



### Animal Health Research Programs of the Cooperative State Research Service: Strengths, Weaknesses, and Opportunities (1986)

Pages  
113

Size  
8.5 x 10

ISBN  
0309321603

Committee on CSRS Animal Health Research Programs; Board on Agriculture; National Research Council

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# Animal Health Research Programs of the Cooperative State Research Service

## Strengths, Weaknesses, and Opportunities

Committee on CSRS Animal Health Research Programs  
Board on Agriculture  
National Research Council

Order from  
National Technical  
Information Service,  
Springfield, Va.  
22161  
Order No. PIB87-150405

NATIONAL ACADEMY PRESS  
Washington, D.C. 1986

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NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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This study was supported by Grant No. 59-3159-443 between the National Academy of Sciences and the Cooperative State Research Service, Science and Education, of the U.S. Department of Agriculture.

Copies available from:

Board on Agriculture  
National Research Council  
2101 Constitution Avenue, NW  
Washington, D.C. 20418

Printed in the United States of America

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National Technical  
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## PREFACE

Recognizing the importance of animal agriculture in America, J. Patrick Jordan, administrator of the Cooperative State Research Service (CSRS), requested the Board on Agriculture of the National Research Council to review and evaluate CSRS animal health research activities. Specifically, he requested the study to (1) assess the two CSRS animal health programs: the Animal Health and Disease Research Program (Section 1433) and the Animal Health Special Research Grants Program; (2) evaluate the role of CSRS in coordinating its programs with other U.S. Department of Agriculture (USDA) research agencies, state agricultural experiment stations, schools of veterinary medicine, and the private sector; and (3) identify high priority areas for expanded research.

The Food and Agriculture Act of 1977 (P.L. 95-113) articulated a national concern for disease losses in livestock and other food producing animals. The legislation also addressed the need to protect consumers from food-borne animal diseases and drugs and pesticide residues in meat. P.L. 95-113 authorized several new extramural programs to provide USDA support for animal health and disease research, including the Animal Health and Disease Research Program (Section 1433) and the Animal Health Special Research Grants Program (Section 1414(c)(1) amending P.L. 89-106). Animal health research was further strengthened under amendments included in the Agriculture Appropriations Act for the fiscal years 1979-1984 (P.L. 97-98), and funds were provided to carry out the animal health research authorized in P.L. 95-113.

The Food and Agriculture Act of 1977 also established the Animal Health Science Research Advisory Board to advise the Secretary of Agriculture on how to set priorities and implement the animal health research authorized by the act. Meeting on October 17, 1983, the advisory board recommended that the National Research Council conduct a study to summarize the accomplishments made during the 5-year period that the new animal health research programs had been in operation. The board also recommended that the study identify other animal health research needs, highlight significant research accomplishments, and define where emphasis should be directed in the future.

The Board on Agriculture established a 12-member committee of animal health scientists with expertise in microbiology, virology,

immunology, genetics, reproduction, and parasitology, and a knowledge of beef and dairy cattle, swine, poultry, horses, sheep, goats, and aquaculture research. William J. Benton, University of Delaware, was liaison to the committee from the Experiment Station Committee on Organization and Policy (ESCOP). Kenneth E. Wolf, U.S. Fish and Wildlife Service, was a member of the committee but resigned in March 1985 because of a change in his work obligations.

The committee held its organizational meeting in Washington, D.C., on January 23-24, 1985. During a subsequent meeting, representatives from commodity groups and trade associations, state agricultural experiment stations, veterinary schools and colleges, the American Veterinary Medical Association, the National Association of State Universities and Land-Grant Colleges, and the U.S. Department of Agriculture provided information on animal health problems and issues (see Appendix D for a list of individuals who provided special information to the committee). Two meetings were held at the National Academy of Sciences Woods Hole Study Center to prepare the report and its recommendations. A final meeting was held in Washington, D.C. to review the final draft of the report.

On behalf of the entire committee, I wish to thank Philip Ross, the project staff officer, for his leadership and skill in preparing this report; Selma P. Baron, staff officer, for her assistance; Chris Elfring, consultant, for editing the report; Earl J. Splitter, USDA/CSRS; and the many representatives of commodity groups who participated.

Charles C. Muscoplat  
Chairman

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EXECUTIVE SUMMARY AND RECOMMENDATIONS

At a time when the agricultural economy is severely stressed, animal diseases are a continuing drain on the multibillion-dollar U.S. agricultural industry. Livestock and poultry losses from endemic diseases, parasites, pests, and biological and management inefficiencies have been estimated to cost \$14 billion annually, a 20 percent loss of farm income for the animal production industry. Reduced reproductive efficiency results in another 14 to 20 percent loss for animal agriculture. Although these industry losses are widely quoted, they are only best estimates and their accuracy should be improved. Such estimates do not include hidden losses, those from chronic livestock illness, for example. Thus, despite the considerable research that has been conducted, much remains to be done to solve problems that affect animal health. The goal of animal health research is not only to eliminate disease losses, but to enhance productivity and the efficiency of animal production.

As part of its ongoing efforts, the Board on Agriculture of the National Academy of Sciences/National Research Council was asked by the Administrator of the Cooperative State Research Service (CSRS), U.S. Department of Agriculture (USDA), to assess the two CSRS animal health research programs--the Animal Health and Disease Research Program (Section 1433 of P.L. 95-113) and the Animal Health Special Research Grants Program (Section 1414(c)(1) of P.L. 95-113 amending P.L. 89-106).

This report discusses publicly and privately supported animal health programs and examines the research programs supported by CSRS. It also critically evaluates the animal health research supported by the CSRS animal health research programs, discusses how to set research priorities, and recommends actions to strengthen the role CSRS plays in animal health research.

CSRS AND OFFICE OF GRANTS AND PROGRAM SYSTEMS  
ANIMAL HEALTH RESEARCH PROGRAMS: A STATUS REPORT

Status of CSRS Programs

Animal health research is supported by four CSRS programs: the Hatch Act Program, the Evans-Allen Program, the Animal Health and

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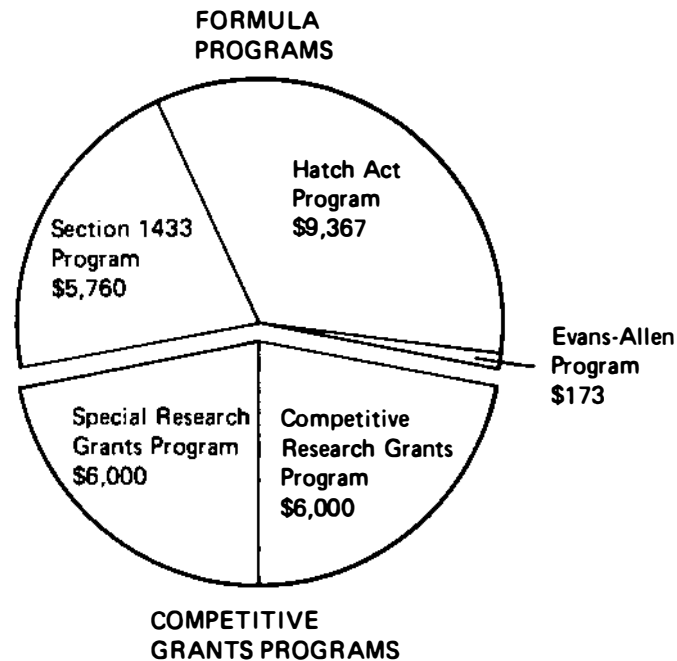


FIGURE 1-1 FY 1985 funding of animal health research in the CSRS and OGPS programs (\$, thousands). Source: USDA, compiled data, 1985.

Disease Research Program (Section 1433), and the Animal Health Special Research Grants Program. The Animal Health Science Advisory Board provides advice and guidance essential to the implementation of the Animal Health Special Research Grants Program and the Section 1433: Animal Health and Disease Research Program. Animal health research is also funded by the Competitive Research Grants Program administered by the Office of Grants and Program Systems (OGPS). (See Table 4-1 for funding levels of the five programs for the years 1975 and 1979 to 1985.) Figure 1-1 shows the fiscal year (FY) 1985 level of funding for the different CSRS programs related to animal health research.

#### Hatch Act Program

In 1985, approximately 6 percent of the total Hatch budget (or about \$9 million) was allocated to support animal health research. One-third of these funds went directly to schools and colleges of veterinary medicine, while the remainder was distributed by the state agricultural experiment stations to veterinary schools, departments of veterinary science, and other animal health related programs. Hatch funds play an important role in animal health research because they provide a reliable base from which new and established scientists can explore other funding areas and because they facilitate collaborative efforts. The Hatch Act Program is a strong formula-funded program administered at the local level and addressing local problems.

### Evans-Allen Program

The Evans-Allen Program was initiated in 1967 to support agricultural research in the land-grant colleges of 1890 and Tuskegee Institute (now Tuskegee University). Funding of animal health research from the Evans-Allen Program was \$173,000 in 1985.

### The Animal Health and Disease Research Program: Section 1433

Section 1433, as this formula-based funding program is commonly called, is directed toward improving the health and productivity of animals and the welfare of producers and consumers of animal products; protecting human health by controlling animal disease transmissible to humans; minimizing livestock and poultry losses caused by transportation and handling; facilitating the effective treatment and prevention of food animal and horse diseases; protecting livestock and poultry from wildlife diseases; and providing improved methods to control birth of predators and other animals.

During FY 1985, the seventh year of the program, 39 state agricultural experiment stations and 16 schools and colleges of veterinary medicine qualified individually, and 12 such stations and 12 colleges qualified as combined institutions, for Section 1433 funding. The program received funds totaling \$5.76 million and supported 1 research on more than 400 projects seeking solutions to infectious diseases, noninfectious diseases, and parasite problems of food animals and horses.

### National and Regional Grant Program: Section 1434

P.L. 95-113, enacted in 1977, authorized Section 1434 funds to support research on specific national and regional animal health or disease programs. However, no funds have been allocated for research.

### Animal Health Special Research Grants Program

Animal health research under the Special Research Grants Program has emphasized the solution of high priority, nationally important problems. In 1985, 446 proposals were reviewed by peer panels, and 54 proposals were funded for a total of \$5.76 million.

During the 7 years the Special Research Grants Program has operated, 3,046 proposals have been submitted, requesting approximately \$400 million. Only 502 proposals (16 percent) have been funded, distributing approximately \$47.6 million. Special Research Grants awards are made in a competitive, peer review panel process. Specific diseases of concern and the amount of available funds allocated for each research area are determined by the Animal Health Science Research Advisory Board.

## Status of OGPS Program

### Competitive Research Grants Program

During FY 1985, grants were awarded in the Competitive Research Grants Program for basic research in selected areas of plant science, human nutrition, biotechnology, animal science, insect pest science, acid precipitation, soybean research, forestry research, and alcohol fuels research. The program received 2,592 proposals, and 504 were funded for a total of \$51.7 million. Eighty-seven animal research projects were funded for a total of \$12.07 million. Approximately one-half of these proposals were in the animal health area. Successful animal health research proposals were in the areas of animal science and biotechnology (animal growth and development and animal molecular biology).

### Institutional Impacts of the Programs

The formula based programs--Hatch, Evans-Allen, and Section 1433--- have had considerable impact on institutional programs in animal health and have significantly enhanced the federal-state partnership in animal disease research. They have stimulated research on common food animal problems using basic laboratory and clinical techniques, trained young scientists, and provided start-up funds for new faculty. Animal Health Special Research Grants and animal health projects funded under the Competitive Research Grants Program have helped initiate high quality, productive research across a broad spectrum of nationally important animal diseases.

### CSRS ANIMAL HEALTH RESEARCH PROGRAMS: A CRITICAL EVALUATION

Each of the CSRS animal health research programs was initiated for different purposes, under varying circumstances, and at different times in history. However, despite their diverse origins, each of these programs addresses a distinct need in the total animal health research picture and the overall CSRS program functions in an unexpectedly efficient manner, addressing national and local needs in a well-integrated program. Therefore, CSRS funds, however distributed, are valuable incremental dollars, and CSRS funding is an efficient use of federal research dollars. However, there are several areas that need attention in order to strengthen the role of CSRS in animal health research.

### Overall Mission and Planning

The committee believes that the CSRS animal health research programs lack strong overall mission, goals, and objectives. A more thorough and coordinated planning process, combined with the

establishment of long-range plans, is needed to clearly define program goals and objectives. Criteria to evaluate research productivity need to be developed so that assessment procedures and site visits can measure the progress made toward fulfilling these goals and objectives. The program plans must be communicated through a constituency education program to elicit and maintain the support of the various self-interest groups that have supported the program in the past.

### CSRS Animal Health Research Programs

#### Animal Health and Disease Research Program: Section 1433

The committee investigations revealed a clear consensus in the animal health and disease research community that Section 1433 formula funds are needed, appreciated, and well used. These funds are not redundant with other sources of funds, but rather are complementary. Formula funds fill a definite, well-defined niche in the overall network of funds available for animal health and disease research. Several distinct factors underscore this utility.

- Formula funds are distributed on a formula basis to institutions. This allows institutions some latitude in planning budgets and directing research and training programs. This also allows institutions to obtain equipment necessary to develop new research capabilities, to improve laboratory facilities, to provide "seed" money for young scientists, and to support research on local problems.
- Section 1433 formula funds are committed expressly to animal health and disease research. Commitment of funds allows institutions to train graduate students for careers in animal health research and to fund productive research and not to cover operational expenses or institutional overhead.
- Formula funds represent an excellent investment of the federal research dollar. Virtually all of allocated funds go directly to financing the research project. Furthermore, provisions in the original legislation that authorized formula funds called for states that received \$100,000 or more of these monies to match these amounts with state appropriated dollars designated specifically for animal health research.
- The trend toward peer-reviewed competitive grant allocation of formula funds promotes research excellence. Institutions are increasingly awarding money to researchers on the basis of intramural, peer-reviewed evaluation of scientific merit.

The committee identified several points that undermined the effectiveness of formula funds. First, the funding levels are inadequate to maximize the potential benefits of the program. Despite increasing numbers of veterinary colleges, animal disease researchers, and potential graduate students, as well as the ever increasing costs of doing research, the amount of available formula funds has remained static for the last 3 years. Second, annual funding is uncertain and therefore

does not allow for efficient long-range planning. The Section 1433 program has not been included in the original USDA budget submitted to Congress and has only been included and approved later on in the course of budgetary debate and compromise. Administrators are unable to undertake long-range planning of research programs based on formula funds when these funds appear to be in annual jeopardy. Third, current methods of dispensing funds promote inefficiency and impair productivity. Two important factors contribute to this problem: (1) annual delay in congressional approval of formula funds, and (2) the federal requirement that all funds allocated in a specific year be expended or returned by the end of the federal fiscal year. This system encourages inappropriate or unwise expenditure of funds each year as the end of the fiscal year approaches.

### Special Research Grants Program

The Special Research Grants Program provides a focus for innovative and contemporary approaches to fundamental problems in animal health. This has happened despite the very modest funding levels assigned to it and a correspondingly frail administrative system. The program has adhered to the intent of the 1977 amendment to P.L. 89-106. It has established processes to assure research priority selection and balance, and for peer review of proposals. The resulting research output has been of a quality and quantity that more than justifies the hopes of the legislation. Accomplishments of the program are discussed in the text of the report.

This committee's review of the Animal Health Science Research Advisory Board annual reports shows that a mechanism has been set in place to facilitate expert assessment of species/commodity-based priorities for research. While it may now be time to broaden the scope of scientific input into the advisory process, the board's funding decisions over the past 6 years have fairly represented the opinions on disease priority areas within each species sector and the contributions of each commodity to livestock production as a whole.

The committee's survey of project titles, objectives, and approaches was by necessity incomplete and biased because of the more ready availability of information from the universities with which committee members were affiliated. Nevertheless, clear trends showed that research focused on the most important disease problems in each species, in many cases using appropriate contemporary technology and addressing questions fundamental to an understanding of disease processes and therapeutic strategies. Some more conventional but not unimaginative projects have also been supported; in certain cases, research was constrained by lack of facilities and equipment.

There is ample evidence that projects funded by Special Research Grants draw on additional and complementary support at each institution. Project personnel take advantage of links within and between institutions, and projects frequently involve cross-disciplinary collaborations. These collaborations sometimes reach between universities and experiment stations, and occasionally to USDA

laboratories. Such connections are not always easy to trace, but their advantages should not be overlooked where scarce resources need to be effectively deployed.

Researchers have not been required to identify Special Research Grants support in their publications, and so the program's productivity may be underrecognized; this contributes to the difficulty in evaluating the program. Conversely, CSRS's evaluation of project output does not pay sufficient attention to evidence of research productivity by publication in refereed journals. However, administrative reports on Special Research Grants contributions from a sample of institutions left no doubt about the quality of output. Special Research Grants funds have also helped attract and involve young investigators in modern approaches to animal health research and in seeking funding through the competitive "peer review" process.

It is expensive to involve professionally qualified scientists and implement experimental systems with livestock. Thus, the quality of research is constrained by the current budget ceiling on awards. It is also important to strive for continuity of support for productive programs. In the past, there has been a bias in favor of support for new investigators rather than maintaining funding for established projects. This probably reflects the intense competition and desire to ensure wide distribution of support, but it is nonetheless unfortunate.

In spite of its brief existence, the Special Research Grants Program has supported research that shows promise of enhancing animal health in the future. More details regarding the program status of particular commodities is presented in the text of this report.

#### Administration

Effective operation of the CSRS animal health programs depends on the availability of an adequately funded and staffed administrative unit. Administrative units are needed to administer grant funds, to coordinate research grant peer reviews and formula funds allocations, to monitor and review progress of research through evaluation of publications and by site visits, to coordinate efforts among agencies where appropriate, to provide information about the program as needed, to recommend changes in direction or in magnitude of funding, and to provide interested parties and Congress with information about the programs. Because of the lack of staff, there has been no time available to review Section 1430 projects critically, coordinate efforts among different institutions or agencies, visit these institutions, or conduct effective long-range planning.

A list of scientists for peer review panels was developed when the Special Research Grants Program was initiated. However, the list has not been formally updated since that time and is currently not used to select panel members.

The use of peer review panels to review research proposals for funding under the Special Research Grants Program is critical to the program's success. Selection of peer panel members and the operation of the review process has been carried out carefully. However, panel

members tend to be selected from a small pool of scientists. Peer review panels should have representation from both the public and private sectors. A file of qualified scientists in each animal health discipline should be maintained by the administrator of CSRS. This file could be compiled from the recommendations of deans of veterinary schools, directors of state agricultural experiment stations, directors of federal animal health laboratories, industry representatives, and other appropriate persons.

Panel members have voluntarily assumed enormous workloads and great responsibility, dealing with very large numbers of proposals each year. With scant time and minimal secretarial backup, panels have done their best to make fair judgments, but, understandably, they can offer little constructive feedback to unfunded investigators.

Another weakness in the CSRS animal health research programs is the great diversity in the use and management of Hatch, Section 1433, and Special Research Grants funds at various research locations. Since different institutions use the funds for vastly different purposes, and there are no systematic criteria to guide use of the funds or standardized procedures for the regular review of the CSRS programs, it is impossible to compare the outputs or effectiveness of the various programs, and it is impossible to identify which fund contributed to the progress made by a research project.

Furthermore, the committee could not determine from the Animal Health Science Research Advisory Board public reports what long-term impacts may have resulted from funded projects or whether solid scientific reports had been assembled. Nor could the committee determine the extent to which formula funded projects may have acted as "seeds" and given rise to successful competitive Special Research Grants projects. It was also difficult to judge the depth and quality of research.

