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Public Policy and Animal Biotechnology in the 1990s: Challenges and Opportunities+

American agriculture has enjoyed momentous success over the past 50 years as measured by the quantity, quality, variety and cost of food and fiber. In the years proceeding World War II, the U.S. agricultural sector has experienced a significantly high rate of growth in productivity—a level more than three times the magnitude of the nonfarm industrial sector.

Into this agricultural system with all its strengths, complexities and challenges—both biological and political—comes biotechnology. Because of its importance to increased competitiveness in today's expanding global economy, biotechnology is viewed as one of the keys to U.S. agriculture's continued success in the years ahead. Moreover, it is predicted that the world's population will increase at a rate of approximately 90 million people annually. At this rate, the current global population of just over five billion is expected to double during the next century. World hunger and malnutrition will not be simply problems of inequitable distribution. Expanded food production will be essential to accommodate the nutritional needs of this rapidly growing global population. Herein lies one of biotechnology's most pressing demands.

AN INDUSTRY COMES OF AGE

After years of speculation and commitment, agricultural biotechnology is moving slowly from the research laboratory to the barn, the field and the processing plant. The puissance of agro-food biotechnology is no longer fantasy. Already, diagnosis of disease using biotechnology tools is a reality which is

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* The views and opinions expressed in this article are the authors and do not necessarily represent the official policy or interpretations of the U.S. House Committee on Agriculture.

changing the face of both human and animal medicine. We are now in what some call the age of biology, moving from the age of chemistry.

The U.S. has maintained its preeminence in biotechnology, bolstered by strong research programs and well-established foundations in pharmaceuticals and agricultural science. For instance, in 1991, sales from biotechnologies totaled approximately $5.8 billion, an 18 percent increase over 1990, with net exports exceeding $600 million (Burrill and Lee, 1991; Raines, 1991). Furthermore, the Council on Competitiveness in the Office of the Vice President (1991) projects that by the year 2000, biotechnology will be a $50 billion industry. Currently, private industry spends approximately $2.1 billion annually on technology development (Office of Technology Assessment, 1991a). The federal-state agricultural research system spends roughly $1.9 billion annually on agro-food biotechnology research and development (Office of Technology Assessment, 1991c).

These figures merely underscore the fact that what scientists have come to understand thus far about plants and animals is impressive. Moreover, this basic knowledge has been rapidly carried forward by a whole host of viable applications.

IMPACT OF BIOTECHNOLOGY ON ANIMAL AGRICULTURE

Over the next 15 years, American farmers and ranchers will be offered an extensive array of new technologies that could revolutionize food animal production. Ongoing research in the areas of computers, information systems and processing, robotics, controlled environments and biotechnology are expected to provide numerous on-farm practical applications (National Research Council, 1990). Such technologies point to more efficient growth rates, less feed per unit of output, improved disease resistance and increased prolificacy (Van der Wal et al., 1991).

Today, biotechnology has provided animal agriculture with safer, more efficacious vaccines against viral and bacterial diseases such as pseudorabies, enteric colibacillosis, and foot-and-mouth disease. We are beginning to seek answers to questions regarding complex systems that only a few years ago we could not even think to ask. This increased ability is particularly important in light of the fact that food animal products account for approximately one-half of all U.S. agricultural revenues on an annual basis. Producing leaner, high quality meat and meat products to satisfy today's health-conscience consumer is of paramount importance (Pearson and Dutson, 1990; Kopchick, 1992).

Further, the first few commercialized on-farm animal biotechnology products will be of particular significance since: 1. they will heavily influence public attitudes about other emerging products and applications; 2. will establish substantive and procedural precedents in the legislative and regulatory arenas; and 3. will impact the future willingness of the corporate community to invest in like or similar product research and development (Kalter, 1985; National Research Council, 1987; Office of Technology Assessment, 1991 d).

