8.7.87

Public Experimentation and Innovation--An Effective Past But Uncertain Future

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In 1987, we celebrated the 200th anniversary of our Constitution, and the 100th anniversary of the Hatch Agricultural Experiment Station Act. In 1989, the 200th anniversary of the year that the Constitution went into effect, we will be celebrating the seventy-fifth anniversary of the Cooperative Extension Service. The Constitution has been threatened from time to time, not least by a Civil War, and its interpretation is still debated. Nevertheless, in spite of modern-day threats from the far right and the far left, the Constitution is accepted, even treasured, by a vast majority of the American people. Agricultural research and education, like the Constitution, are still accepted, but by a declining number of people. In 1961, former Secretary of Agriculture Henry A. Wallace was applauded when he said: "Scientific understanding is our joy. Economic and political understanding is our duty" (Wallace, 1961). In 1986, in a major address before the American Agricultural Economics Association, James T. Bonnen said: "The public attitude toward science has shifted from unqualified support to a questioning ambivalence and even fear of its consequences" (Bonnen).

Unqualified support for public experimentation and education was present in the 1950's and 1960's, began to fade in the 1970's, and came under severe questioning in the 1980's. I propose to look briefly at some of the earlier periods in our history to determine if there were cycles of such support and criticism, relate what we might learn from the past to the present, and take a guarded look ahead.

Washington

AAEA paper, 1987

Early Experimentation and Innovation

Two hundred years ago, 90 percent of Americans lived on farms and another five percent in small towns and villages. About one-half of the delegates to the Constitutional Convention derived most of their income from farming, and the presiding officer, George Washington, claimed farming as his occupation. Thus, it could be assumed that farming interests would be cared for because the new nation was made up of farmers.

Even though the Constitution embodied farm interests in many respects and agricultural improvement societies were flourishing in the 1790's, George Washington recommended the creation of a national board of agriculture in his last annual message to Congress. Congress did not adopt the recommendation.

In the 1830's, Henry L. Ellsworth, Commissioner of Patents, began distributing seeds and publishing annual compilations of reports on farming, activities resented by commercial seedsmen and publishers of agricultural journals. Ellsworth obtained some Congressional support by sending the seeds and reports to farmers recommended by Congressmen and Senators, a tactic not unknown today. However, no real research was undertaken until after the Department of Agriculture was created by a bill signed by President Abraham Lincoln on May 15, 1862 (Baker and others, 1963).

A Department of Agriculture and the Land Grant Colleges

The law created an independent Department of Agriculture, headed by a Commissioner responsible to the President. Congress stated in the bill:

"...there is hereby established at the seat of the Government of the United States Department of Agriculture, the general designs and duties of which shall be to acquire and to diffuse among the people of the United States useful information on subjects connected with agriculture in the most general and comprehensive sense of that word, and to procure, propagate, and distribute among the people new and valuable seeds and plants." This law, very broad in scope, has remained the basic authority for the Department ot the present time. The Department was raised to cabinet status in 1889 (Ross, 1946).

Meanwhile, many agricultural leaders were pointing out the desirability of agricultural education. State agricultural colleges were established in Pennsylvania and Michigan as a result of acts of the state legislatures in 1855, in Maryland by an act of 1856, and in Iowa by an act of 1858.

While efforts were being made to establish state-supported institutions, a number of leaders were urging that the federal government assist in making agricultural education generally available. In 1857, Justin S. Morrill, representative in Congress from Vermont, introduced a bill to donate public land to the states for colleges of agriculture and the mechanic arts. The land grant bill was passed in 1859 but was vetoed by President James Buchanan on February 26. Reintroduced in 1861, it became law with President Lincoln's approval on July 2, 1862 (Ross, 1938). A second Morrill Act in 1890 permitted the establishment of separate agricultural colleges for Blacks.