Research administrators as well as the committee are concerned about the unpredictability of Section 1433 funding. The uncertainty of funding from year to year has made national research management and planning difficult for both researchers and administrators. Another concern is the \$150,000 limit placed on individual Special Research Grants for up to 5 years duration. Experts believe that this limit tends to diminish both the quality and quantity of research conducted. A higher ceiling would allow more in-depth and longer-term investigation, thereby increasing research productivity and efficiency.

#### SETTING RESEARCH PRIORITIES

As a first step in setting research priorities, an overall plan is necessary that clearly sets long-range goals for animal health research. Such goals must be derived from an objective and quantitative analysis of the real needs in animal agriculture. Thus, a certain percentage of research should be devoted to determining the economic and social impact of animal diseases, and the Animal Health Science Research Advisory Board needs access to advice in these areas. Ad hoc members with expertise in quantitative measurements of animal



disease costs, epidemiology, disease reporting, agricultural economics, and related fields should be appointed to the board.

Research priorities set by the Animal Health Science Research Advisory Board have changed little over the years, and they tend to be narrowly focused. However, newer methods of quantitative epidemiology, applied economics, and advances in technologies have improved researchers' ability to understand and solve animal health problems. These new methods suggest that subclinical health problems are of greater importance than commonly perceived.

Today, new and powerful tools are available that can revolutionize the researcher's ability to help improve the efficiency of production in animal agriculture, and thus restore profitability in place of government subsidies such as in the dairy industry. The new technologies of greatest potential are computer-based information and decision support systems, and molecular biology.

Since basic knowledge of the pathogenesis of animal diseases is often the same in the various species of livestock, the committee suggests that a systems approach using multidisciplinary research that cuts across commodity lines is necessary. The committee also suggests that priority research is needed to investigate

- environmental factors affecting animal health and productivity, and behavior as a determinant of animal disease and production efficiency; and
- integrated health management systems that consider farm management, nutrition, and the economics of livestock production.

## RECOMMENDATIONS

In reviewing the animal health research in CSRS, the committee noted the complementary nature of the programs and the many strengths in management and activities. But the committee also noted weaknesses that reduce the effectiveness and productivity of the CSRS-sponsored efforts. The following recommendations were prepared to help CSRS develop stronger and more efficient animal health research programs, and thus help solve disease problems that threaten livestock agriculture in the United States. While the committee urges appropriation of additional financial support, many of its recommendations relate to planning, management, and administrative procedures.

### Funding for Animal Health Research

The accomplishments of the Special Research Grants and Section 1433 programs fully justify the recommendation that USDA, the Office of Management and Budget, the Office of Science and Technology Policy, and Congress, by joint action, continue to expand these two programs. There are critical, current needs and opportunities in animal health research that can best be addressed by the CSRS system through

provision of a continuing, strong, stable institutional funding base, and through growth of the nationally competitive Special Research Grants Program.

The committee was not asked to critically review all federally funded animal health research, such as that supported within the Agricultural Research Service (ARS), Animal and Plant Health Inspection Service (APHIS), Food Safety and Inspection Service (FSIS), or Food and Drug Administration (FDA). However, in focusing on CSRS animal health programs, the committee could not help but notice the unique approach and the self-evident value of the cooperative method of research funding when compared to other programs; specifically, CSRS taps the vast body of talent and knowledge resident in the universities and colleges throughout the land. The role of the academic scientist is to lead the way in developing new methods and new solutions to problems. Therefore, the resources made available through CSRS funding provide one of the most effective ways to bring innovation to bear on national animal health problems.

CSRS animal health research programs have enhanced understanding of disease processes and will eventually provide large benefits to animal agriculture. The uncertainty of support and funding of recent years have decreased the programs' effectiveness, and will jeopardize their potential if allowed to continue. One problem is that USDA has not consistently included these programs in its annual budget request. This unpredictability makes national research management difficult for both researchers and administrators, and discourages scientists from seeking careers in animal health research.

Officials of USDA must ensure that appropriations for CSRS animal health research programs are included in the annual USDA budget. It is important for these programs to receive not only stable, but increased support. Animal health research is expensive because of the costs of the animals involved and because modern technologies are needed. Expansion of the research investment is essential for continued progress. Given the needs, new funds should be additionally allocated for the programs.

Funding levels for the Special Research Grants Program must be increased to the original level allocated, \$10 million, with annual increases to reflect inflation costs for doing research. The current \$150,000 ceiling for individual grants should be raised to \$250,000.

As a result of inflation and real funding decreases, the Special Research Grants Program now receives less support than when it was initiated in 1979 (\$10 million in 1979 versus \$6 million in 1985). Allocations for this program should be increased to \$10 million as originally allocated in 1979 and should be defended in the USDA budget. Increased funding that includes inflation costs is needed to take advantage of new technology, to ensure support for many excellent proposals not funded each year, and to provide funds for sustained, long-term research efforts. The \$6 million to \$7 million provided each year for the past 4 years and the \$150,000 per grant limit threaten to

undermine the effectiveness of this nationally competitive research program. In order to maintain research efforts consistent with other nationally competitive, federally funded research programs, the upper limit for Special Research Grants should be approximately \$250,000 per project. Only through increased funding can the United States develop and maintain a corps of animal health scientists and decrease the loss of animals from disease.

The current level of funds appropriated for the Section 1433 Program must be increased over the next 5 years to reach the original allocation ceiling of \$25 million authorized by Congress.

Funds allocated to eligible institutions through the Section 1433 Program have remained fixed at a level of \$5.76 million for the last 3 years. This level represents only 23 percent of the funds authorized for the program by Congress in the original legislation and represents a decrease of real dollars available through the program since it includes no annual correction for inflation, nor for the steadily increasing costs of doing research. Furthermore, the funding level provides no accommodation for the several new veterinary colleges that have been created over the past few years. The newer colleges often have the most up-to-date research facilities and highly qualified scientists, and the research potential of the faculty scientists can only be fully exploited by making Section 1433 funds available in appropriate amounts.

Institutions eligible for Section 1433 funds, particularly veterinary colleges, now rely on those funds to pursue a wide range of research activities on local and regional animal disease problems, to train graduate students for careers in animal health research, and to maintain research equipment and laboratories. With their funding base diminishing, administrators cannot undertake long-range planning. They cannot ensure the maintenance of their physical research facilities, nor attract talented graduate students and faculty to their institutions, and they cannot assure local livestock producers that they are capable of providing solutions to animal disease problems that threaten the producers' livelihoods.

Animal health research faces a crisis of modernization. Contemporary technological developments in molecular biology and computer science applicable to animal agriculture can revolutionize animal health research and significantly strengthen the contribution of the research community in ensuring the economic health of the livestock industry. However, to avoid obsolescence and successfully incorporate these new technologies into existing animal health research programs, a substantial infusion of funds is necessary to upgrade current physical facilities, modernize and adapt laboratory space, purchase sophisticated new equipment, and train a new generation of animal health scientists. This committee strongly recommends that the annual funding allocation of Section 1433 funds in the USDA budget be increased over the next 5 years to reach the original ceiling of \$25 million authorized by Congress.

Legislation should be enacted to allow the use of Section 1433 funds to be carried over into the next fiscal year to permit some flexibility in research management.

As currently administered, Section 1433 funds must be obligated by the research scientists in the year of appropriation. Because of delays in allocating monies, the funds are often only available for use 6 to 9 months before the end of the fiscal year. This means that a full 12 months of research is not possible. Funds for a given research project cannot be used efficiently under these circumstances.

The National and Regional Grants Program (Section 1434) should be funded at its authorized level.

The Section 1434 Program to support research on specific national and regional animal health or disease problems has been authorized but not funded. Public Law 95-113 authorized \$15 million annually for this program and stipulated that no overhead funds will be charged in this program. The Animal Health Science Research Advisory Board has not recommended funding of this program in order to prevent reduction in funds for Section 1433. The board also felt that the Special Research Grants Program would accomplish the intent of Section 1434. Some regional animal health and disease problems are common to two or more states and could be attacked most effectively by joint research efforts combining eligible institutions in more than one state. The committee identified highly suitable research areas appropriate to this regional concept: first, to gain further knowledge of the pathogenesis, diagnosis, therapy, and control of new or recurring epidemic diseases, such as avian influenza; second, to study aspects of the animal industry that have strong social and political consequences beyond agriculture, such as antibiotics in livestock feeds or hormone implants; and third, to develop new techniques for quantifying the effects and types of subclinical and clinical diseases of livestock in order to acquire objective information with which to set national and regional research priorities in animal health research. The Animal Health Science Research Advisory Board should consider endorsing this program, and CSRS should include funding for the program in its budget.

#### Overall Mission and Planning

CSRS must develop a comprehensive animal health research program plan that capitalizes on the uniqueness of the cooperative system and its capacity to draw upon the creative intellectual resources of state universities. Program objectives must project far enough ahead to ensure sustained attention to contemporary needs and priorities, but be responsive enough to address new concerns and incorporate new technologies as they arise.

CSRS animal health research programs differ from others sponsored by USDA in their incorporation of the federal-state partnership

concept. The program goals should reflect this broad access to qualified personnel and physical resources, and efforts should be made to promote interactions elsewhere within the USDA system. Continuity and commitment are keys to attracting and using the considerable experiment station and university talents and experiences that can be focused on carefully selected animal health research priorities. The Animal Health Science Research Advisory Board should appoint an ad hoc panel to develop a program plan.

Criteria need to be developed to evaluate the progress made toward fulfilling the research program objectives. Assessments of productivity and accountability are needed at regular intervals using established criteria.

During the course of this review of the CSRS animal health research programs, it was apparent that an accountability system for measuring the productivity of the programs was not in place. The Current Research Information System (CRIS) was used where possible; however, it did not provide the information necessary to assess critically the productivity of these programs.

At present, there are no standardized criteria available for CSRS to assess the progress of research funded through its animal health research programs. Procedures should be developed for 5-year institutional program reviews, and they should evaluate (1) institutional program plans, including definition of animal health problems, research goals and objectives, and the methods and resources needed to obtain the goals; (2) scientific competence of participating faculty; (3) opportunities to develop manpower through support of graduate student training; (4) the peer review process for allocating resources and funding of Animal Health and Disease Research Program, Section 1433, projects at the local level; (5) local and CSRS budgets, including the process for allocating Section 1433 funds; and (6) research accomplishments, including the listing of publications in refereed journals.

These 5-year reviews need to be carried out by a group of three to seven research scientists and supporting CSRS staff. Only states that receive more than 1.5 percent of the total Section 1433 funds in a 5-year period need to be reviewed by site visits. Those receiving less than the minimum level would need to submit documentation addressing the criteria described above. These should be reviewed by a CSRS panel to assess their program productivity.

Any program that fails to meet the minimum standards should be denied Section 1433 funding until it complies with the evaluation criteria.

CSRS should communicate animal health research needs, objectives, and accomplishments with Congress, commodity groups, consumers, scientists, and other federal and state agencies using publications, newsletters, and other media resources.

To carry out its long-range plans, CSRS needs to better communicate animal health research needs, objectives, and accomplishments. At the present time, the Animal Health Science Research Advisory Board's Annual Report, which describes the animal health research programs and some of the accomplishments, is sent to the state agricultural experiment stations, colleges and schools of veterinary medicine, and commodity groups. A wider dissemination of information is necessary. Also, a constituency education program should be developed to elicit and maintain support from the various special interest groups and members of Congress that have supported the program in the past.

All the various agencies, departments, schools, and other groups with animal health programs need to facilitate collaborative programs and formulate an overall animal health plan.

Veterinary schools, veterinary science departments, and animal health investigators in universities represent a wealth of expertise that can be brought to bear on the diverse needs of animal agriculture. To take advantage of these resources, CSRS, APHIS, ARS, FSIS, and FDA's Center for Veterinary Medicine along with producer and consumer groups need to formulate an overall animal health plan that addresses the needs of agriculture and society. Representatives from the Association of American Veterinary Medical Colleges should also be included in the development of the plan.

This joint planning process will help assure a broad base of support for animal health efforts, and it will foster more collaboration among the different agencies and the university community. Once program needs are identified and objectives of a unified animal health plan are defined, manpower and technological expertise can be identified to address the priority areas. Universities offer training opportunities and in some instances resources and experiences outside of traditional animal disease and health disciplines, and these may be needed to solve certain problems. Manpower needs can be identified as well as openings for graduate students who can pursue projects and careers in the needed areas. Other collaborative efforts could include scientist exchanges for short- or long-term sabbaticals and seminar exchanges.

#### Setting Research Priorities

CSRS must appoint several ad hoc members to the Animal Health Science Research Advisory Board whose combined expertise encompasses quantitative measurements of animal disease costs, epidemiology, statistical disease reporting, agricultural economics, technology assessment, basic computer models, and quantitative analytical systems for studying animal disease and its impact on productivity. Computer software development, as well as training to adapt it to animal disease situations, should receive a significant portion of research dollars. CSRS must support research aimed at quantifying actual animal disease

costs because this is the only way to prioritize animal health problems correctly and provide appropriate guidance to the advisory board.

To accomplish the objectives of any animal health research program, CSRS should seek greater and more formalized guidance from the scientific community. Methods must be developed to quantify accurately disease problems, incidence, severity, cost, impacts on food supplies, and impacts on foreign trade. New approaches for studying disease complexes and new factors affecting animal health should be considered for research funding. Broadening the focus of animal health funding from a concentration on infectious diseases to include other areas, such as reproductive, metabolic, and nutritional diseases, is now warranted. Since many animal health problems and production inefficiencies are multifactorial in origin, the funding structure should be flexible enough to support work on disease complexes that do not readily fit into the traditional priority categories established by the advisory board.

To keep pace with new developments in animal health research, the following research areas should be eligible for funding in addition to the already established categories: (1) a systems approach to understanding disease mechanisms; (2) environmental factors affecting health and productivity, and behavior as a determinant of animal disease and production efficiency; and (3) integrated health management systems that include consideration of farm management, nutrition, and the economics of livestock production.

Setting research priorities based on commodities is one way to study many animal disease problems, especially infectious diseases. However, new approaches to disease complexes, new factors affecting animal health, and new species should be eligible for research funding.

In many instances, the pathogenic mechanisms of diseases are similar for a variety of species. Thus, a systems approach (i.e., reproductive, respiratory, and immune systems, etc.) that cuts across species lines must be given priority. In many instances such an approach will prove to be more economical since much of the basic information may be obtained using less expensive animal models. This approach would also capitalize on available expertise, models, and reagents already developed for some other species. In many cases, the use of small animal or companion animal models may prove to be very helpful in understanding the disease processes and potential control strategies in livestock.

A second area that merits funding concerns environmental factors and behavior. Environmental conditions influence many infectious and noninfectious diseases of domesticated animals. Support for research in this area would provide a greater understanding of the effect of environmental conditions on disease susceptibility, as well as the relationship of livestock behavior to disease incidence and production efficiency. A third promising area is farm management. Already, new farm management systems that have been developed to enhance production have resulted in changes in incidence and types of disease problems.

Research is needed to ensure that newer designs of farming systems and facilities promote animal health and well-being while maintaining profitability for the producer.

If proposals are solicited from these three new areas, the researchers must show that they can work cooperatively in a multidisciplinary approach. The proposals must be peer reviewed by a multidisciplinary panel rather than by existing disciplinary panels. Consideration should be given to setting higher funding ceilings for multidisciplinary proposals.

#### Administration

Funds and staff to administer Section 1433 and Special Research Grants programs must be substantially increased if CSRS is to carry out effectively its administrative responsibilities essential for high quality programs.

No program can be effective without support for its administration, and that requires adequate administrative funds and staff. To date, the administration of Section 1433 and Special Research Grants programs has been done admirably considering the limited available resources.

CSRS programs are a critical part of animal health research. Achieving excellence in such programs requires a highly organized, efficient, and respected administrative unit to coordinate all CSRS responsibilities. The administrative unit must have sufficient resources to carry out its mission. In the past, 4 percent of appropriated funds for the programs has been retained by the USDA to administer the programs. However, some of the money has been allocated to other administrative units within the USDA, so that the amount available for actual use for the CSRS scientific staff has been inadequate. More of these funds should be reserved for the professional staff.

CSRS should establish and maintain a file of qualified scientists willing to serve on peer review panels.

A list of scientists was developed when the Special Research Grants Program was initiated. However, the list has not been formally updated since that time, and the list currently is not used to select panel members. The peer review process is only as good as the individuals that judge the research proposals; therefore, the committee recommends that a file of qualified scientists in each animal health discipline be obtained from deans of schools of veterinary medicine, directors of state agricultural experiment stations, directors of federal animal health laboratories, industry, and other appropriate persons. Also, every effort should be made to secure an appropriate representation of scientists with practical experience in animal disease and health research under field conditions. This list should be reviewed and updated annually and used to select qualified panel members.



Criteria used to nominate candidates for peer review panels should include, but not be limited to, an in-depth knowledge of the subject area based on personal research experience; a substantial publication record; a successful record of obtaining peer-reviewed, extramurally funded research; and prior experience in reviewing research proposals or research publications.

All state agricultural experiment stations and schools of veterinary medicine should maintain a file of research projects funded by CSRS animal health research programs and should be accountable for the accuracy of reports, funding sources, research productivity, and personnel trained.

All these eligible institutions depend heavily on the CRIS reporting system to do their bookkeeping and reporting on CSRS-funded research. This system appears to be inappropriate. CRIS can do a serviceable job of cataloging research titles and maintaining running accounts of dollar expenditures. However, CRIS provides very little detailed information to identify concrete accomplishments of CSRS-funded research, such as patentable discoveries, refereed publications, and graduate degrees awarded. It is essential that this type of information be collected by institutions receiving CSRS funds if the CSRS administration and eligible recipient institutions are to compete effectively for continued support of animal health programs. An annual report including specific information from institutions receiving CSRS funds should be required.

#### CONCLUSION

Research in animal health provides many benefits to society: a stable food supply, jobs, maintenance of the U.S. competitive advantage in animal agriculture, increased international trade, and improved animal well-being.

Over time, most federally funded research programs have resulted in significant economic returns on the dollars invested. However, in animal agriculture many innovations achieved through research cannot be converted directly into marketable products in the private sector. Examples include improved management systems, better animal welfare, and well-trained future scientists. Since society benefits from these outcomes of animal health research, society must continue to expand its support of these efforts.

In addition, the committee emphasizes that research is a long-term investment and must be evaluated accordingly. Today's scientific breakthroughs will not lead immediately to new methods of health management; rather, they will need to be refined and modified by practice and repeated applications. The committee expects research to lead to solutions for important animal health problems and is confident in its justification for supporting and improving these research programs.

The Commission on Veterinary Medicine analysis of the USDA budget reveals a great disparity between funding for animal agricultural and plant agricultural research. For example in the FY 1986 ARS budget, proposed funding for plant sciences is \$188.6 million while that for animal sciences is \$88.2 million, or only 32 percent of the funds budgeted for these areas. The ratio of funding for plant sciences to that for animal sciences through the agricultural experiment stations is approximately 1.8/1.0. Based on 1983 data, farm income derived from livestock and their products was \$69.2 billion and that for crops was \$69.5 billion. Only about 6 percent of Hatch funding supports animal disease research. When these factors are considered along with the availability of a large pool of veterinary scientists interested in animal health and disease research and with the magnitude of animal disease losses (\$14 billion), animal agricultural research funding should be increased significantly to bring it into a more equitable position with plant agricultural research and to address more effectively the needs of the agricultural community.