Unfortunately, there is a lack of recognition in some circles that biotechnological applications complement, rather than replace, the traditional methods used to enhance agricultural productivity. In reality, many of the so-called "new" biotechnologies involve concepts based on centuries-old applications (Moses and Cape, 1991). Bovine somatotropin (BST) is an interesting example—a product that elaborates familiar disciplines such as breeding, animal nutrition, animal physiology and veterinary science, supplemented with the basic disciplines of molecular genetics, biochemistry, microbiology and bioprocess engineering (Office of Technology Assessment, 1991 d).

CURRENT CHALLENGES FACING ANIMAL AGRICULTURE

Meeting the challenges of international competitiveness, sustaining a high quality food supply, preserving natural resources and protecting the environment will require a heightened level of knowledge over and above what was required to solve previous problems of years past (National Research Council, 1989). In fact, an array of thought-provoking questions are being posed from both within and outside the agricultural sector. For example, how can the safety of biotechnologies, which may be used in food production or processing, be systematically evaluated? Will the release of genetically modified organisms into the environment pose threats to human health or to natural ecosystems? Is new legislation necessary to regulate the agro-food and fiber products that are likely to be developed utilizing biotechnologies? These and other intricate questions are being voiced with a heightened urgency.

Clearly, the issues and strategies have become increasingly complex. Legislative authority and jurisdiction have become widely dispersed among several congressional committees and subcommittees with differing and like perspectives. Nonetheless, in the end, an effective biotechnology policy must knit several dimensions into a coherent framework—including basic research, development and application, marketing and economic competitiveness, effective regulation, ethics and public policy (Office of Technology Assessment, 1991a).

OVERCOMING OBSTACLES TO CHANGE

Worldwide, biotechnology is debated on three fundamental planes. The risks and benefits are disputed on scientific grounds, socioeconomic grounds and on the basis of public perception (von Oehsen, 1988; Wald, 1992). As with any other new technology, many questions of adjustment to change are posed. Concern about the effects of technological change has been a constant in the history of industrial development. But how should a democratic society establish public policies on advanced technical issues like biotechnology?

The primary difficulties inhibiting adoption would appear to lie in the provinces of administration, economics, management—and politics. The political debate surrounding biotechnology begins at the edge of scientific

knowledge and lies in the realm of "What if?" Consequently, the barriers are both technical and institutional (Ruttan, 1991). Although we live in a society where the words of acknowledged experts are often received as gospel, our fascination with authority shows some indication of waning. Scientists, industrialists, politicians and educators have been found to be as fallible as other human beings and their "expert" information is greeted with skepticism by some, and with open defiance by others.

Today, the agricultural research community, and production agriculture in general, face several formidable outside forces. Such influences are frequently referred to as *externalities* which can either have a positive or negative effect upon agricultural research and its use—particularly for agro-food biotechnology. The ultimate judge of emerging technologies will be the consumer-—whether that be the farmer, homemaker or general public (Harlander, 1991). It is they who will appraise the merits of a particular product or process and determine its success or failure.

UNDERSTANDING CONSUMER CONCERNS

Within the past few years the popular press has captured the public's attention with the perceived role biotechnology might play in agriculture, citing both positive and negative aspects, whether realistic or wildly speculative. Further, many of the terms used in current discussions of biotechnology have negative overtones. For example, words such as "genetic manipulation" and "genetic engineering" have a pernicious ring to the general public, and it is significant that those campaigning against BST continually refer to the product as "bovine growth hormone."

Part of the problem surrounding the broad acceptance of biotechnology stems from the frequently espoused concern that the processes of scientific research, and the applications derived therefrom, seem difficult to access and thus opaque, especially to the ordinary citizen. An examination of the testimony received by the U.S. House Committee on Agriculture over the last several years would seem to indicate that concerns regarding biotechnology and other advancements facing animal agriculture fall into two broad categories—those relating to animal and consumer safety issues and those relating to social and ethical issues. Furthermore, the testimony submitted by various public interest groups can be summarized under four question headings: 1. Is it natural? 2. Is it right? 3. Is it fair? and 4. Do we need it?