The State Agricultural Experiment Stations

The establishment of the state colleges of agriculture marked a notable step in the advancement of American agriculture. Nevertheless, agricultural courses of a college level had to await the development of experiment stations that would provide basic knowledge upon which such courses could be built. Scientists and others urged their establishment. In 1875, the efforts of Samuel William Johnson led to the founding of the Connecticut Experiment Station, the first state supported agricultural experiment station in the United States. The University of California established an experiment station in the same year and a number of other states followed. Meanwhile, an organized movement to secure federal and state aid for agricultural experiment stations was under way. In 1887, the Hatch Act was approved by Congress and signed by the President (Kerr, 1987).

The new law provided for a yearly grant to each state for the support of an agricultural experiment station. Within a year, every state had accepted the provisions of the act, and within a decade the stations were devoting themselves to research. The stations brought system and gave direction to the land grant colleges, and more than any other factor assured their continuation.

Early Criticisms

But even as the USDA-Land Grant University system was being established, it was being criticized. Many farmers were caught up first in the post-Civil War depression and then in the major depression

of 1873-1879. The Granger movement saw the railroads, industrial monopolies, and grain traders as the villains, with the new agricultural colleges offering no help in what many farmers felt was a battle against the interests. Some Granges and farm journals dismissed the new organizations as theoretical, with no relation to the real problems of farming. To some farmers, the new agricultural colleges were not training young people to be better farmers, they were training them to leave the farm (Marcus).

Most farmers, suspicious of book farming, ignored the experiment stations. A number of state legislatures directed the stations to inspect seeds, fertilizers, feeds, and foods. Some farmers, more knowledgeable than others, sent soil samples to the experiment stations for analysis and for recommendations as to the fertilizer that would make the land productive. In fact, this activity is still with us today (Rosenberg; Barns; Kerr, 1985).

The Department of Agriculture was faring little better so far as criticism by farmers, farm organizations, and farm journals was concerned, although the Grange, which originated with Department employees, generally supported it. Many farm journals were indignant that the Department should issue periodic reports and thus compete with private industry. A statement in 1881 by Congressman J.W. Covert of New York, chairman of the Committee on Agriculture of the House of Representatives, was even more discouraging:

> The controlling idea involved in the creation of the department is that our wide domain should be tested,

> to ascertain what can be most successfully produced in its various sections. Experiments in this direction cannot be profitably conducted forever. Sooner or later the work of the department should be closed, and meanwhile I cannot see why the farmer should not, like other men engaged in other pursuits, learn to experiment for himself and act for himself without reference to governmental aid (Baker and others, 1963).

Winning Acceptance

The agricultural colleges, the experiment stations, and the Department had to win acceptance. As the experiment stations undertook research, they developed a body of scientific and applied knowledge that became the bases for college courses and that, in some cases, at least, could be applied to solving particular problems of the farming community. This was not a simple matter. The colleges wanted to emphasize disciplinary research and, in some instances, used Hatch funds to strengthen their teaching programs. The experiment stations themselves were pressed to discover scientific truths and at the same time to act as bureaus of information (Porter).

Two organizations helped deal with these problems, although they have never been completely resolved. The Association of American Agricultural Colleges and Experiment Stations, now the National Association of State Universities and Land Grant Colleges, was organized in 1887, to address problems common to the colleges and experiment stations,

to resolve issues of college and station relations, and to work with the USDA on administration of the Hatch Act. The Experiment Station Committee on Organization and Policy was created within the Association in 1905. The United States Department of Agriculture created the Office of Experiment Stations (now the Cooperative State Research Service) in 1888 to carry out its obligations under the Hatch Act.

Establishing an effective structure for handling conflicts within the system was essential, but more was needed to secure widespread public support. The answer lay in problem solving. Some of this work grew into such sciences as agronomy and horticulture, but the first necessity was to demonstrate the usefulness of research.