It is imperative that CSRS funding for animal health research be increased to authorized levels. The committee is overwhelmingly supportive of the Section 1433 formula program and the nationally competitive Special Research Grants Program. It is supportive of the Section 1433 program because (1) formula funds are committed expressly to animal health and disease research, (2) formula funds allow institutions some latitude in planning budgets and directing research and training programs, and (3) institutions are increasingly awarding money to researchers on the basis of intramural, peer-reviewed evaluation of scientific merit. The committee is supportive of the Special Research Grants Program because (1) most animal health problems are of national importance, (2) competitive national peer review ensures that the best researchers receive funding, (3) these competitive programs are highly visible and receive continued scrutiny by the scientific community, and (4) research awards are large enough to allow significant research efforts to be focused on a particular problem. The committee feels that the present ratio of formula funds to competitive research funds is adequate. The committee is aware of the pressure to cut federal programs budgets; however, the committee strongly recommends that the Section 1433 and the Special Research Grants programs must not be compromised, cut back, or altered.

Increased funding for the diverse animal health research programs is important to help solve national, regional, and local problems and to maintain the physical and human resources necessary for a modern research endeavor.

## INTRODUCTION

The agricultural economy is in a time of stress. Farmers in the animal agricultural industry in the United States are more concerned than ever about the profitability of the business and they are striving for production efficiency. One of the major impediments to improved productivity is the continuing burden of animal disease. Animal disease causes significant losses for the multibillion-dollar U.S. agriculture industry and it is a significant cause of suffering for animals. Livestock and poultry losses from endemic diseases, parasites, pests, and biological and management inefficiencies have been estimated at \$14 billion annually, or a 20 percent loss of farm income for the animal production industry (USDA, 1983b). Reduced reproductive efficiency produces another 14 to 20 percent loss (Association of American Veterinary Medical Colleges, 1984).

Animal agriculture is an integral component of the U.S. economy; it generates about 50 percent of the country's total gross farm income (\$69 billion in 1983). In 1983 farm assets in livestock were estimated to be \$49.8 billion. Foreign trade in animals and animal products in 1983 amounted to \$3.7 billion, 11 percent of the total agricultural exports (USDA, 1984d). Furthermore, 70 percent of the total U.S. agricultural area is rangeland, public grazing area, permanent pasture, or hayland. Many products from these types of lands (e.g., alfalfa) must be "cycled" through animals before they are consumed by humans.

### JUSTIFICATION FOR FEDERAL SUPPORT FOR ANIMAL HEALTH RESEARCH IN THE CSRS

#### The Crisis in American Animal Agriculture

The U.S. livestock industry, for over a century the international standard-bearer of animal agriculture, today faces a crisis of confidence not very different from that experienced by the automobile industry in the last decade. Increasing costs of production at home and heightened competition in the marketplace from foreign producers are eroding America's leadership position in animal agriculture, with dire economic consequences.

The dairy industry faces competition at home and abroad from Europe, Australia, and New Zealand. Intensive, cost-competitive swine rearing operations are appearing throughout Asia. Some Asian nations are also on the cutting edge of technological development in the growing enterprise of aquaculture, or commercial fish farming. The U.S. lamb and wool markets are under intense pressure from aggressive marketing and lower production costs in Australia and New Zealand. Foreign beef increasingly competes with U.S. meat in both domestic and foreign markets. These developments do not augur well for sustained economic health in the American livestock industry, traditionally a major contributor to the gross national product. Regular media reports of farm foreclosures and banking crises in farm states underscore the dimensions of the current threat.

#### The Importance of Research and Development in Agriculture

The viability of any industry, agricultural or otherwise, depends on the ability to regulate factors that threaten profitability. The principal factors involved include containing the costs of labor and materials and improving the efficiency of production. The costs of labor and materials are subject to such a wide range of influences that the livestock industry is, in general, unable to control this variable. In contrast, promoting the efficiency of production by technological advancement through research and development offers the best alternative for maintaining a competitive edge in the U.S. livestock industry.

#### The Distribution of Research Benefits Between Producer and Consumers

The nature of supply and demand relationships for agricultural products is such that a significant part of the agricultural research benefit is passed on to consumers in the form of lower food prices, which in turn releases consumer dollars for other activities. Since the entire nation then benefits, it is reasonable that there should be significant public investment in such research.

Evidence obtained over the last 10 to 15 years shows clearly that animal health measures offer unusually large economic benefits. This is principally because the nature of disease is such that it substantially lowers the efficiency with which inputs (e.g., fertilizer, feed) to the production processes are used to produce marketable livestock products and because a diseased animal is inherently less productive than a healthy animal, although it may well consume the same amount of feed. The impact of the newer alternative farming practices on animal health needs study. Thus, animal health research deserves high priority among the areas funded to support the livestock industries.

### The Responsibility of Government to Fund Agricultural Research

In most large industries, the major unit of production is the corporation. In agriculture, it is the individually owned farm. Whereas major corporations usually have the resources to support their own research and development activities, the highly fragmented farming industry does not. American agriculture depends on a network of land-grant colleges, state agricultural experiment stations, state universities, and federal research institutions to provide the farmer with technology to improve productivity and the efficiency of production. The farmer's expectation that the government will provide appropriate research and development has a strong historic precedent in this nation, as evidenced by the land-grant college system. Today's livestock producers expect continued governmental assistance in research and development. This support is fully justified, and more necessary than ever before in the context of the current economic pressures faced by American agriculture.

The partnership of animal agriculture and government-supported research has a proud history. The United States produces a food supply of exceptional quality and abundance. Consumers are assured of an unparalleled variety of wholesome, nutritious food products. Catastrophic, exotic animal diseases common to other continents have been kept from U.S. shores. Livestock production has been improved using research aimed at preventing animal disease, improving animal nutrition, controlling or manipulating animal reproduction, and genetically improving livestock through selective breeding. Ironically, through these efforts productivity has increased so dramatically that in some cases overproduction has undermined profitability for livestock producers.

### The Need to Apply New Technologies to Animal Health Research

Today, new and powerful tools are available that can revolutionize the researcher's ability to help improve the efficiency of production in animal agriculture, and thus restore profitability in place of government subsidies. The new technologies of greatest potential are computer-based information and decision support systems, and molecular biology. Australia and several European nations have pioneered exciting computer applications in animal agriculture that demand further exploitation here in the United States. Use of such information systems can increase the power of epidemiologists to quantify, monitor, and even predict trends in animal disease. Improved quantification and prediction of animal disease patterns can help to set regional and national research priorities and provide reliable criteria for allocating research funds. Through the use of information systems it is also possible to identify and measure the effects on production efficiency of subclinical diseases, conditions that may not produce obvious signs of illness yet continuously impair the animal's ability to grow or produce profitably. These subclinical diseases are now a major focus of animal disease research.

Computers are also now being used to model livestock production systems, and can be used to predict the impact of various management, nutritional, and therapeutic interventions on production efficiency. For example, models can be used to compare the benefits and costs of implementing such procedures as antibiotic use, vaccination, or improved sanitation to eliminate or reduce disease. This information can help producers avoid unnecessary and costly inputs and procedures, and can help researchers focus on appropriate new approaches to problem solving. These various computer-based approaches are now being integrated to develop complete "decision support systems" that will use microcomputers to help the livestock producer and veterinarian work jointly to evaluate alternatives for dealing with particular herd problems and selecting the most appropriate option for the circumstances.

In the area of molecular biology, hybridoma and recombinant DNA technologies have accelerated the understanding of infectious disease mechanisms and the animal's resistance to infection. These insights are leading to the development of a new generation of safer, more effective vaccines, which will help provide therapeutic alternatives to antibiotic administration in livestock, an issue of growing national concern. These advancements, however, represent only the beginnings of agricultural applications of molecular biology. Scientists envision the ability to manipulate the genetic code of domestic livestock to provide built-in disease resistance, accelerate growth rates, improve feed efficiencies, and enhance production by amplifying naturally occurring hormonal triggers. These techniques can lead to production efficiencies on a scale previously unimaginable.

#### The Importance of an Expanded Funding Base for Agricultural Research

The implementation of these new technologies in the service of agriculture requires a renewed intensity of commitment by state and federal agencies directly supporting agricultural research and development programs. To undertake research in these new areas, currently active agricultural research institutions will need to upgrade physical facilities, purchase sophisticated new equipment, remodel laboratories, and train new scientists with skills in molecular biology and computer science. Clearly, without sustained government commitment and support for agricultural research, talented young scientists are going to turn to other fields, such as engineering and the biomedical sciences, rather than apply their talents to agricultural research careers. This so-called "brain drain" from agriculture already appears to be in progress and must be reversed.

Private industry cannot be expected to train the new generation of scientists, nor can industry be depended on to fully exploit new technology in the agricultural arena, since many potential applications cannot be readily translated into marketable, profitable products. The responsibility for supporting growth in agricultural research and development continues to belong to state and federal governments. But government cannot cut back on its support for traditional approaches to

animal health and disease research by diverting already limited funds to new technologies. Traditional research inquiries, as well as innovative new approaches, are both necessary.

### The Role of Federally Funded Research Programs in Animal Health

Throughout the long history of government support for agricultural research, a number of federal and combined federal-state programs have been created to support the livestock industry either through regulatory activity or research. Agencies with primarily regulatory responsibility, such as the Food Safety and Inspection Service (FSIS) and the Animal and Plant Health Inspection Service (APHIS), provide surveillance to ensure that foreign animal diseases are not introduced into the nation's livestock and that the consumer is assured of safe, wholesome animal food products. The limited research done in these agencies is directed specifically toward improving their primary surveillance functions, and this research is essential.

The Agricultural Research Service (ARS) of the U.S. Department of Agriculture (USDA) maintains and administers a network of federally funded laboratories dedicated to animal health and disease research on problems of national concern. The activity of ARS represents the most significant component of animal disease research carried out at nonuniversity affiliated laboratories in the United States.

The Cooperative State Research Service (CSRS) of the USDA administers those animal health and disease research programs involved in the federal-state research partnership; namely the Hatch Act Program, the Animal Health and Disease Research Program (Section 1433), the Evans-Allen Program, and the Animal Health Special Research Grants Program. These programs apply federal research dollars to research activities carried out in state-supported academic institutions, which represents an efficient use of federal funds. These programs, in general, are responsive to local and regional animal disease problems, draw on the talents and resources of a national network of university based scientists, and encourage flexibility and innovation in problem solving at a reasonable cost. A critical evaluation of these federal-state partnership CSRS programs is the focus of this report.

### LIVESTOCK AND POULTRY AT RISK

The number and value of livestock and poultry in the United States are impressive. Table 2-1 indicates U.S. livestock inventories for 1983 or 1984, and Table 2-2 shows the value of products from these animals for 1983.

### THE COSTS OF ANIMAL DISEASES

Death losses significantly affect animal agriculture. The USDA 1985 Fact Book of U.S. Agriculture estimates (in Tables 23-25) that in

TABLE 2-1 U.S. Livestock Inventories for 1983 or 1984

Livestock	Number	Value <sup>a</sup> (\$, thousands)
Cattle and calves (1984)	114,040,000	45,119,309
Hogs and pigs (1983)	55,819,000	3,288,826
Sheep and lambs (1984)	11,411,000	594,457
Chickens, nonbroilers (1983)	364,584,000	716,192
Chickens, broilers (1983)	4,183,660,000	--
Turkeys (1983)	169,768,000	--
Horses (1984)	8,463,000 <sup>b</sup>	--
Milk cows and heifers, calves and replacements (1984)	15,681,000	--

<sup>a</sup>Value equals the number of livestock times the price per head.

<sup>b</sup>National Horse Council estimate.

SOURCE: USDA (1984d).

1983, disease killed 1,880,000 cattle, plus 3,621,000 calves, 4,958,000 hogs, 682,000 sheep, and 942,000 lambs (USDA, 1984c). However, even greater than death losses are losses in production efficiency that result from a broad and serious range of animal health problems, although these are much more difficult to identify and quantify. Collecting data on these losses is not possible in any systematic nationwide manner because the United States does not have a national animal morbidity and mortality reporting system. APHIS has developed a pilot National Animal Disease Surveillance (NADS) system that has been in operation in several states on a trial basis, but it will be at least 5 years before the system is operational nationwide. In the meantime, the consequences of animal diseases in the livestock, poultry, and aquaculture industries can only be estimated based on experimental data, state diagnostic laboratories, and clinical experiences.

### Beef and Dairy Cattle

Ten years ago, USDA estimated that cattle death losses from diseases exceeded \$4.6 billion annually. Since then, nothing has changed. Production losses associated with subclinical disease; loss of export business due to infection with some viruses, notably bluetongue and bovine leukosis viruses; and condemnation at slaughter would raise this figure significantly.

Over the years, changes in management practices have complicated respiratory, enteric, metabolic, and reproductive diseases in U.S. beef



and dairy cattle. These changes include increased herd sizes with associated crowding, emphasis on more rapid weight gain and higher milk production, and alternate sources of animal nutrition.

Mastitis causes the greatest economic inefficiency in U.S. animal agriculture. Recent studies show that economic losses to dairy farmers caused by mastitis average \$180 per cow per year, or more than \$2 billion annually. In dairy herds with clinical mastitis, losses may exceed \$300 per cow; however, approximately 70 percent of all losses come from decreased production caused by undetected, subclinical mastitis. In addition to the economic losses, mastitis causes significant problems with milk quality; dairy manufacturing practices; nutritional quality; antibiotic residue in milk, meat, and the environment; public health; and premature loss of excellent genetic stock. The major public health concern is focused on outbreaks of salmonellosis and listeriosis that have resulted from improperly processed contaminated milk.

The annual economic loss due to mortality caused by bovine respiratory tract disease of beef and dairy cattle is estimated to be between \$200 million and \$400 million annually. Losses from subclinical, chronic respiratory diseases cannot be determined, but clinical impressions suggest that 50 percent or more of cattle less than a year of age suffer from some form of respiratory disease.

Reproductive disease losses of beef and dairy cattle have been estimated to exceed \$1 billion annually, and are a constant problem for every farmer, especially in the dairy industry.

TABLE 2-2 Value of U.S. Livestock Production 1983<sup>a</sup>

Livestock	Value (\$, thousands)
Cattle and calves	22,073,689
Milk (farm value)	19,129,098
Hogs	9,808,405
Chickens	5,017,867
Turkeys	1,261,311
Eggs	3,464,502
Sheep and lambs	351,924
Fish	350,000
Wool	61,460
Mohair	42,930

<sup>a</sup>Value equals the amount of the commodity sold times the average price received by the farmers.

SOURCE: USDA (1984d).

Enteric diseases of beef and dairy calves are estimated to cause \$70 million in deaths annually and uncalculable losses from decreased weight gain in affected calves that do not die. Estimates of losses from Johne's disease, an enteric disease of adult cattle, may be as high as \$100 per cow when infection is endemic in a herd. It has been suggested that Johne's disease is present in up to 25 percent of all cattle herds.

Losses due to immunologic disorders of beef and dairy cattle during the first 6 months of life, the age at which the highest mortality occurs, are impossible to calculate, but may account for most of the losses attributed to infectious disease for animals in this age group. Examples include failure of passive transfer of colostrum antibody; age-related immunologic immaturity; and nutritional, environmental, and viral immunosuppression.

### Swine

The National Pork Producers Council (NPPC) estimates that 10 percent of their product's value is lost to disease, causing about a billion dollar loss annually in a \$10 billion industry. Production losses associated with subclinical swine diseases are not included in this figure. Twenty-five percent of all pigs die before weaning, and this statistic has not improved significantly in the past 25 years. Vaccines for some diseases either are not available or are only partially effective. The most important areas of loss are reported from respiratory infections--\$400 million, reproductive disorders--\$200 million, nematodiasis--\$242 million, enteric infections--\$214 million, and mastitis-metritis-agalactia--\$100 million (USDA, 1976).

Swine producers have attempted to maintain their income by increasing the numbers of marketed hogs. However, concentration of swine enormously magnifies disease losses, especially those of the respiratory, enteric, and reproductive systems. There is global concern in animal agriculture about these so-called "production diseases." Unfortunately, understanding of these diseases is insufficient to provide producers with effective preventive or therapeutic measures.

### Poultry

USDA estimates that poultry disease losses are approaching \$2 billion annually. Respiratory diseases account for \$500 million in losses, skeletal diseases cost \$300 million, immunodeficiency mediated diseases cost \$200 million, and neoplastic diseases cost \$153 million.

The poultry industry spends about \$100 million per year to prevent coccidiosis, either through prophylactic medication or by a crude system of vaccination using live, virulent parasites. The effects of this disease reduce the value of production by another \$200 million per year.

Turkey production is an important segment of the \$10 billion poultry industry. Eight percent of young turkeys never reach market, and at processing there is a further 1.5 percent loss as a result of condemnations. About 80 percent of the condemnations are related to disease problems in the flocks prior to marketing. The total loss from disease and management-related problems is estimated at \$150 million per year.

The 1983-1984 avian influenza outbreak in Pennsylvania, New Jersey, Maryland, and Virginia cost producers \$55 million, taxpayers \$60 million in indemnity payments and program costs, and consumers \$350 million for increases in the price of beef, pork, and poultry products. If the disease had spread throughout the entire eastern poultry region--the area east of the Mississippi River--producers could have lost \$500 million and consumers over \$5 billion (APHIS, 1984).

Losses from respiratory infections account for 25 percent of the mortality and morbidity losses in poultry. Respiratory disease outbreaks usually involve multiple infections. Large flocks, multiple ages, intensified rearing, and concentrated production all help achieve production efficiency, but they also provide opportunity for the rapid increase of multiple respiratory infections.

Losses from enteric infections account for 10 percent of the mortality and morbidity losses suffered during the production period. Enteric infections dramatically reduce feed efficiency through malabsorption of essential nutrients, resulting in many stunted birds. A number of viral agents of the intestinal tract have been identified, but the role of these agents in the malabsorption syndrome is not understood.

### Sheep and Goats

The sheep and goat industries account for smaller but nonetheless important commodities. Although the sheep census has declined over the last 30 years, the United States still has 12 million sheep and lambs providing wool and protein. The industry remains an important and viable segment of agriculture in many parts of the country. Renewed interest in lamb as an excellent source of lean animal protein has significantly increased the importance of this species for consumers. Losses attributed to disease and predators severely affect the profitability of this industry. For example, bluetongue, foot rot, chlamydia, polyarthritis, gastrointestinal parasites, caseous lymphadenitis, and pneumonia all cause significant losses to sheep producers.

Small farmers and ranchers in the United States have shown an increased interest in goats for milk, meat, cheese, and angora mohair products over the last 2 decades. Goats are the most important animal to subsistence farmers in Third World countries. Goat diseases are thus assuming increasing importance for both small and large producers in the United States as well as in Third World countries. The most important diseases leading to losses in productivity or death include

caseous lymphadenitis, gastrointestinal parasites, caprine arthritis-encephalitis, and abortion.

### Horses

Horses are plagued with a wide range of health problems, including respiratory diseases, parasites, laminitis, and others. Colic kills more mature horses than any other disease, causing millions of dollars in losses each year. Potomac horse fever, a deadly diarrheal disorder, is spreading rapidly from Maryland where it was first identified 5 years ago. Equine viral arteritis has been endemic in the United States for the past 30 years. Equine encephalitis is found throughout the United States, and contagious equine metritis has been found in horses imported from Europe. The costs of these diseases are not readily calculable because of the variability in the value of horses (value of a work horse versus a racing thoroughbred).

### Aquaculture

The aquaculture industry is the most rapidly growing livestock agricultural enterprise in the United States, and the growth of the catfish and crawfish industries has contributed greatly to this expansion during the last 10 years (Dupree and Huner, 1984). Total 1984 U.S. aquaculture production of all species was about 470 million pounds with a producer value of slightly over \$500 million. Total U.S. catfish production is about 240 million pounds. Mississippi and Alabama alone send 179 million pounds of catfish with a wholesale value of \$118 million to processing plants (USDA, 1985b).

