university and industry: the case of biotechnology." Pp. 21-50 in Joseph J. Molnar and Henry Kinnucan (eds.), *Biotechnology and the New Agricultural Revolution*. Boulder, Colo.: Westview Press.
- Mazur, Allan
1981 *The Dynamics of Technical Controversy*. New York, N.Y.: Communications Press, Inc.
- Mellon, Margaret
1988 *Biotechnology and the Environment*. Washington, D.C.: National Wildlife Federation.
- Molnar, Joseph J., Henry Kinnucan, and Upton Hatch
1987 "Anticipating the impacts of biotechnology on agriculture: a review and synthesis." Pp. 254-267 in Homer M. LeBaron, Ralph O. Mumma, Richard C. Honeycutt, and John H. Duesing (eds.), *Biotechnology in Agricultural Chemistry (ACE Symposium Series 334)* Washington, D.C.: The American Chemical Society.
- Molnar, Joseph J. and Santi Patiyasikhan
1987 "Public perceptions of the impact of new agricultural technology: implications for biotechnology." Paper presented at the Annual Meeting of the Rural Sociological Society, Madison, Wisconsin.
- Moses, Phyllis B. and Charles E. Hess
1987 "Getting biotech into the field." *Issues in Science and Technology* 4(1):35-41.
- Mulford, Charles L.
1984 *Interorganizational Relationships: Implications for Community Development*. New York, N.Y.: Human Sciences Press, Inc.
- Nowak, Peter J.
1987 *The Political and Methodological Context of Social Impact Assessment: A Case Example of Bovine Somatotropin*. Pp. 209-233 in *Proceedings of the National Invitational Workshop on Bovine Somatotropin* held on September 21-23, 1987 in St. Louis, Missouri. Washington, D.C.: USDA-Extension Service.

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Office of Technology Assessment

- 1984 **Commercial Biotechnology: an International Analysis.** Washington, D.C.: U.S. Government Printing Office.
- 1986 **Technology, Public Policy and the Changing Structure of American Agriculture.** Washington, D.C.: U.S. Government Printing Office.
- 1987 **New Directions in Biotechnology - Background Paper: Public Perceptions of Biotechnology.** Washington, D.C.: U.S. Government Printing Office.
- Offutt, Susan and Fred Kuchler**
- 1987 "Biotechnology: is safety all that matters?" *Choices* (Fourth Quarter):12-15.
- Perrow, Charles**
- 1984 **Normal Accidents: Living with High Risk Technologies.** New York, N.Y.: Basic Books.
- Porter, Alan L. and Frederick A. Rossini**
- 1983 "Technological innovation and its assessment." Pp. 727-752 in Stuart S. Nagel (ed.), *Encyclopedia of Policy Sciences.* New York: Marcel Dekker.
- Rogers, Everett M.**
- 1983 **Diffusion of Innovations** (third edition). New York, N.Y.: The Free Press.
- Schnaiberg, Alan**
- 1980 **The Environment from Surplus to Scarcity.** New York, N.Y.: Oxford University Press.
- Stallman, Judith I. and A. Allan Schmid**
- 1987 "Property rights in plants: implications for biotechnology research and extension." *American Journal of Agricultural Economics* (May) 69:432.
- Tweeten, Luther and Mike Welsh**
- 1987 "The economics of agricultural biotechnology: a discussion." *American Journal of Agricultural Economics* (May) 69:440-442.
- Wenk, Edward**
- 1986 **Tradeoffs: Imperatives of Choice in a High-Tech World.** Baltimore, Md.: The Johns Hopkins University Press.
- Ziman, John**
- 1984 **An Introduction to Science Studies: The Philosophical and Social Aspects of Science and Technology.** Cambridge: Cambridge University Press.
- Zuckerman, Harriet**
- 1988 "Sociology of science." Pp. 511-574 in Neil J. Smelser (ed.), *Handbook of Sociology.* Beverly Hills, Calif.: Sage Publications.