Science, of course, could be used to solve problems. Stephen M. Babcock, chief chemist of the Wisconsin experiment station, devised a simple, accurate test for determining the quality of butterfat in milk. He announced the test in 1890 and concluded his description by stating: "The test is not patented." This contribution to the dairy industry aided in developing confidence in the experiment stations at a time when their future was still uncertain (Carstensen).

The Department of Agriculture was also drawing on science to solve problems. Two examples might be mentioned--the introduction of the vedalia beetle to control cottony-cushion scale, and the conquest of Texas or tick fever in cattle. The vedalia beetle was brought into the United States by the USDA in 1889 and saved the California citrus industry (Rasmussen, 1975).

After the Civil War, with the drives of vast numbers of cattle from Texas to the north, northern cattle began suffering from a deadly fever after being exposed to apparently healthy Texas cattle. The Department's Bureau of Animal Industry found that cattle ticks transmitted the organism from diseased to healthy animals. The research cost some $65,000; it saved cattlemen as much as $40 million a year. Even more important it triggered new research on human diseases, leading to discoveries that yellow fever, malaria, typhus, bubonic plague, and Rocky Mountain spotted fever were all insect borne and making possible their control (Wiser and others).

The experiment stations and the Department were winning the acceptance of farmers and rural communities by solving problems. In most instances, this required the application of the best scientific knowledge of the times. While the goal was to solve a specific problem, research into a particular situation often added to scientific knowledge within a discipline.

Getting Knowledge to Farmers

Even as the experiment stations and the USDA were making progress in problem solving through research, some leaders were becoming more and more concerned over how to make the results of the research available to farmers. Meanwhile, many of the state experiment stations began issuing bulletins for farm people. For example, George Washington Carver at Tuskegee Institute published a series of simple bulletins aimed at helping sharecroppers and small farmers become more self sufficient

in food. The New York station employed an editor who prepared brief popular bulletins based on the longer and more technical publications of the station ((Hines; True).

More was needed, though, than bulletins and Yearbooks. A number of the colleges began giving short courses on specialized topics. This was followed in many states by the inauguration of farmers' institutes, whereby specialists from the college or station would give lectures and demonstrations at various locations around the state. Around the turn of the century, railroads, colleges, and experiment stations cooperated in running farm demonstration trains through their state. Institute leaders and others began boys' and girls' corn, canning, and other clubs on the proven assumption that a young person adopting a new technology resulting in increased production led to its adoption by the parents (Scott).

The Office of Experiment Stations cooperated with the states in promoting farmers' institutes. Meanwhile, much of the cotton South was being devasted by the boll weevil. The USDA's Bureau of Plant Industry assigned Seaman A. Knapp to work with farmers in controlling the weevil by particular methods of production. In 1906, at Knapp's suggestion, W.C. Stallings was appointed the first county agent in Smith County, Texas. In the same year, Knapp appointed Thomas M. Campbell of Tuskegee Institute and J.B. Pierce of Hampton Institute to work with Black farmers in Alabama and Virginia (Baker, 1939).

While Knapp was working in the South to meet the threat of the boll weevil, W.J. Spillman of the Office of Farm Management was studying

the business and agricultural management practices of successful farmers. The office cooperated with state agricultural experiment stations in appointing demonstration agents to work with farmers and help them become better managers.

The Cooperative Extension Service

These and other efforts came together in the Cooperative Extension Service, established nationally in 1914. The new service was to give "instruction and practical demonstrations in agriculture and home economics" to persons not attending the land grant colleges. The new agency was unique in that each of its three parts--the federal, state, and county--had particular functions to perform that related to the other two while retaining a considerable element of independence.

With the passage of the Smith-Lever Act, each state had a basic structure of formal education, research, and extension education. The Department of Agriculture had a national responsibility in coordinating research and education. Thus, in addition to the structure within each state, we had a national system made up of the Department of Agriculture and the Land Grant Universities with their Colleges of Agriculture, Experiment Stations, and Extension Services. Congress strengthened the system in 1922 when it appropriated funds for a Bureau of Agricultural Economics, and again in 1925 with passage of the Purnell act authorizing the expenditure of funds for economic, sociological, and home economics research by the State experiment stations.