U.S. trout production is approximately 50 million pounds, valued at \$54 million. Crawfish production is approximately 100 million pounds valued at \$50 million, of which crawfish farmers produce 60 million pounds valued at \$30 million. Other species, such as shrimp, oysters, lobster, mollusks, eel, Chinese carp, and bait fish, make up the remainder of the U.S. aquaculture production. Without national records available that tabulate losses of aquaculture animals to disease, it is difficult to measure the effects of disease on production; however, it has been estimated that 15 percent of all aquaculture production, valued at about \$75 million, is lost to infectious disease. The most important infectious diseases of aquacultural animals include viral, bacterial, and parasitic organisms.

### POTENTIAL ANIMAL HEALTH RESEARCHERS AND RESOURCES

If animal health research is to continue making progress in the future, a stable and experienced cadre of researchers will be necessary. One source of investigators is the animal scientists and veterinarians now teaching and doing research. They are employed in schools of medicine, veterinary medicine, dentistry, pharmacy, and

agriculture; in colleges of arts and science; in industry; and in such government agencies as USDA, the National Institutes of Health (NIH), and the Food and Drug Administration (FDA). The question is how to get and keep these researchers involved in the agricultural field.

Education in the animal sciences and veterinary medicine can provide skilled scientists. But without past research, teachers would have little to teach, and without current research, the future scientific base of animal health would be in jeopardy, resulting in serious detrimental effects to society. Graduate training in biomedical institutions, including veterinary schools, colleges of agriculture, and related science departments, is particularly important.

One indicator of how many scientists are interested in animal health issues is the number who compete each year for an Animal Health Special Research Grants award. During the 6 years of competition in the Animal Health Special Research Grants Program (1979-1984), 2,601 proposals have been submitted, and only 424 have received awards. In 1984, 416 animal health proposals were submitted, yet funds were available for only 67. In 1985, 446 proposals were submitted, and only 54 proposals could be funded. The 1985 success rate for funding of proposals was 12 percent compared to 16 percent in 1984. Based on quality of the research proposals, the peer review panels consider that many of the nonfunded proposals should be funded. Thus, the availability of scientists is far greater than is now being tapped.

Another indicator of the number of scientists interested in animal health research is the Competitive Research Grants Program. In FY 1985, this program received 519 proposals, and 87 were funded in the animal science and biotechnology area. Of these, approximately 50 percent were for animal health research. The success rate of funded projects was 17 percent. An equal number of nonfunded proposals was considered by the review panels to be of high quality and suitable for funding. For comparison, the success rate in other competitive programs is much higher. NIH funds 35 percent of the total grant applications received and the National Science Foundation (Division of Cellular Biosciences) funds approximately 30 percent of the total grant applications received.

### ANIMAL HEALTH RESEARCH PROGRAMS: A DESCRIPTION

Agricultural research, and in particular animal health research, is conducted by a number of government agencies, by state institutions, and by the private sector. Most support for agriculture research comes from federal programs, state appropriations, sale of products by the state agricultural experiment stations, and industry. Sources of funds to state agricultural experiment stations (SAES) and other institutions for all agricultural research in fiscal year (FY) 1983 are summarized in Table 3-1.

Animal health research receives a minor part (about \$22 million from the Cooperative State Research Service [CSRS]) of the total agricultural research funding and is discussed in more detail below and in Chapters 4 and 5. This chapter describes the various agencies and institutions involved in animal health research. Chapter 4 provides details on the status of programs, and the institutional impacts of the programs. Chapter 5 evaluates the success of the various programs in meeting their goals and objectives.

#### ANIMAL HEALTH RESEARCH PROGRAMS IN THE USDA

Animal health research programs in the U.S. Department of Agriculture (USDA) are carried out in five main units--the CSRS, the Office of Grants and Program Systems (OGPS), the Agricultural Research Service (ARS), the Animal and Plant Health Inspection Service (APHIS), and the Food Safety and Inspection Service (FSIS). These agencies provide the knowledge and regulations for controlling and eradicating livestock and poultry diseases and for providing the consumer with a safe and wholesome food supply.

#### Cooperative State Research Service

Publicly supported agricultural research is conducted in a relatively centralized system, principally in USDA, coupled with a decentralized system of research in the states. The focal point for the federal-state partnership is the CSRS, the federal agency that administers USDA funds appropriated by Congress for agricultural research in the states and facilitates communication and planning with states and other federal

**TABLE 3-1 Sources of Funds to State Agricultural Experiment Stations and Universities for Agricultural Research, FY 1983**

Source of Funds	Amount (\$, thousands)
Cooperative State Research Service	204,878
USDA (contracts, grants, cooperative agreements)	38,924
Other federal (other than USDA)	95,198
State appropriations	576,514
Product sales	65,378
Industry	66,668
Other (nonfederal sources)	49,106
<b>Total</b>	<b>1,096,666</b>

SOURCE: USDA (1984e).

agencies (ESCOPE, and CSRS, 1984). A system of federal-state cooperative research in agriculture has evolved since Congress enacted the Hatch Act in 1887. This system includes 6 USDA units, 56 state agricultural experiment stations, 28 colleges and schools of veterinary medicine, 61 schools of forestry, and 16 land-grant colleges of 1890 and Tuskegee University.

Continued participation by state institutions has been made possible through a series of laws: (1) the Hatch Experiment Station Act as amended in 1955 (P.L. 84-352); (2) the McIntire-Stennis Cooperative Forestry Research Act (P.L. 87-788); (3) several provisions under P.L. 95-113 including the Evans-Allen Program (Section 1445), the Animal Health and Disease Research Program (Section 1433), the Competitive Research Grants Program (Section 1414(b)), and the Animal Health and Disease Research on National or Regional Problems (Section 1434); (4) the Animal Health Special Research Grants Program (P.L. 89-106 as amended by P.L. 95-113, Section 1414(c)(1)); (5) the Experiment Station Facilities Act (P.L. 88-74); and (6) the Rural Development Act of 1972, Title V (P.L. 92-419). Administration of the Animal Health and Disease Research Program (Section 1433) and the Animal Health Special Research Grants Program (Section 1414(c)(1)) is under the guidance of the Animal Health Science Research Advisory Board.

#### **Animal Health Science Research Advisory Board**

The Animal Health Science Research Advisory Board was established in 1977 by P.L. 95-113 Subtitle E, Title XIV, "to consult with and

advise the Secretary with respect to the implementation of this subtitle and to recommend immediate priorities for the conduct of research programs authorized under this subtitle, under such rules and procedures for conducting business as the Secretary shall, in the Secretary's discretion, prescribe." This includes two programs authorizing extramural, federal support for animal health research--Section 1433, the Animal Health and Disease Research Program, and Section 1414(c)(1), Special Research Grants for animal health.

The board provides CSRS with recommendations for administering the Section 1433 Program. It helps set the scope and priorities of eligible research, helps determine the research capacity of eligible institutions, and answers other questions on program administration. The board emphasizes research for the solution of high-priority diseases or other animal health hazards in the production of livestock, poultry, and aquaculture species. Board membership is described in Appendix A.

Eligible diseases and the priority given various topics within the Special Research Grants Program are identified annually by the board, which relies on recommendations from national livestock and poultry commodity organizations and other groups concerned with animal health. The board also makes recommendations on the distribution of funds among the different commodities.

#### Hatch Act Program

The Hatch Act Program is the largest formula research program administered by CSRS and includes all areas of agricultural research. The program was established by Congress in 1887 to encourage the development of centers for agricultural research in the state land-grant colleges or, in some cases, agricultural experiment stations. Hatch Act funds are distributed largely on the basis of the states' rural and farm populations. The program places responsibility for administration of funds and program under a director at each eligible institution. Research subjects and level of funding for each institution are the responsibilities of the director. Some institutions include a local peer review process for research proposals, with final approval required in CSRS before expenditures can be allowed. Schools of veterinary medicine participate to a limited degree in the Hatch program because of local administrative decisions or because they are located at noneligible institutions.

In 1985 approximately 6 percent of Hatch funds were used for animal health research. About 25 percent of the total Hatch funds must be used in "regional research" projects. This program provides a mechanism for joint research planning and exchange of research information on problems common to two or more states. In 1985 there were 12 regional research projects concerned with animal health problems, with the number of states participating in each ranging from 8 to 17. The ARS participates in most of these projects, and the APHIS participates in several.



## Evans-Allen Program

This program was initiated in 1967 under P.L. 89-106, the Special Research Grants Program, to support agricultural research in the land-grant colleges of 1890 and Tuskegee Institute (now Tuskegee University). In 1972, funds under P.L. 89-106 were earmarked for these colleges on a formula basis. The Food and Agriculture Act of 1977 (P.L. 95-113, Section 1445) provided a formula program that is now used to support agricultural research in 17 colleges of 1890 and Tuskegee University. Administration of funds and program is similar to that discussed under the Hatch Act Program. A research director has program responsibility at each institution.

## Animal Health and Disease Research Program: Section 1433

This program earmarks funds specifically for animal health research in eligible institutions. Efforts to establish such a program were begun in the early 1970s because there was a need for greater emphasis on animal health research and a need to establish a stable, continuing base of support in schools of veterinary medicine and agricultural experiment stations. The Food and Agriculture Act of 1977, P.L. 95-113, Subtitle E, was enacted to authorize the current program. Amendments were made in the Agriculture and Food Act of 1981 that limited eligible institutions to state agricultural experiment stations and to schools of veterinary medicine. An earlier authorization had defined eligibility to include any college or university having a department of veterinary science or animal pathology. Funds were first appropriated in FY 1979 and have continued yearly. Administrative requirements are similar to the Hatch Act Program.

The formula provisions in Section 1433 are unique in that funds are distributed to the states in relation to a state's livestock importance and its capacity to conduct animal health and disease research. Livestock importance is measured by USDA data on livestock "income" and "value." Animal health research capacity is measured by expenditures and scientist years in animal health research at the eligible institutions. When more than one eligible institution exists within a state, the state's entitlement is distributed to these institutions in accordance with their animal health research capacities. State contributions to expand animal health research are encouraged; each state is required to match any Section 1433 funds received annually in excess of \$100,000.

This program differs from the Hatch Act Program and other CSRS formula programs because it restricts research to diseases and pests affecting food animals (including aquaculture) and horses; to wildlife diseases that endanger livestock production; to animal diseases transmissible to humans; and to the control of livestock predators.

Currently, 67 institutions are eligible to receive funds under the Section 1433 Program. These include 39 state agricultural experiment stations and 16 schools of veterinary medicine qualifying individually,

plus 12 such stations and 12 schools of veterinary medicine qualifying as combined institutions.

#### **Animal Health Special Research Grants Program**

Appropriations under P.L. 89-106 have generally been made for research on specific agricultural problems and may be awarded competitively or through a negotiated process. Funds for animal health were first appropriated in 1965 for bovine leukemia. Other disease areas that received funds in the early stages of this program include salmonellosis of poultry, agalactia of swine, and bovine respiratory disease.

P.L. 89-106 was amended by the Food and Agriculture Act of 1977 (P.L. 95-113) to provide several different kinds of grant programs. Under Section 1414(c)(1), competitive Special Research Grants are authorized, and substantial funding for animal health was appropriated beginning in FY 1979. Nearly all animal health research awards have been made in a competitive, peer review process. Specific eligible diseases and the amount of available funds allocated for each is determined by the Animal Health Science Research Advisory Board.

Research proposals are sought for fundamental and innovative approaches to resolving program problem areas established by the Animal Health Sciences Research Advisory Board. The proposals are reviewed and rated by one of six peer review panels.

#### **Office of Grants and Program Systems**

##### **Competitive Research Grants Program**

This program was authorized in the present form by the Food and Agriculture Act of 1977, Section 1414(b). Prior to FY 1985, funds were appropriated only for certain basic research areas of plant science and human nutrition. In 1985, funds were appropriated for brucellosis research (\$500,000), and other possibilities for funding animal health research exist in the areas of biotechnology and animal science. The Competitive Research Grants Program was initiated to increase basic research knowledge in important agricultural areas and to enlist participation by outstanding scientists from throughout the country, regardless of institutional affiliation.

#### **Animal and Plant Health Inspection Service**

The basic mission of USDA's APHIS is to protect the animal and plant resources of the nation from disease and pests. APHIS's programs are national and international in scope and encourage cooperation among states, nations, the federal government, and industry. Major functions include preventing the introduction of foreign diseases and pests, preventing the interstate spread of diseases and pests, and protecting

the marketability and exportability of U.S. agricultural products. Basic activities are carried out by (1) port-of-entry interception effort, (2) domestic surveillance and detection, (3) emergency response capability, (4) domestic disease control and pest control, (5) specialized technical support, (6) biologics regulation, and (7) international cooperation and coordination (USDA, 1984c). In FY 1985 extramural research for specific program-related studies was handled under eight cooperative agreements and three grant awards.

### Agricultural Research Service

The mission of the ARS is to plan, develop, and implement research that is designed to produce the new knowledge and technologies required to assure the continuing vitality of the nation's food and agricultural enterprise. As a federal research agency, ARS (1) addresses problems that are of legitimate national concern, (2) conducts research that is appropriate for the federal government, and (3) exploits the unique capabilities of ARS scientists and the facilities they operate--a combination that forms an integrated and coordinated national resource that is not duplicated by others in the U.S. agricultural research and development system (USDA, 1983b).

ARS is the largest agricultural research organization in the world with an annual budget of about \$550 million in FY 1986. ARS has more than 8,500 employees working at 132 different locations in the United States and in 8 foreign countries. About one-third of these employees (3,189) are research scientists and engineers; the remainder are technicians, laboratory assistants, and support personnel. Many of the scientists are located at the 10 major ARS agricultural research centers: Eastern Regional Research Center, Philadelphia, Pennsylvania; Northern Regional Research Center, Peoria, Illinois; Southern Regional Research Center, New Orleans, Louisiana; Western Regional Research Center, Albany, California; Beltsville Agricultural Research Center, Beltsville, Maryland; National Animal Disease Center, Ames, Iowa; Plum Island Disease Center, Plum Island, New York; Richard B. Russell Research Center, Athens, Georgia; Roman L. Hruska U.S. Meat Animal Research Center, Clay Center, Nebraska; and Jamie Whitten Delta States Research Center, Stoneville, Mississippi.

Numerous small ARS laboratories are located throughout the United States. There are five major human nutrition research centers, which are located at Beltsville, Maryland; Boston, Massachusetts; Grand Forks, North Dakota; Houston, Texas; and San Francisco, California. The remainder of the scientists and engineers are in research locations at or near universities scattered throughout the continental United States, Alaska, and Hawaii. These research locations often consist of one or more scientists who work closely with university scientists on problems of regional or national importance.

Animal health research is supported by direct funds to the research laboratories and by extramural agreements and grants. For FY 1986, ARS has allocated \$56 million for in-house and cooperative research on animal diseases, parasites, and toxicants affecting animal health. In

FY 1985, approximately 150 cooperative agreements and grants were awarded for extramural research in two program areas: (1) to prevent or control losses from disease, parasites, toxicants, and other substances that limit performance and reduce the quality of animal products; and (2) to control insects, ticks, and mites that affect animals and man.

### Food Safety and Inspection Service

The FSIS assures that meat and poultry products moving in interstate and foreign commerce for use as human food are safe, wholesome, and accurately labeled. The agency has five major program units: Meat and Poultry Inspection Operations, Meat and Poultry Inspection Technical Services, Science, International Programs, and Administrative Management (USDA, 1984b). FSIS administers Memoranda of Understanding (MOU) for research with other government agencies and cooperative agreements for extramural research with other organizations and universities.

### ANIMAL HEALTH RESEARCH PROGRAMS IN OTHER AGENCIES

#### Food and Drug Administration

Within the Food and Drug Administration (FDA), the primary mission of the Division of Veterinary Medical Research is to develop and communicate scientific data to the Center for Veterinary Medicine to support its regulatory decisions concerning the safety and efficacy of veterinary drugs. The division funds extramural research on minor use animal drug development, on aflatoxin in food-producing animals, on comparative drug metabolism in fish, and on animal nutrition. It also sponsors various symposia and the animal drug compendium.

#### National Science Foundation and National Institutes of Health

In 1950, Congress established the National Science Foundation (NSF) with the primary purpose of fostering and supporting basic research in the United States. Even though NSF is one of the largest funding agencies of basic research, it does not fund animal health research. However, some of the basic research in physiology and cellular and molecular biology may have an impact on animal health research.

The National Institutes of Health (NIH), like NSF, is a major national agency that funds basic research. NIH is primarily concerned with research for human health; however, livestock and poultry are sometimes used in the research, and the information gained from this research may influence and benefit animal health research.

**TABLE 3-2 FY 1983 Funding of Animal Health Research Problem Areas by State Appropriations and Product Sales**

<b>Research Problem Areas</b>	<b>State Appropriations (\$)</b>	<b>Product Sales<sup>a</sup> (\$)</b>
Control of animal pests	2,590,000	206,000
Control of animal diseases	35,144,000	4,860,000
Control of internal parasites	3,397,000	256,000
Protection of animals from toxicants	3,797,000	576,000
Transmission of animal disease to humans	506,000	277,000

<sup>a</sup>Money returned to research.

SOURCE: USDA (1984e).

#### STATE APPROPRIATIONS FOR ANIMAL HEALTH RESEARCH

Animal health research in state colleges and universities is also supported by state appropriations. The CSRS compiles annual statistical tables on research conducted by USDA, SAES, forestry schools, colleges of 1890 and Tuskegee University, schools of veterinary medicine, and other institutions. The tables are published in the Inventory of Agricultural Research. The amount and distribution of FY 1983 animal health research funds for SAES and other institutions are summarized in Table 3-2. Other research problem areas may include some topics related to animal health research, such as animal reproduction, but these are not included because of the difficulty in separating out the animal health research component.

#### ANIMAL HEALTH PROGRAMS IN THE PRIVATE SECTOR

Research on animal health is carried out by industries in their own laboratories, by funding research through contracts, or by collaboration with scientists in colleges and universities. Research in colleges and universities is also funded by foundations and by commodity groups and trade associations.

**TABLE 3-3 FY 1983 Funding of Animal Health Research Problem Areas by Industry**

<b>Problem Area</b>	<b>Funds (\$)</b>
Control of animal pests	283,000
Control of animal diseases	3,387,000
Control of internal parasites	505,000
Protection of animals from toxicants	293,000
Transmission of animal disease to humans	254,000

SOURCE: USDA (1984e).

### Industry

The basic mission of animal health research in the private sector is to develop marketable products for profit. In the United States, total sales of animal health products exceed \$2 billion, with worldwide sales greater than \$5 billion. Examples of products include antibiotics, feed additives, vaccines, hormones, growth promoters, and anthelmintics.

Animal health research is conducted by hundreds of companies worldwide, ranging from small local enterprises to large multinational corporations. Research is conducted mainly by in-house scientific investigators, and the projects are selected according to such criteria as technical feasibility, total and available market potential, compatibility with corporate purpose and companion products, regulatory barriers, benefits to society, competitive products, and the cost of research versus expected return. Research generally uses existing technologies. Pure research, where no product application can be envisioned for many years, is rare. However, private corporations are critically dependent on the long-term, basic research conducted at universities, colleges, and research institutions.

Industry supports animal health research in the state agricultural experiment stations in the research problem areas most relevant to animal health as summarized in Table 3-3.

### Foundations

Several foundations support research on animal health. The Morris Animal Foundation supports research on companion animals--dogs, cats, and horses--and zoo animals. For the year ending April 30, 1985, the Morris Animal Foundation distributed \$492,593 for research. The Harold

Wetterberg Foundation provides support for animal health and nutrition of cattle. Two other foundations, the Robert J. Kleberg and Helen C. Kleberg Foundation and the Geraldine R. Dodge Foundation, have funded several projects related to animal health. There are other foundations that fund special research areas.