Many characteristics have been identified in the literature that appear to influence consumer acceptance of innovation. Among them are relative advantage, compatibility, complexity, trialability, observability—and risk (Herbig and Day, 1992).

Undoubtedly, citizens in the U.S. and around the world are going through an often mind-numbing debate about risk and reward in many aspects of their lives. Whether it is food safety, car safety, atomic energy, liabil-

ity laws or even nuclear weapon proliferation, we are in the midst of a debate about the "balance" of risk and reward in society. Public attitudes can vary, often for reasons beyond the influence of more or better information about potential personal, environmental or socioeconomic consequences of a technology. Moreover, some people may react negatively to the perceived impacts associated with anything new or innovative.

What happens if the consumer does not change and refuses to use a technology? Should one blindly accept the scientists' opinion of what is best? Do the vested interests which exist in a company or industry for an innovation mean that consumers must accept their decision? There are a whole host of questions and public concerns which must be properly considered and adequately addressed if we are to clearly see what the perspectives are for introducing biotechnology in farm animal production. The creation and maintenance of the public trust is surely one of the pivotal tasks to be undertaken (Harlander, 1991; Stenholm and Waggoner, 1992).

THE NEED TO COMMUNICATE

There are those who ask, "Why do we need to understand the consumer's acceptance mechanism?" The answer is simple and straightforward: If scientific advances are to be allowed to provide an affordable, nutritious and sustaining diet for all, the information gap between science and the lay public must be narrowed and the consumer's perspective understood. Once the public is knowledgeable and properly informed, the word "biotechnology" in connection with food production should not raise a red flag of fear, but rather present thoughts of reduced food costs, more nutritious food supplies, a safer food supply and a healthier environment in which to raise one's family.

In an effort to foster the public trust, greater efforts are needed in providing useful information about the working areas of biotechnology and its applications in animal production (Office of Technology Assessment, 199 Id; Moses and Cape, 1991). Such information could help support an open and balanced public debate, and thus, form a firmer basis for sound decision-making and sufficient monitoring. We must ensure that our systems of oversight, legislative and regulatory, are transparent and open to full participation by all responsible parties (Stenholm and Waggoner, 1992). At a time when more and more of American life is rooted in science and technology and when the nation's economic well-being depends as never before on its understanding and utilization, the federal government cannot be complacent about the public's interest and confidence in science. Of course, there will always be some degree of risk, but as understanding grows the circle of consensus will widen.

A sure prescription for disaster is for each of the many sides of the discussion to treat the others with contempt. Sincere understanding of the obstructions, and a mutual willingness to confront them, is a critical first step toward positive conflict resolution.

FLEXIBILITY IS THE KEY

A competitive and profitable agriculture will depend on flexibility—on the industry's ability to respond to, and operate within, an uncertain and rapidly changing environment. This means we must learn to view agriculture as a system. We cannot be "smart in the parts" and "dumb in the whole."

Today's current federal meat inspection scheme is a useful example where flexibility and science-driven decisions are presently in short supply. After visiting numerous modern meat processing facilities operating all across America, one should recognize that meat hygiene is a complex subject involving aspects of animal husbandry and physiology as well as food technology and microbiology. Growing scientific consensus supports the view that the allocation of inspection resources in modern meat and poultry production and processing enterprises should reflect a distribution according to risk rather than a distribution according to the classical rules of meat inspection which rely heavily upon human organoleptic methods of detection (General Accounting Office, 1992). Unfortunately, resistance from the inspector's labor union and ongoing concerns within consumer advocacy groups has so far prevented the full implementation of a truly science-based, risk-oriented scheme.

In protecting the public health, a stable and sound regulatory regime is essential. However, since the agro-food industries experience rapid breakthroughs in the discovery of new techniques and products, it is important to ensure that regulatory systems do not lag behind emerging, proven developments (Office of Technology Assessment, 1988; Council on Competitiveness, 1991).