Rise of Agricultural Economics

The new Bureau of Agricultural Economics was the outgrowth of work by a number of pioneer rural social scientists. The person most influential in establishing the Bureau was Henry C. Taylor, who, while at the University of Wisconsin, had done much to define the field of agricultural economics. In the Department he was building upon some of the earlier work in farm management by William J. Spillman. The discipline was developing in the universities under the leadership of such men as George F. Warren of Cornell, Thomas N. Carver of Harvard, Andrew Boss of Minnesota, Kenyon Butterfield of Massachusetts, Benjamin H. Hibbard of Wisconsin, and others. Research in agricultural economics was offering farmers, or, perhaps more correctly stated, county agents and others working with farmers, new insights into economic and social problems in particular states and in the nation (McDean).

War and Depression

As today's USDA-Land Grant University system came into place with passage of the Smith-Lever Act and more attention to farm management, it faced its first test. The nation called upon its farmers to increase production because, as President Woodrow Wilson and Secretary of Agriculture David F. Houston said, "Food Will Win the War." There was little time to conduct research. Instead, efforts were turned to reaching farmers with the knowledge already available. Production increased, in part because of the new knowledge being made available, but also because of high prices and demand.

World War I was followed by an economic crisis in agriculture that, with ups and downs, lasted into the 1930's. Research, now well organized, was called upon for help. It, in general, was directed to helping farmers increase productivity while cutting costs. Farmers were advised to diversify and to produce commodities for which there was a market. They were urged to adopt the best farm practices, to carry out farm management programs, and to pay more attention to marketing, helped with the new outlook and situation work. Cooperatives were seen by economists and others as a means by which farmers could cut costs for what they bought and increase returns for what they sold. Many farmers were helped but many others failed and left farming. Some economists, notably Henry C. Taylor, who was fired as chief of the Bureau of Agricultural Economics for his efforts, endorsed federal intervention whereby farmers would be assured parity or cost of production for production for domestic use. However, none of these laws were passed during the 1920's. As the agricultural depression deepened and the nation slide into the "great depression," agricultural research was criticized from two sides. Farm groups said that not enough was being done to really help the farmers. Others questioned helping farmers increase production when there were unmarketable surpluses.

Research During the New Deal

In 1933, what has been called a "new" Department of Agriculture, geared towards active intervention in agriculture, began with passage of the Agricultural Adjustment Act. This act was the result of research and

thought by a number of agricultural economists, including John D. Black, Mordecai Ezekiel, and M.L. Wilson. Essentially, the law said to farmers if they would cut back on production, usually as measured by acres farmed, they would be guaranteed a certain price for what they produced--the basic idea still back of the price support programs of the late 1980's.

Scientific research continued under attack, with funds being cut from $17 million in 1932 to $11 million in 1935. Secretary of Agriculture Henry A. Wallace, speaking to the Committee on Appropriations of the House of Representatives in 1934, said that agriculture must be efficient and that efficiency resulted from scientific research. A dollar invested in research often brought back a hundred dollars.

Perhaps because of the Secretary's interest, Congress rather quickly turned the research situation around. The Bankhead-Jones Act of June 29, 1935, represented a major step forward. The Secretary of Agriculture, through the Department, experiment stations, and land grant colleges was to conduct scientific, technical, economic, and other research into laws and principles underlying basic problems of agriculture in its broadest aspects; to conduct research to improve the quality of agricultural commodities; to develop new and improved methods for production and distribution; to discover uses for farm products and byproducts; and to study the conservation, development, and use of land and water resources for agricultural purposes. In addition, new funds were authorized for the further development of the cooperative extension system.