#### Commodity Groups and Trade Associations

Several commodity groups and trade associations have formed foundations to administer research grants in their specialty area, for example, the Guernsey Research Foundation and the National Cattlemen's Foundation. Other commodity groups and trade associations administer research grants directly, for example, the National Association of Animal Breeders, the National Pork Producers Council, the Southeastern Poultry and Egg Association, and the Catfish Farmers of America.

**COOPERATIVE STATE RESEARCH SERVICE AND OFFICE OF GRANTS AND PROGRAM  
SYSTEMS ANIMAL HEALTH RESEARCH PROGRAMS: A STATUS REPORT**

Animal health research is supported by four Cooperative State Research Service (CSRS) programs: Hatch Act Program, Evans-Allen Program, Section 1433 Program, and the Animal Health Special Research Grants Program. The National and Regional Grant Program (Section 1434) was authorized in 1977, but has not been funded. Animal health research is also funded from the Competitive Research Grants Program administered by the Office of Grants and Program Systems (OGPS). Table 4-1 indicates the funding level of the five programs for the years 1975 and 1979 to 1985.

**STATUS OF CSRS PROGRAMS**

**Hatch Act Program**

In 1985, \$9.3 million of Hatch funds were allocated to support animal health research. This amount represents approximately 6 percent of the total Hatch budget. One-third of these funds, approximately \$3.1 million, went directly to schools of veterinary medicine. The remainder was distributed by state agricultural experiment stations to animal health-related programs in veterinary schools and departments of animal and veterinary sciences.

Since the inception of the Animal Health Special Research Grants Program and the Section 1433 Program, the amount of Hatch funding dedicated to animal health research has increased steadily between 1975 and 1985, from \$3.7 million to \$9.3 million. This is attributed in part to society's greater awareness of the importance of animal health research. It is also a result of inflation and the increased cost of contemporary research. The availability of new formula funds and competitive research monies has stimulated additional researchers to turn their attention to animal health problems, and this has led to the documentation of additional problems.

Hatch funds provide a small but stable base for animal health research. They help maintain a foundation from which scientists can research problems on a long-term basis as well as explore other funding sources. A majority of these funds are devoted to faculty salaries and support for long-term projects. Hatch funds support research that may



**TABLE 4-1 Animal Health Research Funding by Programs**

Program	Funding (\$, thousands)							
	FY 1975	FY 1979	FY 1980	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985
Hatch <sup>a</sup>	3,724	6,726	7,077	7,589	8,775	8,972	9,151*	9,367*
Evans-Allen <sup>b</sup>	241	431	403	447	150	166	169*	173*
Special Research Grants <sup>c</sup>	0	10,000	7,000	5,050	7,156	7,156	7,156	6,000
Section 1433	0	5,000	6,000	6,500	5,760	5,760	5,760	5,760
Competitive Research Grants <sup>d</sup>	0	0	0	0	0	0	0	6,000**
<b>Total</b>	<b>3,965</b>	<b>22,157</b>	<b>20,480</b>	<b>19,586</b>	<b>21,841</b>	<b>22,054</b>	<b>22,236</b>	<b>27,300</b>

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<sup>a</sup>Funds expended; program established in 1887.

<sup>b</sup>Funds expended; program authorized in 1967.

<sup>c</sup>Funds appropriated.

<sup>d</sup>Program authorized.

\*Estimate.

\*\*Approximate funds awarded to projects relating to animal health.

be difficult to fund under the Special Research Grants or Competitive Research Grants umbrella because it seems too "local" or long-term. In addition, Hatch funds facilitate collaborative efforts by providing a mechanism to develop regional research concepts.

#### Evans-Allen Program

The Evans-Allen Program was initiated in 1967 under P.L. 89-106, the Special Research Grants Program, to support agricultural research in the land-grant colleges of 1890 and Tuskegee University. In 1972, funds under P.L. 89-106 were earmarked for these colleges on a formula basis. The Food and Agriculture Act of 1977 (P.L. 95-113, Section 1445) provided a formula program that is now used to support agricultural research in these colleges. Funding of animal health research from the Evans-Allen Program has increased slowly from \$150,000 in 1982 to \$173,000 in 1985.

#### The Animal Health and Disease Research Program: Section 1433

Section 1433 of the Food and Agriculture Act of 1977 (P.L. 95-113) authorized a new source of federal appropriations for continuing animal health and disease research programs. These formula funds are distributed to the various states on the basis of a formula that accounts for both the animal health research capacity of each state, as well as the importance of livestock (income and value) in the state.

All 50 states and Puerto Rico have received funds through this program since the monies were first made available in 1979. The disbursements to each state are given in Appendix C, Table C-1. Eligible institutions in the various states include agricultural experiment stations and schools of veterinary medicine. The funds are disbursed as matching funds. Any state receiving over \$100,000 from this program must provide an equivalent amount of state support for animal health and disease research.

The original legislation allowed Congress to appropriate up to \$25 million for this program annually. However, funds allocated and distributed annually since 1979 have never exceeded \$6.5 million, which was the maximum distributed in 1981. Since 1982, the level has remained constant at an annual disbursement of \$5.76 million.

The stated purpose of the Section 1433 Program is to provide federal funds to improve the health and productivity of animals and the welfare of producers and consumers; to protect human health through control of animal diseases transmissible to people; to minimize poultry and livestock losses due to transport and handling; to facilitate the effective treatment and prevention of food animal and horse diseases; and to protect livestock and poultry from predators and the diseases of wildlife. To implement these goals, Section 1433 legislation designated that allocated funds be used to (1) meet the expenses of conducting animal health and disease research, (2) provide administrative planning and direction, and (3) purchase equipment and

supplies necessary to conduct appropriate research. The original legislation also called for the formation of a Science Advisory Board to set research priorities for the use of formula funds.

In practice, research priorities are set at the local level. To receive its annual appropriation, each eligible state institution submits an annual research program for review by the CSRS administration. If these local programs are broadly consistent with advisory board recommendations, then the programs are approved and funds are released to the eligible institution.

There is considerable variation among institutions as to how research programs are generated and funds are awarded. Increasingly, funds are made available to individual researchers at eligible institutions on a competitive basis, with in-house peer review panels deciding on the scientific merit of the proposals submitted. Researchers are free to determine their own areas of investigation. Alternatively, research staff and administrators may agree on common institutional goals, and then researchers compete for funds to support individual, but directed, research programs. Less often, formula fund allocations may be dispensed at the discretion of program administrators, either to specific research projects or for institutional needs, such as equipment purchases or creation of specialized laboratories.

#### The National and Regional Grants Program (Section 1434)

P.L. 95-113, enacted in 1977, authorized Section 1434 funds to support research on specific national or regional animal health or disease problems. Research to be undertaken would be mutually agreed on by the Secretary of Agriculture and eligible institutions. The Animal Health Science Research Advisory Board would develop plans for the use of the funds. Congressional and executive actions on agricultural appropriations for fiscal year (FY) 1979 made \$5 million available for distribution under Section 1434 or Section 1433 or both. The Animal Health Science Research Advisory Board recommended that none of these funds be used under Section 1434 in order to prevent undue diminution of Section 1433 funds to ineffective levels. The board also felt that the availability in FY 1979 of \$10 million for Special Research Grants in animal health research would accomplish a substantial part of the intentions of Section 1434 (Animal Health Science Research Advisory Board's 1978 Animal Report). Since 1978, no funds have been allocated for research under Section 1434.

#### Animal Health Special Research Grants Program

P.L. 89-106 was passed to provide appropriations for research on specific agricultural problems. An amendment to P.L. 89-106, the Food and Agriculture Act of 1977, was passed to provide several different kinds of grant programs. The Special Research Grants Program was authorized under Section 1414(c)(1), and funding for animal health

research was appropriated in substantial amounts beginning in FY 1979. Nearly all of the research awards have been made in a competitive, peer review process. Specific diseases of concern and the amount of available funds allocated for research on each are determined by the Animal Health Science Research Advisory Board.

During the 7 years of competition in the Animal Health Special Research Grants Program (1979-1985), there has been a total submission of 3,046 proposals requesting approximately \$400 million. Only 502 proposals (16 percent) have been funded, totaling approximately \$47.6 million. All colleges and universities having faculty scientists of appropriate expertise are eligible to receive awards under this program. Although federal scientists cannot be direct recipients of Special Research Grants, a number of projects have involved U.S. Department of Agriculture-Agricultural Research Service (USDA-ARS) scientists as research collaborators. The Special Research Grants Program has had a major impact on animal diseases.

#### STATUS OF OGPS PROGRAM

##### Competitive Research Grants Program

During FY 1985 the Competitive Research Grants Program administered by USDA's OGPS awarded standard grants and a small number of continuation grants to support basic research in selected areas of plant science, human nutrition, biotechnology, animal science, insect pest science, acid precipitation, soybean research, forest research, and alcohol fuels research. The program received 2,592 proposals, and 504 were funded for a total of \$51.7 million. Eighty-seven animal research projects were funded for a total of \$12.07 million. Approximately one-half of these proposals were for animal health research. The numbers of proposals and awards related to animal research are shown in Table 4-2.

#### INSTITUTIONAL IMPACTS OF THE PROGRAMS

Hatch, Evans-Allen, and Section 1433 formula funding programs have had considerable impact on institutional programs in animal health and have significantly enhanced the federal-state partnership in animal health research. These three formula funding programs have helped support research on common food animal problems using basic laboratory and clinical techniques, as well as limited field trials of ideas developed in the research laboratory. Funds also are used for local projects not readily funded by other agencies because of their local nature. Formula funds have been used to establish research laboratories and programs adding significantly to the overall research environment. For example, the College of Veterinary Medicine at the University of Illinois established laboratories for the study of leukocyte function (mastitis, uterine infections, respiratory disease) and drug assays (e.g., antibiotic assays) mainly based on formula funds.

**TABLE 4-2 FY 1985 Competitive Grants for Animal Research**

Area	Number of Proposals	Number of Grants Awarded	Amount Awarded (\$, millions)
<b>Animal sciences</b>			
Reproductive efficiency	176	21	3.81
Brucellosis	15	3	0.48
<b>Biotechnology</b>			
Animal growth and development	154	26	3.40
Animal molecular biology	174	37	4.38
<b>Total</b>	<b>519</b>	<b>87</b>	<b>12.07</b>

NOTE: The ratio of submitted versus funded proposals equals a 17 percent success rate.

The Section 1433 Program has been a major stimulus to faculty involvement in food animal health research at veterinary schools. The funds have been used to train young scientists by providing veterinary student and graduate student stipends, to start projects for new faculty, and to encourage established faculty to move into new areas of research. The funds have focused skilled scientific manpower on the animal health problems of today, attracted well-recognized guest researchers and postdoctoral fellows, and improved the ability to generate additional support from other sources. Since animal research is costly, formula money has been used to purchase laboratory supplies, animals, and equipment and thus provides base support for animal health research. Examples of research accomplishments from the Section 1433 Program at the University of California include the following:

- A highly sensitive enzyme linked immunosorbent assay (ELISA) has been developed for determining progesterone levels in plasma and milk samples of cattle. The ELISA system has been used to diagnose pregnancy or early embryonic deaths in cattle or both by analyzing milk samples.
- Monoclonal antibodies and ELISA systems have been developed for infectious bronchitis virus (IBV) of chickens. These highly sensitive systems are greatly increasing the ability to diagnose IBV-infected chickens through serologic tests as well as identification of virus-infected tissues.
- Human recombinant interleukin 2 (IL-2) has been found to have an immunopotentiating effect on cattle and pigs. This product appears to favorably enhance the immune response of animals. It has the potential of increasing the effectiveness of vaccines and of helping to curb certain infections.

COOPERATIVE STATE RESEARCH SERVICE ANIMAL HEALTH  
RESEARCH PROGRAMS: A CRITICAL EVALUATION

Each of the Cooperative State Research Service (CSRS) animal health research programs was initiated for different purposes, under varying circumstances, and at different times in history. However, despite their diverse origins, these programs address distinct needs in the total animal health research picture. The overall CSRS program functions in an unexpectedly efficient manner, addressing national, regional, and local needs in a well-integrated program. Research funds are awarded both competitively and by distribution through formula schemes. The efficiency of the system results from the fact that CSRS monies are applied to an existing base of physical and human resources already provided by state governments through their university system, the state agricultural experiment stations, and schools of veterinary medicine. Therefore, even though CSRS funds may appear small and inconsequential, they are actually valuable incremental dollars. Because the programs are complementary, their impacts and effectiveness are greater than might be expected.

OVERALL MISSION AND PLANNING

In evaluating the mission of the CSRS animal health research programs, the committee felt that the system needed to set stronger goals and objectives and develop evaluative criteria to assess the progress made in fulfilling the objectives. To ensure effective use of available animal research funds, a more thorough and coordinated long-range planning process is needed to administer all segments of the CSRS animal health research programs. This would require the development of clearly defined program objectives based on national and state needs as well as scientific merit. These plans and objectives must be coordinated with other agencies involved in animal health research, such as the Agricultural Research Service (ARS), the Animal and Plant Health Inspection Service (APHIS), the Food Safety and Inspection Service (FSIS), and the Food and Drug Administration (FDA).

To develop goals, objectives, and priorities for research, the Animal Health Science Research Advisory Board should seek greater direct guidance from the scientific community and producer groups.

Active researchers, including scientists with actual field-oriented research, as well as livestock producers could be invited to serve on the advisory board or be retained for short periods as consultants. Research scientists could attend board meetings to discuss progress in their research. Research priorities should be reviewed every 5 years and changed to reflect advances in technology and changes in research approaches.

Accountability of research programs is a must in today's society. Various methods can be used to assess accountability; the method currently used for the animal health and disease programs is the Current Research Information Service (CRIS) reports. But CRIS reports lack data that are important for assessing productivity. For instance, information on published research reports and statements of accomplishments are missing from CRIS reports.

The reactivation of a peer-reviewed, 5-year evaluation of local (state) program goals with written reports or site visits or both seems highly desirable. The benefits in the quality of science, increased productivity, and exchange of information would add substantially to the credence of CSRS programs. Such evaluations would help assure that funds are being placed in projects with the greatest potential impact on animal health issues. Program planning at the local and regional levels would help determine which research areas are in need of national attention. Local planning can force the establishment of objectives by which accomplishments and hence accountability can be measured. Continued federal support should be predicated on favorable compliance with program guidelines and the quality of the research.

Although the committee does recommend the establishment of long-range plans, it also believes that the animal health research programs must be flexible so that adjustments can be made in the distribution of program funds as priorities change. At the same time, commitments to invest in a problem for a reasonable length of time need to be assured. To carry out the long-range plans, CSRS must better communicate its needs and objectives with Congress, commodity groups, consumers, scientists, and other federal and state agencies.

#### CSRS ANIMAL HEALTH RESEARCH PROGRAMS

The various CSRS animal health research programs, even though initiated for different purposes, work effectively and complement each other. However, in reviewing the programs the committee found some weaknesses and saw numerous opportunities to strengthen the programs.

##### Hatch Act Program

A primary weakness of the Hatch Act Program is the inadequate funds devoted to the animal health area. Hatch funds devoted to this area currently total less than 6 percent of the Hatch budget. This small allocation is out of proportion to the importance of animal agriculture, the impact of disease on productivity, and the complexity

of problems to be solved. It would be impossible to carry out meaningful research with funds derived solely from the Hatch Program.

A second concern is that a majority of Hatch funds are committed to faculty salaries or personnel support. The faculty tenure system combined with departmental funding commitments results in inflexible research programs. This inflexibility makes it difficult to shift funds to new problem areas or to take advantage of emerging technology. Funds are often locked into programs that are no longer relevant, or they are committed to persons who are no longer at the cutting edge of scientific expertise.

Directors of agricultural experiment stations are under pressure from numerous constituencies to develop programs that serve their interests. This posturing of research to self-interest groups often leads to deviation from research program plans, as well as spreading of funding over too many areas, resulting in overall inadequate funding.

#### Evans-Allen Program

Support from the Evans-Allen Program for animal health research in 16 land-grant colleges of 1890 and Tuskegee University has been small, but it has provided some funds for research equipment, salaries, and supplies. The funds provide a necessary incentive for drawing competent scientists into animal health research. Because of the size of the program, it is difficult to evaluate its effectiveness in comparison with other CSRS animal health programs.

#### The Animal Health and Disease Research Program: Section 1433

This committee's investigations revealed a clear consensus in the animal health and disease research community that Section 1433 formula funds are needed, appreciated, and well used. This belief is echoed by the commodity groups representing livestock producers who recognize that formula funds are the most effective way to address health problems of a regional or local nature. The committee strongly believes that this source of federal funding for animal health and disease research is not redundant with other sources of funds, but rather is complementary. It is particularly critical to maintain quality research programs at the nation's schools of veterinary medicine. Formula funds fill a definite, well-defined niche in the overall network of funds available for animal health and disease research. Several distinct factors underscore this utility.

- Formula funds are distributed on a formula basis to institutions rather than to individual researchers on a competitive basis. This allows institutions some latitude in planning budgets and directing research and training programs. This also permits some administrative control and responsiveness to the needs of the institution, its staff, and the local and regional livestock industries they serve. The discretionary nature of these funds permits institutions to obtain



equipment necessary to develop new research capabilities and improved laboratory facilities so all researchers at the institution can benefit. Also, access to internally administered funds can be important for beginning research scientists or faculty who might otherwise have difficulty competing for extramural funds.

- All formula funds received under Section 1433 are committed expressly to animal health and disease research. Access to a source of funds committed expressly to animal health and disease research allows institutions to train graduate students for careers in animal health research. Further, it is advantageous to have access to funds that can be used totally to fund productive research and not to cover operational expenses or institutional overhead. And of course, receiving funds earmarked specifically for animal health research ensures that such work is done. This is in contrast to Hatch Act formula funds where the percentage of total funds received by an institution that is directed specifically toward animal-related research is at the discretion of the institutional administrators. In this context, it should be noted that with a continual annual increase in overall Hatch Program funding, the average national percentage of Hatch funds committed specifically to animal health and disease research has remained constant at approximately 6 percent of the total funds available.

- Formula funds represent an excellent investment of the federal research dollar. When institutions direct formula funds toward support of competitive research grants by staff researchers, virtually 100 percent of allocated funds goes directly to financing the research project. Overhead costs at participating institutions are absorbed primarily through state operating budgets and indirect cost assessments that are tacked onto research budgets funded through other extramural sources. Furthermore, provisions in the original legislation that authorized formula funds called for states receiving \$100,000 or more of these monies to match these amounts with state-appropriated dollars designated specifically for animal health research. Encouraging states to commit funds to animal health research through the incentive of matching federal dollars enhances the investment value of these federal research dollars.

Unfortunately, it appears that in practice many states do not actually match federal funds received with newly appropriated animal health research funds. Rather than appropriating new state dollars for animal health research, reallocation procedures are used to create the appearance of the required matching funds in eligible institutions. These procedures include the addition of faculty salaries and operating budgets in research accounting. These practices should be investigated and monitored by CSRS, and institutions not complying with the original intent of the formula fund legislation should be encouraged to seek appropriations for actual matching funds.

- The trend toward peer-reviewed competitive grant allocation of formula funds promotes research excellence. Despite the latitude administrators have for discretionary use and distribution of funds, institutions are increasingly awarding money to researchers on the basis of intramural, peer-reviewed evaluations of scientific merit.