The key to improved competitiveness will lie in a relatively more flexible industrial structure and social organization capable of quickly taking advantage of new technological advances (Office of Technology Assessment, 1991b). Further, industry should not rely on the regulatory process as the only mechanism to influence public opinion. The biotechnology and food industries need to strengthen and promote their own credibility to reduce the burden on, and necessity of, the review and inspection processes.

THE INTERNATIONAL DIMENSION

Biotechnology knows no international boundaries. A number of nations have targeted biotechnology as being critical for future economic growth—giving rise to several nationally based research and development programs (Office of Technology Assessment, 1991a). As a result, agricultural systems throughout the world continue to adopt new and advanced technologies that enable them to become more efficient and competitive in developing new markets and capturing old markets for their agricultural products (National Research Council, 1987). The Japanese government, in particular, has organized research consortia among companies, has sponsored research into biotechnology by industry, and has greatly enlarged its overall funding of biotechnology

research (Yuan and Dibner, 1990). Consequently, the speed in which innovations are adapted to commercial purposes is a critical factor in achieving and maintaining America's own international competitiveness.

In many critical, high-technology sectors such as biotechnology, American firms are facing competitors whose business risks are shared by their governments (Office of Technology Assessment, 1991b). The U.S. approach to promoting particular industries has been one of refrain and "hands-off," the underlying belief being that the national economic interest is best served by free and fair competition in the marketplace—at home and abroad. Does this approach still make sense in a world where governments in most advanced industrial nations, including those of our most able competitors, are cooperating with private business to promote critically important industries? Maintaining the productivity and competitiveness of U.S. agriculture in the public interest requires a proper balance between public and private sector support for technological change. To move agriculture toward new market opportunities, government must not only support worthy research endeavors, it must also be a partner with industry in moving promising ideas and applications from the lab to the farm (National Research Council, 1989). Further, in such a research-intensive industry, the need to protect innovation is crucial. Many researchers and industry leaders cite protection of intellectual property as being of paramount importance to preserving competitiveness in biotechnology (Office of Technology Assessment, 1991a).

Patenting, licensing and regulatory issues are all areas that affect the rate and cost of technology transfer. They play necessary roles in advancing technology transfer and facilitating the commercialization of research results, especially in capital-intensive fields such as biotechnology. Consequently, efforts should be continued to harmonize and improve intellectual property protection procedures throughout the world (Office of Technology Assessment, 1989; Council on Competitiveness, 1991).

MARKET STRATEGY ESSENTIALS

Will the United States retain its preeminence in biotechnology or will products and services derived from biotechnology be more successfully commercialized in other nations? Acceptance of a new agricultural product seems deceptively simple. Our most superficial experiences tell us that good ideas should work and fittingly render a tidy profit to the innovator. However, all too often the marketing mechanism employed is not *marketing pull,* but *technological push* (Herbig and Day, 1992). Marketers often presume that since the technology exists and an innovation has been created, its diffusion is inevitable—a *fait accompli.* As we have seen in the past, successful innovations are often those which pay more attention to market demand than to technological opportunity.

A product or service must be relevant, have demonstrated value and meet specific needs in order to prosper. Therefore, the ultimate objective of any commercial research and development program should be to secure a better match between the production of resources and their utilization by industry and consumers. As eluded to earlier, public reaction will be vital in determining overall market impacts of animal biotechnology. Consequently, greater effort must be focused toward cost-reducing and environmentally friendly innovations. While there are many promising applications of biotechnology on the horizon, biotechnology is neither a panacea nor a complete replacement for established tools. It provides an additional approach to agricultural problems.

Recent studies have shown, among other things, that emerging products of biotechnology will require considerable management expertise on the part of producers (National Research Council, 1990; Office of Technology Assessment, 199Id; Van der Wal et al., 1991). As with many other technological advances, the farmers that will benefit most will be the more efficient managers and early adopters. Furthermore, price support programs, marketing orders, grading systems and regulatory mechanisms will all need to adapt to tomorrow's dynamic production systems.