An Agricultural Revolution and Its Impact

The Bankhead-Jones Act was a reaffirmation of the belief that research could provide the answers to major problems, a belief that was not truly challenged for four decades. It was strengthened during World War II when research and education, sometimes translated into action, helped American farmers meet food and fiber needs. At the end of the war, the Research and Marketing Act suggested that research could lead to changes that would insure farmers a living without reliance upon price supports. This implied if unexpressed goal was not met although many improvements were made in marketing.

However, a revolution in agricultural productivity was getting under way. One of the nation's outstanding production economists, Sherman E. Johnson, listed changes in farming taking place during World War II that would influence production in the post-war years. These included: a continued shift to mechanical power; the expanded use of lime and fertilizer; the rapid adoption of conservation practices; important varietal improvements; more efficient pest control; improvements in animal breeding; improvements in feeding methods; and the development of new land by irrigation, drainage, and clearing. He also listed the "adoption of combinations of improved practices," which, in the light of later events, was the key factor in bringing about an agricultural revolution. As agricultural scientists and extension workers began to see in the early 1950's, the improvement of every part of the farm operation would result in a vastly greater increase in productivity than might be expected from adding up the increases resulting from individual improvements.

The concept of looking at every part of the farm operation and doing what was possible to improve each part became known as the package of practices idea. This concept, which was the application of systems analysis to farming, was to be the most important force in increasing farm productivity for the next three decades (S. Johnson; Rasmussen, 1986).

In 1950 the average yield of wheat was 16 bushels an acre, in 1986, 37. Corn rose from 37 bushels an acre to 118, soybeans from 21 to 24, and yearly milk production per cow from 5,314 pounds to 13,445 pounds. During this same period the average farm worker went from producing products for 15 people to producing for 75.

This revolution in productivity accelerated what had been longterm trends in the farm population, numbers of farms, and sizes of farms. In 1950, 25 million Americans out of 151 million lived on farms, compared with less than six million of 237 million in 1985. The number of farms declined from 5.4 million in 1950 to 2.3 million in 1985, but the average size increased from 216 to 445 acres. Fewer farmers, cultivating about the same amount of land, produced larger quantities of products than almost anyone had believed possible.

As this new revolution in agricultural productivity and its accompanying changes in farm organization or structure was taking place, a debate over future world food prospects was attracting attention. In 1963, the USDA published Man, Land, and Food, by Lester R. Brown. If major famines were to be avoided by the year 2000, Brown said the world must achieve some degree of population control and must increase its

food supply. William and Paul Paddock, in Hungry Nations, published in 1964, gave still stronger warnings of disaster. Before concern subsided, there was a full shelf of such books.

While such warnings seem unnecessary in the light of surpluses in the late 1980's, we should not forget that as recently as the 1960's drought on the Indian sub-continent led to acute starvation even though the world's food surpluses were devoted to alleviating the situation. Twenty years later, the situation in the Sahel region of Africa showed that distribution problems could lead to starvation even though there were food surpluses in some parts of the world.

Over the long span of human history, food shortages have recurred again and again. Continuing research and education is our best guarantee against famine.

A New Era of Criticism

This brings us then to the question as to whether or not today's research and education programs are what we, the American people, need. They have been attacked by thoughtful critics and by zealots. They have been studied by committees of the state experiment stations, joint USDA-ESCOP committees, the Office of Technology Assessment, the General Accounting Office, universities, and the Congress. They have been organized, reorganized, and organized again.

The first substantive post-World War II attack on the research and education system was by Rachel Carson, a well-known biologist and author. Her book, Silent Spring, published in 1962, was a blistering indictment

of the widespread use of chemicals to control insects, animal and plant diseases, and weeds. The move to the new-type chemicals had come after World War II, when DDT became available for public use. It and similar chemicals came into wide use very quickly, with encouragement from the USDA and the stations.