This trend is no doubt encouraged by the example of the Special Research Grants and Competitive Research Grants programs in animal health and disease research, which require critical peer review. This committee believes that competition for funds and the peer review process help ensure that the best research possible is being performed with the dollars available. Section 1433 funds are also useful for developing pilot research projects in order to obtain preliminary results and thereby assess the feasibility of long-term research. This use of formula funds as "seed money" allows researchers to compete more successfully later for subsequent extramural funds.

In an effort to evaluate the quality of research performed with CSRS funds, as well as the impact of these monies on graduate training, this committee requested specific information on research and training accomplishments from 36 eligible state agricultural experiment stations and veterinary colleges. The responses were disappointing. Sixteen institutions did not respond at all or were unable to compile the requested information during the time permitted to respond. Four institutions suggested that the committee's request for such information was ill-conceived and referred the committee to CRIS reports. Sixteen institutions made a concerted effort to respond to the committee's questions, but the responses were variable in value. Through this exercise it became clear that virtually all eligible institutions depend heavily on the CRIS reporting system to do their bookkeeping on CSRS-funded research, a practice that is inappropriate. CRIS can do a serviceable job of cataloging research titles and maintaining accounts of dollar expenditures. However, very little detailed information is available in CRIS to identify concrete CSRS-funded research accomplishments, such as patentable discoveries, refereed publications, and graduate degrees awarded. It is essential that this type of information be maintained by institutions receiving CSRS funds and forwarded to CSRS in the form of an annual report if the CSRS administration and eligible recipient institutions are going to compete effectively for continued support for CSRS programs.

Several points were identified that undermine the effectiveness of the Section 1433 Program. These points include the following:

- Funding levels are inadequate to maximize the potential benefits of the program. Despite increasing numbers of veterinary colleges, animal disease researchers, and potential graduate students, as well as the ever increasing costs of doing research, the amount of available formula funds has remained static for the last 3 years at \$5.76 million. This level is 23 percent of the amount permitted in the original legislation.

In response to increased pressures for research dollars from expanding research staffs, some institution administrators have set ceilings on the total funds dispensed for each research grant funded from new annual Section 1433 allocations. This ceiling can be so low that even the most resourceful researcher is hard-pressed to produce substantive results in costly livestock research with such budget constraints.

- Annual funding is uncertain and therefore does not allow for efficient long-range planning. For the past several years, the Section 1433 Program has not been included in the original U.S. Department of Agriculture (USDA) budget submitted to Congress, and has only been included and approved later on in the course of budgetary debate and compromise. This process is particularly alarming to research administrators at eligible institutions who believe that the USDA, by virtue of not including the program in its original budget, sends a message to Congress that the program is expendable. Institution administrators are unable to undertake long-range planning of research programs based on formula funds when these funds appear to be in annual jeopardy.

- Current methods for dispensing funds promote inefficiency and impair productivity. Two important factors contribute to this problem. First is the annual delay in congressional approval of formula funds. Second is the federal requirement that all funds allocated in a specific year be expended or returned by the end of the federal fiscal year (FY), September 30. These two factors combined put severe financial and planning constraints on researchers receiving formula funds. In practice, monies received for carrying out a 12-month schedule of research activity are only available for 6 to 9 months. Since carryover of funds into the second or third year of an approved research project is not permitted, the system encourages inappropriate or unwise expenditure of funds each year as September 30 approaches.

In summary, Section 1433 formula funds were created with a well-defined purpose by act of Congress. These funds are greatly valued by the recipient institutions that appear to distribute them fairly, and, in general, use them appropriately and efficiently within the constraint of the law. Funds are directed toward research on local and regional animal health problems, on upgrading technological capabilities, on promoting the scientific development of faculty, and on graduate student training.

There is general agreement among eligible institutions that the level of annual funding needs to be increased to further improve research capacity and efficiency, that the annual availability of these funds needs to be made more certain to allow for long-range planning, and that the continuity of funding from year to year be improved so that ongoing research projects are not undermined by the requirements of federal accounting procedures.

#### National and Regional Grants Program: Section 1434

Funds for Section 1434 have not been appropriated since its authorization in 1977 despite the development of a number of animal disease problems that qualify as national or regional concerns. Among these serious disease outbreaks were the avian influenza epidemic in the Northeast; the spread of swine pseudorabies in the Upper Midwest; persistent vesicular stomatitis of cattle in the Rocky Mountain states; an increase of cattle brucellosis in the Southwest; a new disease,

Potomac Fever, among horses on the East Coast; the national concern for the increasing incidence of bovine paratuberculosis; and a near epidemic of enteric septicemia of catfish in the South. To the credit of animal scientists, veterinarians, and regulatory officials, many of these economically devastating disease problems have been brought under control. However, many important questions remain unanswered with regard to the origin, spread, detection, and therapy of these diseases. Only limited federal funds have been forthcoming to answer these complex questions.

In addition to disease problems, several highly controversial social issues related to the livestock industry have received wide public attention in recent years. These include the issue of antibiotic and other drug residues in animal food products, public concern over so-called factory farming methods, the use of animals in research and teaching, and the sociomedical aspects of the human-animal bond. The scientific community needs to be well represented in public forums dealing with these sensitive issues, and research dollars are urgently needed to provide answers to often emotionally charged questions relating to animals in our society.

One of the more pressing national concerns in animal agriculture today is the task of accurately determining the prevalence, types, and costs of clinical and subclinical diseases affecting livestock. Only through a careful, systematic analysis of disease trends and quantification of the economic losses due to animal disease can national research priorities be objectively established and research funds be appropriately and efficiently distributed.

Powerful new computer applications in animal agriculture are currently allowing a sophisticated level of animal disease surveillance previously unavailable to epidemiologists. Exploration of more extensive applications of computer science in the livestock industry is, in itself, an important area in need of research investigation. Section 1434 allocations could serve as an appropriate funding base for research into computer applications in animal agriculture. The epidemiologic and economic information derived from these research investigations could help government research agencies, such as CSRS, implement long-range planning of research activities and facilitate the more efficient use of limited research dollars.

#### Animal Health Special Research Grants Program

The Special Research Grants Program has certainly lived up to expectations that it would provide a focus for innovative and contemporary approaches to fundamental problems in animal health. This has happened despite the very modest funding levels assigned to it, and the correspondingly frail administrative system that CSRS could afford to implement and support the program. Within these constraints the program has adhered to the intent of the 1977 amendment to P.L. 89-106. The program has established processes for research priority selection and balance and for peer review of proposals, and the

resulting research output has been of a quality and quantity that more than justifies the hopes of this legislative initiative.

The committee's review of the Animal Health Science Research Advisory Board annual reports shows that a mechanism is in place to facilitate expert assessment of species/commodity-based priorities for research. The board's considerations clearly take into account views expressed by livestock producer organizations as well as by spokespersons from academia and industry. While it may now be time to broaden the scope of scientific input into the advisory process, the board's funding decisions over the past 6 years have fairly represented the range of opinions on disease priority areas within each species sector and the contributions of each commodity to livestock production as a whole. The resulting pattern of awards over the 1979-1985 period is shown in Table 5-1, including details about expenditures by commodity, disease, and numbers of projects.

The requisite peer review panels needed to review proposals have been assembled each year. Panel members have voluntarily assumed enormous workloads and great responsibility in the face of the intense competition created by the large numbers of proposals submitted each year. With scant time and minimal secretarial backup, panels have done their best to make fair judgments, but, understandably, they can offer little constructive feedback to unfunded investigators.

Grants have been awarded to individuals in a wide range of locations, and there is no evidence of geographical or institutional dominance. It is clear, however, that some colleges and departments have stronger cadres of research-minded investigators than do others. This is to be expected in a competitive process, and it appears to have given participants a greater awareness of the need for originality and initiative.

The committee's survey of project titles, objectives, and approaches was by necessity incomplete and was biased because of the more ready availability of information from the universities with which committee members were affiliated. Nevertheless, clear trends were evident that research was focused on the most important disease problems of each species. In many cases, research used appropriate contemporary technology and addressed questions that are fundamental to an understanding of disease processes and eventual construction of preventive or therapeutic strategies or both. Some more conventional but not unimaginative projects also have been supported in each area, and in certain cases the research approach was clearly shaped by the constraints of facilities and equipment.

There is ample evidence that projects funded by Special Research Grants draw on additional and complementary support from other sources at each institution. While this at times may make it more difficult to discover which research achievements are specifically attributable to the Special Research Grants Program, it is again an expected outcome since complementarity and matching of research support funds are the rule rather than the exception in most successful projects. Project personnel take advantage of links within and between institutions, and projects frequently involve cross-disciplinary collaborations. These collaborations sometimes reach between universities and experiment

TABLE 5-1 Animal Health Special Research Grant Awards, Fiscal Years 1979-1985

Commodity and Disease	1979-1982		1983		1984		1985		Total	
	Projects	Funds (\$)	Projects	Funds (\$)	Projects	Funds (\$)	Projects	Funds (\$)	Projects	Funds (\$)
<b>Beef cattle</b>										
Respiratory diseases	30	3,721,955	12	1,157,348	8	1,151,693	6	961,759	56	6,992,755
Reproductive diseases (including anestrus)	13	1,609,994	7	900,753	6	760,770	5	599,505	31	3,871,022
Enteric diseases	20	1,957,458	4	368,889	6	575,847	4	473,954	34	3,376,148
Metabolic diseases	5	436,350	0	--	0	--	0	--	5	436,350
Toxicosis	4	356,162	1	100,000	0	--	0	--	5	456,162
Bluetongue	4	506,207	0	--	1	103,000	1	139,303	6	748,510
Internal parasites	14	1,575,555	2	258,826	3	287,923	2	147,366	21	2,269,670
External parasites	8	801,717	2	139,600	1	51,634	1	100,000	12	1,092,951
Other diseases	2	100,920	0	--	0	--	0	--	2	100,920
Subtotal	100	11,066,318	28	2,925,416	25	2,930,867	19	2,421,887	172	19,344,488
<b>Dairy cattle</b>										
Mastitis	19	1,689,470	8	442,663	5	441,200	4	368,439	36	2,941,772
Respiratory diseases	6	490,945	2	188,653	2	189,085	2	157,902	12	1,026,585
Reproductive diseases (including anestrus)	16	1,699,129	2	213,772	4	378,171	2	298,316	24	2,589,388
Enteric diseases	6	340,138	2	203,544	1	126,057	2	210,536	11	880,275
Metabolic diseases	6	502,805	0	--	0	--	0	--	6	502,805
Bluetongue	0	--	1	132,414	0	--	0	--	1	132,414
Internal parasites	2	73,245	0	--	0	--	0	--	2	73,245
External parasites	1	58,500	0	--	0	--	0	--	1	58,500
Other diseases	2	259,837	1	50,000	1	74,123	0	--	4	384,260
Subtotal	58	5,114,069	16	1,231,046	13	1,208,936	10	1,035,193	97	8,589,244
<b>Swine</b>										
Enteric diseases	21	1,697,670	5	317,969	3	316,350	3	221,546	32	2,553,445
Respiratory diseases	7	645,529	3	317,969	3	316,350	2	225,455	15	1,505,303
Reproductive diseases	3	378,062	2	163,194	3	248,735	1	131,389	9	921,380
Pseudorabies	3	459,676	2	208,498	0	--	2	267,071	7	935,245
Mastitis metritis agalactin	5	374,779	2	154,083	1	98,851	0	--	8	627,713
Internal parasites	5	459,663	1	30,000	0	--	2	153,337	8	643,000
External parasites	2	187,980	0	--	0	--	0	--	2	187,980
Toxicosis	2	190,064	1	78,779	4	285,114	1	58,006	8	611,963
Skeletal diseases (lameness)	4	320,386	0	--	0	--	0	--	4	320,386
Subtotal	52	4,713,908	16	1,270,492	14	1,265,400	11	1,056,714	93	8,306,415

<b>Poultry</b>										
Respiratory diseases	26	1,739,173	6	454,450	4	352,358	4	356,656	40	2,902,637
Skeletal diseases	4	427,190	1	146,159	0	--	0	--	5	573,349
Enteric diseases	5	328,380	3	257,008	1	90,741	1	74,230	10	750,359
Neoplastic diseases (Including Marek's disease)	5	264,636	0	--	1	144,666	0	--	6	409,302
Internal parasites	3	337,850	0	--	0	266,414	1	68,432	4	406,282
Toxicosis	4	355,428	0	--	0	266,414	0	--	4	355,428
Other diseases	1	113,410	0	--	2	266,414	2	213,993	5	593,817
<b>Subtotal</b>	<b>48</b>	<b>3,566,067</b>	<b>10</b>	<b>857,617</b>	<b>8</b>	<b>854,179</b>	<b>8</b>	<b>713,311</b>	<b>74</b>	<b>5,991,174</b>
<b>Sheep and goats</b>										
Respiratory diseases	2	209,281	0	--	1	77,145	0	--	3	286,426
Predator control	6	382,404	0	--	0	--	0	--	6	382,404
Reproductive diseases	2	75,078	0	54,842	1	121,000	0	--	4	250,920
Bluetongue	1	60,000	1	100,000	1	122,000	1	120,316	4	402,316
Caseous lymphadenitis	3	244,337	0	--	0	--	1	147,031	4	391,368
Contagious ecthyma	1	147,063	0	--	0	--	0	--	1	147,063
Internal parasites	5	433,465	1	46,591	0	--	0	--	4	192,368
Other diseases	3	72,368	1	120,000	0	--	0	--	4	192,368
<b>Subtotal</b>	<b>23</b>	<b>1,623,996</b>	<b>4</b>	<b>321,433</b>	<b>3</b>	<b>320,145</b>	<b>2</b>	<b>267,347</b>	<b>32</b>	<b>2,532,921</b>
<b>Horses</b>										
Respiratory diseases	6	473,096	2	103,390	1	64,999	1	105,000	10	746,485
Enteric diseases	1	47,587	1	--	--	110,668	0	--	3	231,295
Musculoskeletal disease	3	317,799	0	--	1	148,201	0	--	4	466,000
Internal parasites	2	229,270	0	--	0	--	0	--	2	229,270
<b>Subtotal</b>	<b>12</b>	<b>1,067,752</b>	<b>3</b>	<b>214,058</b>	<b>2</b>	<b>213,200</b>	<b>2</b>	<b>178,040</b>	<b>19</b>	<b>1,673,050</b>
<b>Aquaculture</b>										
Infectious diseases	7	667,552	2	107,375	2	106,945	2	89,308	13	971,180
Parasites	2	170,777	0	--	0	--	0	--	2	170,777
<b>Subtotal</b>	<b>9</b>	<b>838,329</b>	<b>2</b>	<b>107,375</b>	<b>2</b>	<b>106,945</b>	<b>2</b>	<b>89,308</b>	<b>15</b>	<b>1,141,957</b>
<b>Total</b>	<b>302</b>	<b>\$27,990,340</b>	<b>79</b>	<b>\$6,927,437</b>	<b>67</b>	<b>\$6,899,672</b>	<b>54</b>	<b>\$5,761,800</b>	<b>502</b>	<b>\$47,579,249</b>

SOURCE: Animal Health Science Research Advisory Board, Sept. 18, 1985 (minutes).

stations, and occasionally to other USDA institutions. Such connections are not always easy to trace, but their advantages should not be overlooked where scarce resources need to be effectively deployed. It is the investigator's responsibility to develop sound collaborations, but CSRS has an indirect responsibility to recognize and reward the enhanced research output during its evaluation.

Researchers are not required to identify Special Research Grants support in their research publications, and hence the program's productivity may be underrecognized; this contributes to the difficulty in evaluating the program's impact. Conversely, CSRS's evaluation of project output does not seem to pay significant attention to the display of research productivity that is shown when researchers publish in refereed journals. However, administrative reports on Special Research Grants contributions from a sample of institutions left no doubt about the quality of output. The reports also make clear the degree to which these funds have helped attract and involve young investigators in modern approaches to animal health research, and in the competitive peer review process.

It is expensive to involve professionally qualified scientists and to implement experimental systems with livestock. Thus, the quality of research is constrained by the current budget ceiling on awards. It is also important for peer review panels to strive for continuity of support for productive programs. In the past there has been evidence of a bias in favor of supporting new investigators rather than maintaining funding for established projects. This bias is perhaps a reflection of the intense competition and an unarticulated desire to ensure wide distribution of support, but it is nonetheless unfortunate.

In spite of its brief existence, the Special Research Grants Program has supported research that shows promise of improving animal health in the future. More details on the particular commodities are presented in the following sections.

### Beef and Dairy Cattle

Cattle are the largest livestock commodity of any species on a weight basis. Thus, cattle account for the majority of dollars received annually for sales of livestock and poultry. Cattle research receives 60 percent of the funds available in the Special Research Grants Program, a percentage below the actual contribution cattle make to total sales of livestock, yet representative of the overall importance of cattle research. The research community appears to be in relative agreement on the appropriate percentage of funds awarded to cattle research. Likewise, the American Veterinary Medical Association, the National Milk Producers Federation, and the National Cattlemen's Association appear to be in good agreement on the major important diseases in the cattle industry. The priority disease areas and dollars awarded for cattle research include respiratory disease complex (\$8.0 million), reproductive diseases (\$6.5 million), enteric diseases (\$4.3 million), and parasitic diseases (\$3.5 million). Dairy cattle research priorities also include mastitis and Johne's disease.



Bovine Respiratory Diseases Complex (BRDC) Since the inception of the Special Research Grants Program in 1979, bovine respiratory diseases have been identified as the major problem facing the cattle industry. Of the 269 cattle projects funded, 68 have been in the area of respiratory diseases. Research funded by the Special Research Grants Program has focused on a number of specific areas: (1) improved understanding of the etiologic agents involved in BRDC; (2) pathogenesis of the complex, emphasizing the relationship of management practices, disease-causing agents, and host susceptibility; (3) diagnosis of BRDC; and (4) preventive measures for reducing losses from BRDC.

Studies funded in part by the Special Research Grants Program have provided important information in elucidating the agents involved, the mechanism of pathogenesis, diagnosis, and treatment. A few examples of research results are as follows:

- **Etiologic agents:** Many etiologic agents are now recognized as important in BRDC. The following agents are recognized as the most important: viruses--infectious bovine rhinotracheitis (IBR), para-influenza (PI-3), bovine vira diarrhea (BVD), and bovine respiratory syncytial virus (BRSV); bacteria--Pasteurella haemolytica, Pasteurella multocida and Haemophilus somnus; and Mycoplasma sp. Often BRDC is caused by a combination of these infectious agents rather than by only one agent.

Additional factors associated with BRDC include stress associated with transportation, crowding or climate; poor nutrition; and other poorly defined factors associated with bad management practices.

- **Pathogenesis:** The role of viral predisposition to bacterial infection has been better defined. The role of interferon in regulating the immune response and phagocytic mechanisms are being examined, as is the relationship of polymorphonuclear (PMN) leukocytes to protection from infection and in pathogenesis of tissue damage. The role of PMN enzymes in tissue damage and pathology of BRDC has provided evidence that certain antiinflammatory agents may reduce the severity of disease.

Models to determine the role of Pasteurella haemolytica and its various toxins in BRDC have provided important information on the mechanisms that this bacteria employs to avoid being killed by lung macrophages and causing lung pathology with subsequent clinical disease.

Although the interaction of viruses and bacteria has been studied, the exact role of the various agents requires further research if progress is to be made in developing effective prevention or treatment or both required for BRDC.

- **Diagnosis:** Diagnostic tests have been developed to improve the detection of agents associated with BRDC and to measure antibody to the agents. The most significant improvements have come with the use of enzyme linked immunosorbent assay (ELISA) techniques for detection of antigen and antibody. Also molecular probes to detect viral genomes have been developed and are currently being tested to determine their diagnostic value.