LOOKING TO THE FUTURE

Leadership in technology development and utilization is the role the U.S. has, can, and seeks to assert for the rest of the world. As noted earlier, the U.S. federal investment in biological research of the past 30 years has laid the foundation for a strong biotechnology enterprise. Because the field is moving rapidly, historical leadership does *not* ensure continued superiority (Federal Coordinating Council for Science, Engineering, and Technology, 1992).

Looking toward the future, what elements could present a positive sum strategy for animal biotechnology in the 1990s? What will be the challenges that influence animal agriculture in the years to come?

First of all, a sound national strategy for biotechnology in agriculture must focus on solving pivotal scientific and agricultural problems, effectively utilizing the funds and institutional structures available to support research, training researchers in advanced scientific areas, and efficiently transferring technology (National Research Council, 1987). Both industry and government have appropriate roles to play in this process (Council on Competitiveness, 1991). There is a need to construct institutional infrastructures that facilitate more effective collaboration among animal scientists, engineers, agronomists and health scientists to deal with issues of production, environmental change and the health of producers and consumers (Ruttan, 1991).

The Cooperative Extension Service and educational institutions must keep pace with ongoing change to be relevant to the future competitiveness and profitability of American agriculture. Producers of the future will need,

and desire, a new menu of technologies that recognize contemporary goals such as enhanced profitability, increased environmental stewardship, rural revitalization and development, and global competitiveness (National Research Council, 1987). Further, there is a need to increase the involvement of farmers, researchers and allied industry in developmental partnerships. These challenges will demand a correspondingly higher level of vision and sophistication on the part of government policymakers, regulators and industry leaders.

Crucial to all the various points discussed previously is the effectiveness of our world trading system. A global approach to the regulation and acceptability aspects of biotechnology is worth pursuing in order to create an improved atmosphere of mutual confidence between producers, manufacturers and consumers. Moreover, the removal of nontariff trade barriers between the world's trading partners and the development of a common reference point is of vital importance while at the same time providing the flexibility to accommodate unforeseen and justifiably unique national considerations.

CONCLUSIONS

World agriculture stands at the threshold of new scientific and technical developments in animal science, biology, chemistry, genetics, agricultural engineering, information technology and many other fields. In most of the world, the transition from a resource-based to a science-based system of agriculture is occurring within a single century (Ruttan, 1991).

Emerging technologies, industry economics and public policy will play critical roles in shaping U.S. animal agriculture in the decade of the 1990s. Advances in health maintenance, reproduction efficiency and information technology will all affect the industry. Additional research is needed to gain an increased understanding of the factors influencing animal growth, environmental adaptation and well-being, and disease resistance (National Research Council, 1989).

Legislative and regulatory activities that occur in Washington are having a greater effect on animal agriculture each year. A simple statement of need is no longer enough to justify the allocation of funds for new programs, new facilities or new research efforts (Waggoner et al., 1989). Consultancies, affiliate programs, consortia, research parks and other forms of partnership between the public and private sectors that foster communication and technology transfer should be promoted (National Research Council, 1987).

Certainly, we must not overlook or push aside the legitimate concerns of the public and work to establish those principles which govern the safe environmental use of emerging products. In such a fast-moving technological environment, it will be necessary to regularly review the appropriateness of the scientific basis of existing regulation and to make any required adjustments in either the technology or the statutory framework.

There are, of course, numerous scientific and technological bottlenecks and data gaps that still have to be overcome, as can be expected of a technology that has been expanding so swiftly and in so many directions. Granted, the outcome of the best science can be unpredictable. The obstacles to crafting an effective strategy to support competitiveness in animal biotechnology are formidable. However, the potential payoffs are abounding.

The genius that has driven America's prosperity throughout its history has been the ability to combine collective vision with diversity and individualism—to unite grand ideals with arduous pragmatism. As U.S. agriculture enters the 21st century, this genius will be put to its most strident test.

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