Carson believed that the use of modern pesticides was polluting our air and water, poisoning our soils and many of the food crops grown on them, killing fish and wildlife, and endangering man through the gradual build-up of toxic substances in vital organs of the body. The urban press repeated Carson's criticisms of the state experiment stations and the USDA. The Department and the state experiment stations undertook to determine the longterm effects of insecticides, to find replacements for those thought to be dangerous to man, and to find more effective natural controls. Agricultural economists made studies of the costs to farmers and consumers of eliminating or cutting back on some of the chemicals as compared with possible threats they might pose to health.

In 1970, President Richard Nixon created the Environmental Protection Agency (EPA) to monitor pollution-causing activities and to control chemicals found to be dangerous. Since then EPA and the USDA have attempted to protect both the health of the public and the welfare of agriculture, with, as perhaps to be expected, a number of disagreements (Hadwiger). Continued scientific and economic research and education are essential if we are to protect our natural resources and our agricultural productivity against increasing environmental pollution.

An integrated pest management program was developed in the 1970's by researchers from the USDA and the stations to reduce the usage and level of pesticides in the environment, reduce reliance on pesticides, and improve farm profits through increased production by more efficient pesticide use. The program has been quite successful. Nevertheless, research, emphasizing natural controls, must continue, particularly since many harmful insects are becoming resistant to chemical controls.

Agricultural research and education were attacked again in 1972 by Jim Hightower in his book, Hard Tomatoes, Hard Times. As he saw it, mechanization research had been a bad investment, even though it had led to a bounty of food and fiber products. He suggested that research and education had been for the benefit of large, corporate farms rather than for smaller, family farms.

Even as scientists and administrators were writing reports showing how much was being done for small farmers, the Pound Committee report brought further public criticism of research as carried on by the stations and the USDA. The study was undertaken by the National Academy of Science at the invitation of the Secretary of Agriculture, to evaluate the quality of research performed with federal appropriations. The committee, under the chairmanship of Glenn S. Pound of the University of Wisconsin, organized discipline-oriented panels that sampled research projects.

The report characterized the research for the most part as oriented too far towards problem solving and pedestrian in its execution. The report even suggested that there was an inexcusable amount of mediocre and duplicative effort (National Academy of Sciences).

The report recommended that research be funded largely through competitive grants, open to all institutions and awarded through peer reviews. There should be more emphasis on basic science, and less on problem-oriented work. It is probably fair to say that the Pound Report has had a longtime major effect on agricultural research. One minor impact, yet one demanding many man years, was that researchers had to examine their projects, carefully defining what was basic research and what was applied research. And, since the Pound committee had been critical of what it considered to be an over-concentration on the problems of commercial agriculture, every researcher tried to show that his particular project met the needs of many Americans.

Reorganizing Research

The Pound report led to at least some emphasis in USDA and the experiment stations on research projects aimed at small and low-income farmers, communities, and consumers. However, the recommendation that more research be funded through competitive grants caused more controversy than any other. In framing the 1977 farm bill, the chairmen of the congressional agricultural committees--Congressman Thomas Foley of Washington and Senator Herman Talmadge of Georgia--and Secretary of Agriculture Bob Bergland agreed that the new law would authorize

appropriations for competitive grants. Indeed, the new law, in its Title XIV, had at least a little something for everyone. Two new groups to review and make recommendations on research were established--the Joint Council on Food and Agricultural Sciences and the National Agricultural Research and Extension Uses Advisory Board. A Special Grants program of discretionary project grants to state experiment stations and other university research institutions was reauthorized. The program of grants for the 1890 colleges, which had begun in 1967, was given separate authorization for funding at a level equal to 15 percent of the Hatch appropriations. Without detailing other provisions, it might indicate the scope of the bill to note that the Congress listed 16 specific areas of research in which new federal efforts were needed.

Many of the directors of state stations were concerned that they would lose funding because of the competitive grants. That seemed likely at one time, but Jamie L. Whitten, chairman of the House Appropriations Subcommittee for Agriculture insisted that instead of transferring Hatch or Special Project money to competitive grants, new money should be appropriated. Under Whitten's leadership, appropriations for the Agricultural Research Service have often exceeded the administration's requests, particularly in recent years when the administration has called for heavy cuts. However, he has looked upon economic research less favorably, because appropriations have sometimes been less than requested by the administration.