- **Treatment:** Previous recommendations on "preconditioning programs" that include antibiotic treatment have met with limited success. Current modalities for treatment include aggressive antibiotics therapy with antibiotics administered parenterally or locally. Delivery vehicles for antibiotic, such as liposomes, have been used both prophylactically and for treatment of BRDC. This method of antibiotic treatment holds promise because low levels of antibiotic are required and sustained levels of antibiotic can be achieved.

- **Prevention:** New bacterial vaccines and improved bacterins are being developed or have undergone clinical trials. Some appear to hold promise in that they cause fewer adverse reactions than earlier bacterins, and some appear to provide protection against experimental challenge, at least for a transient time period after vaccination. However, it should be emphasized that much research remains to be done, especially using contemporary methods in biotechnology and genetic engineering to provide an optimal vaccine or bacterin.

Improvement in old viral vaccines and development of new vaccines have occurred, but additional improvements are required to significantly limit the role of viruses in pathogenesis of BRDC. Also, it is hoped that the current adverse effects of some of the modified live viral vaccines will be eliminated when "genetically engineered" subunit, synthetic, or truly attenuated modified live vaccines are developed. Although vaccines will not eliminate BRDC, it is hoped they will significantly reduce the effects of BRDC in a cost-effective manner.

Reproductive Diseases In the area of reproductive disorders, the Special Research Grants Program has emphasized infectious diseases caused primarily by bacteria and viruses. However, the program also includes noninfectious causes of reproductive diseases. Disorders associated primarily with physiologic factors are now funded by the Competitive Research Grants Program, and special appropriations for brucellosis appeared in the 1985 Competitive Grants. Projects in the Special Research Grants Program have led to a better comprehension of and improved diagnostics for bovine brucellosis.

Other areas where major studies have been done include the use of prostaglandins for inducing and synchronizing estrus (heat) in cattle. This technique has provided a remarkable degree of reproductive management control for cattle producers, particularly beef cow-calf operators. Managers can now improve reproduction efficiency, reduce labor costs associated with breeding, and increase their control over calving times in relation to weather and market conditions.

Advances in embryo transfer technology have allowed both dairy and beef producers to improve more rapidly the genetic quality of their livestock and to compete more effectively in export markets for quality livestock where restrictions on the shipment of live animals have previously been prohibitive.

Enteric Diseases Enteric diseases are the major cause of neonatal losses in cattle and contribute significantly to mortality and

morbidity in all age groups. Forty-five projects have been funded under this category. Major advances have been made over the last decade in the understanding of and ability to intervene in the neonatal diarrhea complex of beef and dairy calves.

Research developments that have contributed to the understanding of bovine enteric disease complex (BEDC) include the following:

- Etiologic agents: E. coli, Salmonella sp. and Mycobacterium paratuberculosis are recognized as the most common bacterial agents associated with BEDC. The role of viruses like the calf rotavirus and coronavirus in early neonatal diarrhea has been better defined.

Total infection with BVD and subsequent infection or possibly vaccination with BVD is now believed to be the mechanism by which BVD causes mucosal disease.

Cryptosporidia has recently been associated with enteric disease of calves; however, its overall importance in BEDC remains to be determined, as does research to improve methods of isolation or detection of this apparently important agent.

- Prevention: New E. coli and enteric viral vaccines have been developed as have new methods for administration of the vaccines. A "product of biotechnology," a monoclonal antibody to K99 antigen, has revolutionized the treatment of enteric diseases of calves caused by E. coli. Animal agriculture, in the tradition of being first in medical discoveries, is again the first to use commercially a monoclonal antibody to prevent enteric disease caused by E. coli. Additional monoclonal antibodies are being studied in an attempt to determine their effectiveness in preventing viral infections of the gastrointestinal tract.

- Diagnostics: A number of new tests employing monoclonal antibody and ELISA have been developed for detection of antigens or antibody or both to bacterial and viral pathogens associated with BEDC.

New and improved techniques for the identification of M. paratuberculosis are under development or are in clinical trials to determine reliability and usefulness to the cattle industry.

In adult cattle, Johne's disease is recognized as perhaps the most costly enteric disease, leading to both death and production losses in its clinical and subclinical forms. Identified as a special funding category in 1985, Johne's disease has received only limited support. Before further significant advances can be made to understand this disease and develop improved diagnostics, more money should be specifically allocated for research into Johne's disease.

- Treatment: A variety of antibiotics and fluid therapeutics have been used to treat BEDC with a limited degree of success.

Mastitis Mastitis continues to cost the dairy industry more than a billion dollars each year. The Special Research Grants Program has provided approximately \$300,000 to \$500,000 per year for research on mastitis. Projects on traditional problems and approaches to studying mastitis, as well as innovative approaches using contemporary

technologies, have been funded. Mastitis research has significantly contributed to an understanding of the disease and has solved some of the associated problems, but it has failed to reduce significantly the economic losses associated with this disorder.

Parasitic Disease Because a variety of drugs are available to treat parasitic infections in cattle, parasitic diseases have been neglected for years and knowledge of the importance of these problems has been inadequate. Current research has resulted in improved recognition of the hidden impact of parasitism on the growth and development of young stock. It has helped develop important management recommendations for dairy farmers to improve their production efficiency by instituting inexpensive worming programs for growing calves and heifers.

### Swine

The percentage of available funds set by the Animal Health Science Research Advisory Board for swine disease research has been approximately 18 percent from 1979 to 1985, which amounts to \$8.3 million. Of this, \$1.51 million has been spent on respiratory diseases, \$2.25 million on enteric diseases, and \$0.92 million for research on reproductive disorders.

The committee's examination of the accomplishments of the Special Research Grants Program indicates that research is under way on a broad range of important problems confronting the swine producer. The approaches used are generally classical, although there is evidence of an increasing use of contemporary molecular procedures. Results so far have helped develop specific serological and other diagnostic techniques, improved understanding of epidemiology, improved the selection of chemotherapeutic agents, and improved understanding about molecular aspects of the pathogenesis of various complex diseases. Many of these findings will lead directly to practical solutions for problems in the swine industry.

Research supported by the Special Research Grants Program has been highly productive in several areas. Specific accomplishments are presented below.

Swine Respiratory Diseases Studies on swine respiratory disease have elucidated many factors involved in the pathogenesis of this important disease complex. Accomplishments in this area include the following:

- The importance of endotoxin as a virulence factor in swine pneumonia has been discovered. Such vaccines as the mutant J-5 E. coli have been tested and shown experimentally to provide immunity against endotoxin, thereby suggesting a potential vaccine to control Haemophilus pleuropneumonia infections in swine.

- Investigation of toxigenic effects of Pasteurella has been accomplished. Research has led to a clearer understanding of the complex interrelationship between Bordetella bronchiseptica and Pasteurella pneumonia.

- Research has provided a clearer understanding of potential virulence determinants of Bordetella bronchiseptica, such as adenyl cyclase, protein composition, and ciliostatic effects. Scientists must understand these pathogenic elements if they are to develop improved control procedures for this important pathogen.

- The immune response to pseudorabies virus in swine has been examined. Work on DNA fingerprinting and detecting latent virus will greatly improve knowledge of pseudorabies epidemiology and pathogenesis.

- Research has proceeded rapidly to develop subunit pseudorabies virus vaccines that will be particularly important in development of programs to eradicate this disease.

Enteric Disease Advances in studying enteric diseases have also occurred. For instance, in research on piglet diarrhea caused by E. coli, selected drugs were found to be effective in attenuating the secretory diarrheic action produced by the heat-stable enterotoxin. In other work, a stable toxin important in post-weaning diarrhea in pigs was found to act as an aggregate with endotoxin substances, thereby potentiating the toxicity of the disease. This knowledge is directly applicable to developing vaccines for control of many enteric infections.

Progress has also been made in further characterization of binding sites for enteropathogenic E. coli on intestinal cells and in characterizing substances in milk and colostrum that may inhibit this binding.

In work on transmissible gastroenteritis (TGE) of swine, DNA cloning of the TGE virus will help develop a genetically engineered, improved vaccine for the control of TGE.

Agalactia Projects on the mastitis-metritis-agalactia or agalactia syndrome of sows have focused on the role of bacterial endotoxin in the disease and on hormonal factors involved in onset and regulation of lactation in the sow.

Important new information has been presented on the unique susceptibility of the periparturient sow to effects of endotoxin. This work has provided a basis for developing control measures for sow agalactia.

Reproduction Research on swine reproduction includes work on estrus, ovulation and implantation, maintenance of pregnancy, disease and management factors, and genetic regulation of reproductive performance.

Methods have been developed to determine concentrations of zearalenone in feces and feed. Evidence has been gathered that feeding

of zearalenone may delay onset of puberty. In a study of anestrus, prolonged failure to cycle after weaning in late summer and fall was thought to be related to negative feedback of estradiol on gonadotrophin-releasing hormone or lutenizing hormone. In both cases, understanding of the pathogenesis will lead to methods for improved reproductive efficiency in sows.

Diagnostic Techniques Improved immunologic techniques have led to greatly improved ability to perform diagnostic tests both in the laboratory and in the field. Serologic tests have demonstrated immunologic cross-reactivities between Mycoplasma hyopneumoniae and Mycoplasma flocculare. This information will allow scientists to develop more specific diagnostic tests for mycoplasmal pneumonia of swine. Also, many serologic tests are being developed to distinguish between pseudorabies-vaccinated and -infected animals. This information will be critical in any pseudorabies eradication program.

## Poultry

Respiratory diseases are and have long been a major economic concern to all segments of the poultry industry. Monetary losses are associated with the cost of vaccinations and therapeutic drugs, increased mortality, and overall poor performance of affected birds. As documented by CRIS reports, the direction and priority of the research emphasis is appropriate. Over one-third of the research projects listed in the CRIS reports are related to some aspect of important respiratory tract disorders in chickens or turkeys.

Respiratory Diseases Most respiratory diseases affecting poultry have an infectious etiology, but they are often complicated by predisposing environmental and genetic factors. The diseases being evaluated are those of greatest relative importance, including infectious bronchitis, Newcastle disease, mycoplasmosis, and colibacillosis. In addition, much of the research is directly or indirectly related to defining the role of environment and other extrinsic or intrinsic predisposing conditions.

Skeletal Diseases Skeletal diseases, particularly those that affect the legs, are acknowledged by animal health researchers and CSRS as significant problems and funded accordingly. Research is focused on diseases with defined genetic and nutritional associations (such as tibial dyschondroplasia) and classic infectious conditions (such as reovirus-induced viral arthritis and tenosynovitis). The potential interaction of nutrition and infectious agents in producing skeletal abnormalities is also recognized in several projects, including some on malabsorption syndrome.

Immune Deficiency Diseases Characterization of the avian immune system, including infectious and noninfectious factors that contribute to immunopotential or depression, are also appropriately recognized and evaluated. This research generally is accepted as being of a very high priority. Several projects are centered on assessing the importance of infectious bursal disease virus (IBDV) and its variants on immune competence. IBDV is a ubiquitous lymphocytocidal agent that inhibits the ability of chickens to respond to various viable and nonviable antigens and increases susceptibility to infectious disease. Thus far, it is unclear what effects if any this virus might have in turkeys. Other approaches to resolving immune deficiency diseases include examination of immunopotentiators and basic studies on the ontogeny of immune responsiveness.

Enteric and Neoplastic Diseases Enteric and neoplastic diseases receive somewhat less attention in poultry research. These are important diseases, particularly coccidiosis and Marek's disease, but because relatively efficacious vaccination or prophylaxis programs are available, the need for research is not readily recognized.

Overall, research approaches being used for the various poultry diseases appear to be appropriate and contemporary. Many of the projects are basic and are directed at defining immunogenicity and pathogenicity at the cellular, subcellular, and molecular levels. Several institutions are in the process of developing subunit vaccines using recombinant DNA technology. Others are actively involved in establishing more precise and sensitive diagnostic procedures that take advantage of monoclonal antibodies and ELISA systems.

Based on the brief CRIS report summaries, the scientific approaches being used to study most of the diseases are valid and reasonably comprehensive. It would appear, however, that there is limited interaction or collaboration among various institutions, particularly those outside the state agricultural experiment station system. This is a deficiency since there are relatively few qualified poultry disease researchers in the United States and the world, and their effectiveness could be magnified using collaborative arrangements.

## Sheep and Goats

Infectious diseases, parasitism, and predators are the most important animal health problems in the sheep and goat industries. These problems are often critical to marginal livestock operations since they can be the factors that determine whether production is profitable.

Sheep, goats, and cattle are all ruminants, and they share common infectious diseases. For example, gastrointestinal parasites, such as haemonchosis, trichostrongylosis, and ostertagiasis, are important to all three species. Thus, control measure studies in one species can have important implications for other species. Examples of similar

infectious diseases include bluetongue virus infection of all three species and caseous lymphadenitis in sheep and goats. However, significant differences among host responses can exist, and defining interspecies variation to the same infectious and therapeutic agents is an important goal in research in small ruminant species.

Funding for research on sheep and goats has been limited to about 4.5 percent (\$2.5 million) of the Special Research Grants funded since inception of the program in 1979. Current funding is around \$250,000 per year. As a result, only 2 or 3 proposals out of 30 or more (6 to 10 percent) are funded in any one year. Thirty-two projects were reported as ongoing or completed sheep and goat projects. Of these, two dealt exclusively with goats, seven with sheep and goats, and the remainder with sheep. Most of the projects studied infectious diseases and parasites, while three involved predators. Studies have been carried out on diseases of national as well as local concern. For example, one local study examined the consequences of volcanic ash from Mount Saint Helen's on livestock production in Washington.

Projects on bluetongue virus infection in sheep have focused on developing diagnostic techniques and vaccines. The four funded projects attempted to develop a better understanding of the molecular aspects of the virus and its relation to immune responses. Monoclonal antibodies have been developed to characterize subunit proteins for diagnostic and protective immunity studies. Western blotting procedures have been used to characterize protective immune responses. Recombinant DNA technology has been used to develop cDNA probes for diagnostic hybridization tests and cDNA copies of genes needed for eventual vaccine production. The application of biotechnology adds significantly to the development of rapid, sensitive diagnostic tests, and to the eventual development of safe, effective vaccines.

Research on foot rot has focused on the antigenic characteristics of the adhesion sites on pili of Fusobacterium necrophoreus and development of diagnostic tests that would distinguish pathogenic from nonpathogenic bacteria.

Antigens of parasites have been separated by isoelectric focusing. This procedure allows scientists to identify those proteins of parasites that are important for protective immunity. This technology may eventually make it possible to characterize the antigens and consider their role in protective immunity.

## Horses

Seventeen research projects were funded on horse disease between 1979 and 1984 at a total cost of \$1.495 million. Approximately 2 percent of the total Special Research Grants funds have been available for projects on horses. These studies included nine research projects on respiratory diseases, three projects on laminitis, two projects on parasitic diseases, and one project each on colic, metacarpal fracture, and equine infectious anemia. The approaches used in the projects ranged from the use of monoclonal antibodies, molecular virology, immunological studies, and subunit components of bacteria endotoxins



for infectious diseases or for therapeutic regimes for treating pathophysiological conditions.

One important result of research support by a Special Research Grants award involves the identification of a common antigenic site of the equine infectious anemia virus. Recombinant DNA technology is being used to clone the genes into *E. coli*. This breakthrough is critical for making an effective vaccine for equine infectious anemia.

## Aquaculture

Infectious diseases of aquatic animals are among the most important problems for fish farmers. Adequate methods of subclinical disease detection and efficacious controls of aquatic animal diseases are limited. As the aquaculture industry grows and farmers practice more intensive culture procedures, funding for research on the detection, prevention, control, biology (basic and applied), and management of aquatic animal diseases must increase.

Beginning in 1978, CSRS allocated 1.5 percent of the Special Research Grants Program funds to aquaculture. Seventeen projects have been funded for a total of \$1.2 million. In 1980, the USDA began the Aquaculture Research Special Grants Program which also funded infectious disease research. By combining these two sources of monies, CRIS reports indicate that from 1979 through 1985, 30 special research grant projects dealing with infectious diseases of aquatic animals were funded by the CSRS. The total value of these grants was over \$2.4 million. Of the 30 aquatic animal health projects funded by special grants, 13 involved bacteria, 9 involved viruses, 3 involved parasites, and 5 were environmentally oriented. Eight of these dealt with immunity. Of the projects funded, 18 dealt with catfish, 10 with salmonids, 1 with sturgeon, and 1 with crawfish. Since bacterial and viral agents are the most serious disease problems of catfish and salmonids, it appears that projects are being funded in the most important areas.

The various aquatic animal health projects had numerous accomplishments, including a number of prominent ones in viral diseases. Studies showed that serum neutralization of channel catfish virus (CCV) could possibly be used to separate CCV-exposed fish. A CCV-DNA specific probe was developed that detected CCV nucleic acid in tissue of adult channel catfish. It was also demonstrated that CCV is absorbed onto several tissues, including sperm but not eggs. When channel catfish fry were exposed to radiolabeled CCV, the CCV was seen in gills, liver, and gut, but the virus was not neurotropic. Monoclonal antibodies and an ELISA test were developed for infectious pancreatic necrosis virus (IPNV) that was used to identify serological groups of the virus. Progress was made toward developing a subunit vaccine for infectious haematopoietic necrosis virus (IHNV), and the viral protein of IHNV responsible for immunological protection was cloned.

In bacterial research, studies demonstrated that all isolates of Renibacterium salmoninarum (bacterial kidney disease) are antigenically

similar. Biochemical and serological characteristics of Aeromonas hydrophila were isolated from water that differed from A. hydrophila isolated from fish. The pathogenesis of Edwardsiella ictaluri (enteric septicemia of catfish) was further described, and research indicated that channel catfish vaccinated against E. ictaluri were protected when held at 25°C for 5 days prior to water temperature being reduced to 12°C for 60 days.

The relationship of sublethal dissolved copper and infections of protozoan Ichtyophthirius multifiliis was determined. Also, procedures for immunizing channel catfish against this parasite were developed.

Overall, the quality of the research in aquaculture animal health has been good. There seems to be a balance between applied and basic research, with emphasis on the applied. Researchers appear to be adequately trained, but the equipment used in the research facilities is often marginal with respect to age and dependability. Contemporary technology, such as monoclonal antibodies, DNA probes, and unique vaccination techniques are being used, along with standard approaches.

The potential benefits of research funded through the Special Research Grants Program are significant. Results are already being used to improve subclinical disease detection, separate pathogenic from nonpathogenic bacteria, develop effective vaccines for bacterial and viral pathogens, and better understand the pathogen and host relationships. These benefits will become more significant as the aquaculture industry grows and becomes more of an integral part of American agriculture.

#### Summary of Research Supported by the Special Research Grants Program

Cattle research receives 60 percent of the funds available in the Special Research Grants Program. The priority disease research areas that are being supported by the beef and dairy cattle program include respiratory disease complex, reproductive diseases, enteric diseases, and parasitic diseases. Dairy cattle research priorities also include mastitis and Johne's disease. Most of the research is conducted by groups considered to have the expertise and facilities needed to make significant contributions to an understanding of these diseases. Projects are funded that use traditional approaches, as well as unique approaches incorporating contemporary technologies.

Swine research is under way on the most important disease problems confronting the swine producer. The most important losses to the swine industry from diseases are respiratory diseases, reproductive diseases, enteric diseases, and mastitis-metritis-agalactia. Approaches are generally classical, using established experimental procedures. In many areas, only limited use of contemporary molecular approaches is evident.