In 1977, new problems of administering scientific and economic research were created. The Science and Education Administration brought under one administrator the Agricultural Research Service, the Cooperative State Research Service, the Extension Service, and the National Agricultural Library, while the Economics, Statistics, and Cooperative Service incorporated the Economic Research Service, the Statistics Reporting Service, and the Farmer-Cooperative Service. The most difficult problem was the creation of a new administrative level, which made decision making more cumbersome. The directors of the state experiment stations not only had to work with the director of the Cooperative Research branch of the Science and Education Administration, but then had to work through the complex administrative staff of the superagency. In 1981, the superagencies were abolished (Hadwiger).

Between 1981 and 1986, Hatch appropriations rose from $128,615,000 to $155,545,000. However, most of the gain came in 1982. In 1986, the amount of Hatch formula money declined for the first time in the history of the act. The decline was small, but was accompanied by 10.6 percent and 3.8 percent cuts in Special Grants and Competitive Grants. Meanwhile, the 1981 and 1985 farm acts had continued Title XIV with comparatively little change, except for a somewhat stronger direction from Congress as to the lines of research to be followed. Neither the cut in funding nor the more specific directions on lines of research boded well for the future of publicly-funded agricultural research (Kerr, 1987).

What will the future bring? Perhaps what is happening in biotechnology, the newest tool for increasing agricultural productivity,

could give us some clues. Biotechnology is the application of living organisms to improve, modify, or produce economically important products or processes. The process has been used for centuries, but the discovery of new techniques in the 1970's have provided the tools to manipulate organisms at the molecular and cellular level, improving the ability, speed, and efficiency of producing desired alterations in hereditary traits. Such manipulation is often called genetic engineering. This has aroused considerable tension and divergency of viewpoints on issues of ethics, health, and environmental safety.

Biotechnology has or will be used for the production of improved vaccines for animal and human disease, plants that make better use of limited water supplies, disease resistant plants, and more nutritious plants. The new tool will enhance the biological control of insects, permit the breeding of disease-resistant animals, and make possible the production of higher quality livestock. On the other hand, critics of biotechnology, and there are many, both informed and uninformed, see the release of genetically engineered organisms as possibly adversely affecting the environment and even threatening human life. Genetic engineering techniques developed to modify animals could be used to modify human beings--a thought terrifying and totally unacceptable to most Americans. Others see biotechnology as a way for large businesses, particularly the chemical industry, to control food production in the United States through funding the applied research and patenting the resulting processes.

The extremes in hopes and fears for biotechnology as a research tool are probably both greatly exaggerated. Yet there is an area of public concern where we should not permit our hopes for solving both human and animal diseases or our fears of a mutant virus overshadow our need for proper research and the dissemination of reliable information. The public must be educated and informed about technological developments, and scientists must understand the ethical and social concerns of the public (Brill; Buttel).

Biotechnology was and is a research tool that is very closely tied to genetics, a field in which the agricultural experiment stations have been involved for many decades. At first the stations were concerned that they would be charged with serving private commercial interests if they devoted substantial resources to developing and using biotechnological techniques. However, as the field grew, the stations sought new support for their basic biology programs. After much effort, they succeeded in convincing Congress to add $20,000,000 to the Competitive Grants category for biotechnology for 1985. The emphasis in the 1985 amendments to Title XIV indicate that Congress will continue to support this field.

The economic implications of biotechnology are broad and complex. Work is being done in both the Economic Research Service and in several experiment stations in this difficult field.

Looking to the Future

Over the past century, expenditures for public research in agriculture have paid off at significantly high rate.

Agricultural economists have shown this again and again. Yet today, studies by agricultural economists and others, most of them very carefully researched, suggest that the days of glory are past and that from now on, private research and research outside the USDA-land grant university complex will gradually replace the research we have known. The competitive grant system is the direction for the future. This will not happen today or tomorrow, but is inevitable (Ruttan; Evenson; Waggoner and Ruttan; G. Johnson; Feller; Lipman-Blumen and Schram; Office of Technology Assessment).

The historical evidence suggests that such a longterm decline is possible, but not inevitable. Public experimentation and innovation have had ups and downs for a full century. Perhaps a new upturn is at hand, both for scientific and for social science research. However, some decisions must be made and some actions taken if the upturn is to be significant (Rasmussen and Hildreth; Cochrane; Office of Technology Assessment, 1986; Schuh).

Based upon my 50 years within the system and a review of the system's history, I will venture some rather dogmatic assertions, expressing my views or prejudices as to some decisions we should make. The first decision, and it is a hard one considering the criticisms of the last 15 years, is that we must determine that research for problem solving, often involving several disciplines, must come before basic or discipline-based research dedicated simply to increasing man's knowledge. We have failed in problem solving research only in those areas where for political or economic reasons we have not tried very hard. Many times our problem solving has contributed to fundamental or basic

scientific knowledge. Our support has come when we have solved problems, not when we have tried to compete with other institutions on theoretical research. We must pursue our fields, however, with determination, not stepping aside because we have so much to do that we encourage others to take over some of our tasks.

The second decision is to determine whose problems we are trying to solve. We have traditionally and successfully worked with and for commercial agriculture. While I believe we must keep that relationship, the number of commercial farmers is declining to the extent that we must work closely with other groups. We must be willing to work with some we have neglected. Don Paarlberg, in a recent statement regarding the future of extension, said we should concentrate our efforts on the problems of the small and part-time farmers. Others have suggested more effort on problems associated with rural development, a field that has had many ups and downs. I suggest that we turn back to one of the first fields in which the experiment stations worked effectively--nutrition research. Nutrition research is sometimes dangerous in that it can offend particular influential groups, yet it has the potential of meeting the problems and gaining the support of a very large part of the American population.

We must decide, as a third point, to invest more heavily in the social sciences and humanities. Some of the questions facing the biological sciences, for example, in the use of biotechnology techniques, can be answered only with the aid of agricultural economists, sociologists,

and political scientists. Indeed, the most pressing questions facing agriculture today are not in production, but in such economic, social, and political areas as credit, prices, marketing, international trade, and management of the infrastructure. We must, as James Bonnen, Glenn Johnson, Harold Breimyer, James Hildreth and others have repeatedly pointed out, develop new or substantially modify existing institutions. Such modifications must rely upon research in the social sciences and humanities, research aimed at solving problems.

The system of research and innovation that has served the nation so well for a century is pulling apart. We must decide to restore the full cooperative working relationships between the USDA, the experiment stations, the extension services, and the agricultural colleges. This, my fourth point, seems obvious, yet a continuing deterioration is causing problems for every part of the system. We must identify with each other and with a broadening clientele rather than attempt to bolster our status by trying to identify with another system.

Closely related to this fourth point for decision is my fifth and final recommendation. As we bring the services back together, we must emphasize more than ever to the American public that the system which brouht them freedom from famine and a sure supply of healthful food at reasonable cost, led in conserving natural resources for the benefit of everyone, and met one national emergency after another, is at risk. While it is difficult for any scientist or scholar to do so, we must make the American people aware that a system in place which has served them well should be maintained for the future health of the nation. The system has worked well for its first hundred years. It is our duty to see that it continues to work well for the next one hundred years.

Wayne D. Rasmussen retired as Historian, USDA, in 1986. He is presently writing a 75th anniversary book on the Cooperative Extension Service. He wants to thank Vivian B. Whitehead, Jane M. Porter and Norwood A. Kerr of the Agricultural and Rural History Section, ERS, and Howard Disselin, National Association of State Universities and Land Grant Colleges for their assistance with this paper.

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