Respiratory diseases are and have long been a major economic concern to all segments of the poultry industry. Over one-third of the

research projects are related to some aspect of important respiratory tract disorders in chickens or turkeys or both. Enteric and neoplastic diseases receive somewhat less attention. Current research approaches for the various disease categories generally appear to be appropriate and contemporary. It appears, however, that there is limited interaction or collaboration among various institutions, particularly those outside the state agricultural experiment station system.

The important problems of sheep and goats--infectious diseases, parasitism, and predators--have been reasonably well addressed with the limited support available. Conventional and modern techniques are being applied to these problems.

The priority areas for diseases of horses that are being addressed include respiratory diseases, laminitis, colic, and parasitism. The research approaches and techniques applied are current and relevant to the problems.

Infectious diseases are among the most important problems for aquatic animals. While research addresses the major fish diseases, some subjects receive disproportionate attention, and this imbalance should be corrected. Although the techniques and approaches now used in infectious diseases are adequate, there is evidence that new technology is beginning to be applied.

Special Research Grants have supported basic as well as applied research in animal health. In each example described here, special grants contributed in some way to the success of the project. Most, if not all, areas receive some other funds, either from federal or state agencies or even from private industry. However, special grants have provided a foundation for generating fundamental knowledge in each subject area.

#### ADMINISTRATION

No program can be effective without effective administration, and that requires adequate administrative funds and staff. The committee noted that the personnel currently administering the Section 1433 Program and the Special Research Grants Program are highly dedicated and competent, and have done admirably with limited resources. But staff and funds are far short of what is necessary to ensure an effective animal health research program.

Some of the essential administrative tasks that must be done include updating the files of highly qualified scientists for peer review, planning and coordinating meetings of review panels and the Animal Health Science Research Advisory Board, monitoring research progress by reviewing publications and conducting site visits, preparing progress reports, administering grant and formula fund monies, and reviewing program accomplishments. Administrative staff also coordinate efforts among agencies where appropriate, recommend changes in direction or magnitude of funding, and provide interested people with information about the programs.

In the past, 4 percent of appropriated funds for the Section 1433 and Special Research Grants programs has been retained by USDA to administer the programs, but some of the money has been allocated to other administrative units within the USDA so the amount available for actual use by the CSRS scientific staff has been inadequate. Also, because of a staff shortage, CSRS has not been able to critically review Section 1433 projects, coordinate efforts among different institutions or agencies, or develop effective long-range planning.

### Selection and Operation of Peer Panels

The review of research proposals seeking funding under the Special Research Grants Program is one of the most critical aspects of the program's operation. (See Appendix B for a discussion of the operation of the peer review system for the Special Research Grants Program.) While a sound effort has been made to draw on appropriate participants, the time is right to expand this resource and bring a wider range of talent into the process. Participants should be individuals with national stature and proven research productivity. This would minimize the danger that particular disciplines or groups would become entrenched in peer panels and would fail, because of their background, to recognize the merit of creative new ideas and proposals that challenge the assumptions of projects approved in the past.

Technological developments and innovations across a very broad front are increasingly relevant to the practice of animal health research and must be incorporated into the process of shaping the CSRS program. An expanded and updated file of potential peer review panel members should be compiled from suggestions made by appropriate senior scientists and research administrators. Such a file must be constantly reviewed to ensure good balance and breadth. The panels are the lifeblood of the quest for research quality in this program, contributing an immense intellectual resource to maintain standards, ensure originality, and seek promising innovation in technical and conceptual approaches. These panels play a critical role in a program that ultimately depends on the partnership between federal and state administrators and the creative resources of the scientists.

Panel members should be eligible for future service on the same or other review groups if their performance and contribution clearly merit it. The panels currently function as fairly as they can, but the enormous volume of proposals certainly limits the thoroughness of their reviews. Frustratingly brief rejection notices are furnished to unsuccessful applicants, which is very much to the detriment of the program and gives the impression of a superficial and inadequate review process. While the administrative burden of expanded critique is unwieldy, some attention needs to be given to this issue. Perhaps summary critiques could be prepared by panelists or other external reviewers. Panelists should also be bold in their willingness to support ongoing, well-funded projects, rather than spreading awards widely and developing inappropriate biases against projects simply because they have received previous Special Research Grants support.

**Evaluating the record of research productivity through publications in primary journals is the key to sound judgments in these instances.**

### **Evaluation and Review of Research Progress of Projects Funded by CSRS**

There is a great diversity in the management of Hatch, Section 1433, and Special Research Grant funds at various research locations. Because the programs are complementary, it is difficult to identify accurately the contributions made to a research project by various types of CSRS programs or by training. Since CRIS reports are based on forms filled out by investigators, the CRIS system can only be as good as the submitted forms. This means that the quality of the system depends on scientists taking their role in the process seriously, a characteristic which apparently is not widespread. Investigator attitudes toward CRIS forms represent an impediment to the evaluation process, and this in turn limits CSRS's ability to review and evaluate its programs effectively.

The Animal Health Science Research Advisory Board highlights its evaluation of the program in public reports in an enthusiastic and optimistic tone, but it is difficult to assess long-term impacts from these reports or to judge the extent to which solid scientific publications have been assembled. Specific citations of published manuscripts, rather than reference to state agricultural experiment station documents, would be more valuable for critical assessment of achievements. Selected literature citations arising from the Special Research Grants Program funding would be helpful indicators of quality, and they need not undermine the need to communicate highlights in terms understandable to a wide audience.

It is important to note that advisory board reports are directed to an audience that could be misled by overstatement, which implicates that problems have been solved or that solutions are imminent. Reports should be realistic in their appraisal, especially in regard to those research findings relating to vaccines or diagnostic procedures, some of which are far from commercialization.

Currently, no standardized procedures exist to review the use of CSRS animal health research program funds at the institutional level. Evaluation through site visits is not a standard or required procedure, although it has been done sporadically at the request of the local research institution. However, the institution also recommends the review panel members and this shortcoming undermines accountability. Research institutions receiving CSRS funds should be visited to review research progress. The selection of sites and frequency of visits will be affected by budgetary considerations, but the potential for periodic, thorough critical review should exist. Evaluations should compare the research progress made to specific and long-range research plans submitted to CSRS at the time of the initial funding request. An ad hoc committee selected by CSRS could provide names of scientists for site visits. CSRS must make sure that the site unit team has an appropriate balance between basic and clinical scientists. Adequate

preparation time and standardized procedures and forms should be provided to the reviewing scientists.

The evaluation process should identify the contribution made to the research by each type of CSRS fund, so that accountability can be established for each funding source. This process would provide a data base for decisionmaking concerning the future of each of the programs.

#### Interactions with the Public and Private Sector

The committee recognizes that CSRS interacts with other USDA units, other federal agencies, and other organizations via the Animal Health Science Research Advisory Board, peer review panel meetings, site visits, and staff. However, the committee suggests that there is a need for better communication at all levels. Program planning needs to be better coordinated and communicated to all segments of the animal health community. Program plans should be presented in a report that could be widely distributed as part of a constituency education program. In addition to USDA members on the advisory board, liaison members from FSIS, industry, and several of the major commodity groups (e.g., Forum for Animal Agriculture) should be invited to the advisory board meetings.

Scientists selected for the peer review panels for the Special Research Grants Program also interact with CSRS; however, scientists need to be recruited from state agricultural experiment stations, colleges of agriculture, and industry. Meetings of CSRS staff with other granting agencies, i.e., the National Science Foundation (NSF) and the National Institutes of Health (NIH), should be held to review programs, granting mechanisms, and so on. Site visits should be increased to coordinate and communicate program plans, research priorities, progress, and research results (technology transfer).

#### Funds Available for Animal Health Research

CSRS animal health research programs have brought great benefits to animal agriculture. But limited appropriations and the uncertainty of support and funding have decreased the programs' effectiveness. These problems have been discussed in detail in this report.

When Section 1433 and the Special Research Grants programs were initiated in 1979, Congress appropriated funds for both. However, from 1979 until 1985, USDA did not include Section 1433 in its budget request (the Special Research Grants Program was included), and the program was funded only because Congress chose to restore the funds. In its 1986 budget request, USDA has excluded both programs. While Congress is likely to continue to appropriate funds for both programs despite USDA's requests, this kind of funding uncertainty is counterproductive to animal health research. The unpredictability of funding makes research management difficult for both administrators and researchers and forces scientists away from careers in animal health

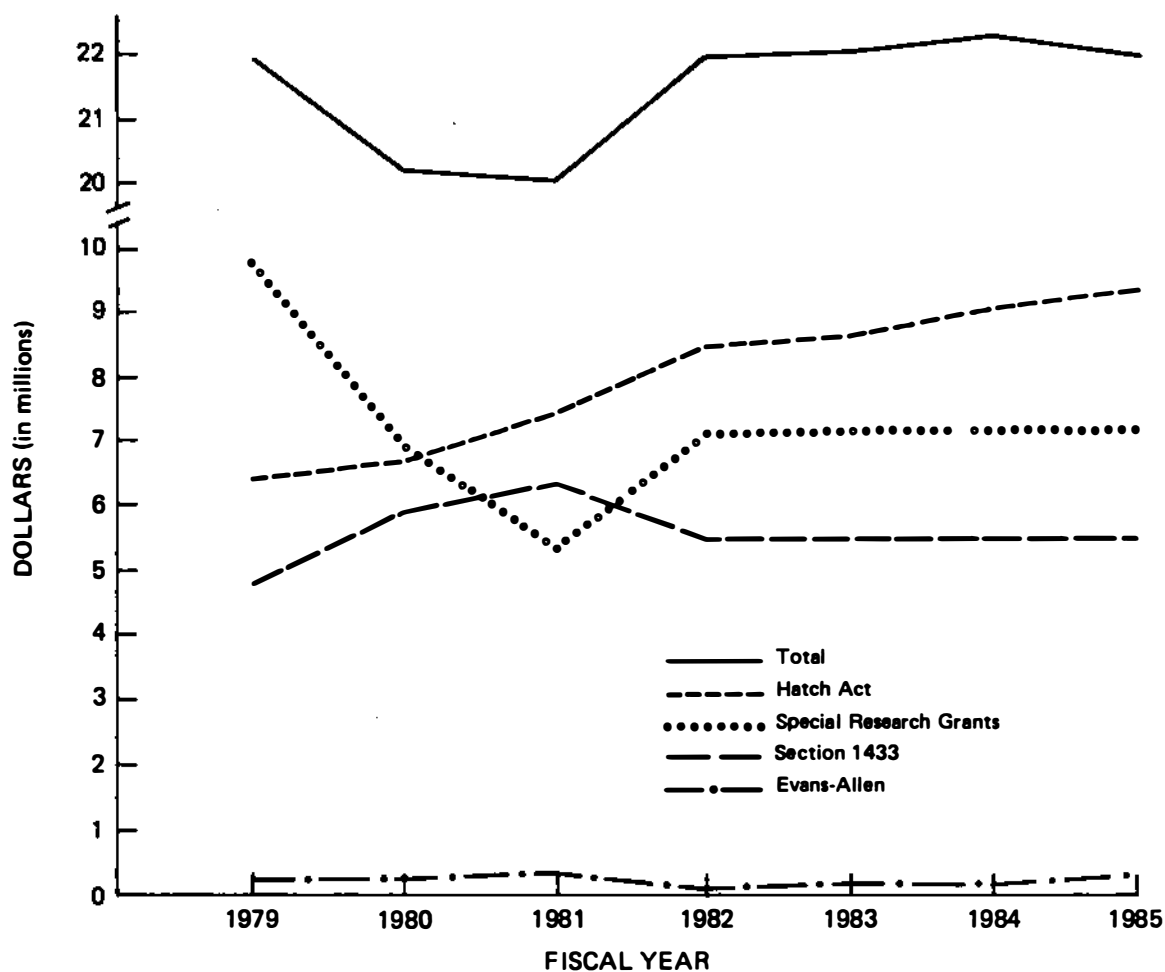


FIGURE 5-1 Animal health research funding of CSRS programs. Source: USDA, compiled data, 1985.

research. A stable foundation is needed if the animal health research system is to be effective.

The level of funding also needs to be examined. Total funds obligated for all agricultural research in the state agricultural experiment stations and other institutions (from both public and private sources) amounted to \$1.1 billion in FY 1983 (USDA, 1984e). CSRS animal health research, in contrast, was approximately \$22 million that year (Figure 5-1).

Funds for animal health research in the Special Research Grants Program have been decreasing since the program's inception in 1979. That year, \$10 million was allocated, and by 1985 only \$6 million was allocated. The committee believes that the level of funding must be returned to the \$10-million appropriated level and increased as soon as possible. This increase would lead to a broader and more effective program. For instance, in FY 1985 only 12 percent of the research proposals submitted to the Special Research Grants Program could be

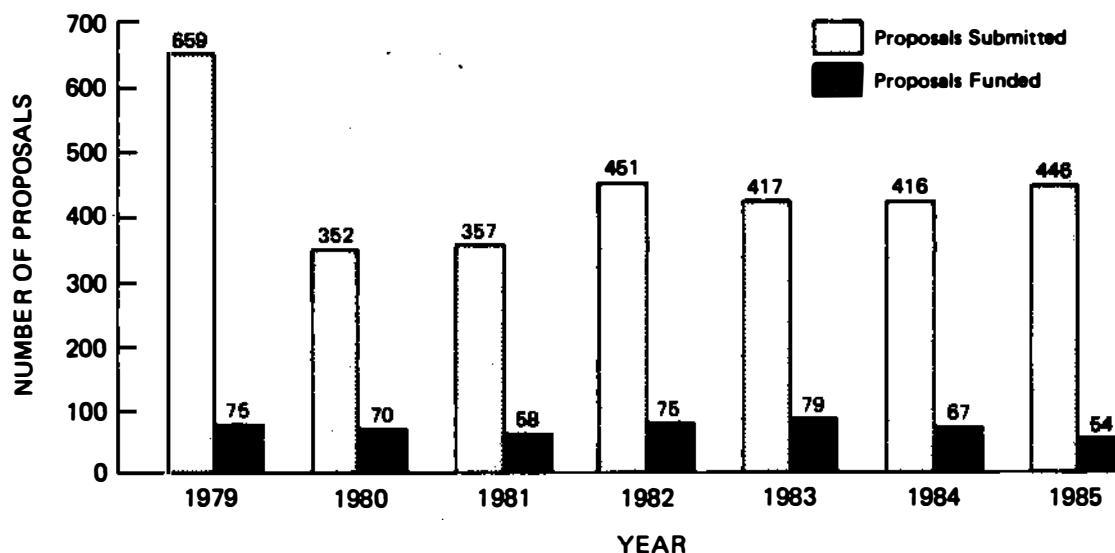


FIGURE 5-2 Number of proposals submitted for review and the number of proposals funded in the Animal Health Special Research Grants Program. Source: USDA, compiled data, 1985.

funded because of the limited money available (Figure 5-2). Yet peer review panels considered an equal number of the nonfunded proposals to be of high quality. Thus, a large number of potential animal health researchers could be brought into the research system if support were available.

Similarly, the upper limit on the amount of awards sometimes inhibits effective research. The current \$150,000 limit on individual grants in the Special Research Grants Program tends to diminish both the quantity and quality of the research conducted. The committee found that \$250,000 is a more realistic ceiling and one that is consistent with the amounts awarded by other federal funding agencies, such as NIH and NSF. This higher ceiling would allow more in-depth and longer-term research.

Other problems exist that merit discussion. For example, Section 1433 research awards are made using a fiscal year cycle, theoretically awarded in October and required to be spent before the next October. However, the actual award may occur much later than October, and scientists are still required to use the money before the end of the fiscal year. More effective use of funds is possible if there is some flexibility in how funds are managed--a mechanism to allow year-end funds to be carried over into the next year.



### SETTING RESEARCH PRIORITIES

The goal of the Cooperative State Research Service (CSRS) animal health programs must be to research economically and socially important animal health problems, as well as to alleviate the pain and suffering that animals now endure because of inadequate knowledge of treatment, control, or prevention of many diseases. That goal can be achieved by promoting a cooperative federal-state research partnership that captures the vast scientific talent within public and private colleges and universities in the United States. CSRS needs to develop specific long-range objectives to measure the success of the program, as well as a mechanism to determine research priorities. And the research community must understand and agree that one of the prime objectives of animal health research is the welfare of animals.

#### LONG-RANGE RESEARCH GOALS AND OBJECTIVES

As a first step in setting research priorities, CSRS must establish an overall plan that clearly sets long-range goals for animal health research and strengthening of the federal-state partnership. Such goals must be derived by objective and quantitative analysis of real needs within animal agriculture and of available human resources. Therefore, a certain percentage of research monies must be devoted to determining the economic and social impact of animal health (including agriculture) problems. Accurate methods must be developed to quantify disease incidence, severity, cost, impact on food supply, impact on international trade, and so on.

CSRS must determine priorities with clear and open communication and cooperation with other U.S. Department of Agriculture (USDA) agencies, such as the Agricultural Research Service (ARS), the Animal and Plant Health Inspection Service (APHIS), and the Food Safety and Inspection Service (FSIS). Presently this exchange of information involves administrators within USDA informally or at the annual meeting of the Animal Health Science Research Advisory Board. A more formal system of addressing the issues facing animal health could markedly enhance USDA's efforts.

CSRS, together with representatives from the Association of American Veterinary Medical Colleges, APHIS, ARS, FSIS, and the Center for

Veterinary Medicine of the Food and Drug Administration, needs to develop an overall plan for livestock health. Such a plan would help everyone involved keep abreast of research direction, personnel needs, and facility needs. It also could foster collaborative scientific exchanges and diverse approaches to problem solving. Also, such a plan could make CSRS more effective in assisting such regulatory agencies as APHIS and FSIS.

## RESEARCH PRIORITIES

In 1978, the first year of the Special Research Grants Program, the Animal Health Sciences Research Advisory Board reviewed commodity recommendations and proposed that the major disease problems of livestock and poultry receive attention in fiscal year (FY) 1979 in the following order: (1) respiratory diseases, (2) enteric diseases, (3) reproductive diseases, and (4) internal and external parasites. Each year at its annual meeting, the board recommends priority disease areas that are announced in the Federal Register to solicit Special Research Grants proposals. Although the board has recommended the same general areas for the past 6 years, the animal health research community faces the uncertainty that disease priorities could be changed each year, perhaps without firm economic or social basis, at any time.

A better system for setting research priorities must be developed. Since priority research as currently defined has not changed over the years, a system should be established to set new priorities, and these should be left standing as long as necessary to sustain productive, relevant research. Periodically, the board should review the programs' accomplishments and any new technologies before issuing new recommendations. However, some reasonable flexibility should be built into the system to accommodate new or emerging diseases, changes in the status of old diseases, and new developments in research methodology and basic science.

The Animal Health Science Research Advisory Board now serves a pivotal role in determining research priorities. Members of advisory groups, including commodity representatives, contribute greatly to the development of a research plan. New methods of quantitative epidemiology, applied economics, technology assessment, computer science, and other new technologies have improved the analysis of animal disease problems and the identification of possible solutions. The effective application of these techniques requires a broader perspective by the board. For example, our understanding of subclinical disease problems, such as in immunological disorders, reproductive disorders, growth and performance, and feed conversion problems, is now limited. Yet new methods of disease detection and surveillance suggest that these subclinical problems are of significantly greater importance than previously perceived.

One problem with the current approach is that research priorities are set on the basis of visible numbers of sick animals. Yet subclinical, chronic, or otherwise difficult-to-diagnose diseases may actually be of greater importance than acute, overt diseases and

therefore may deserve a higher level of research funding and attention. In this context, any national system for gathering health and disease data should be specifically designed to ensure that it gives adequate emphasis to evaluating the impact of subclinical disease, and does not focus unduly on clinically recognizable problems merely because they are easier to record.

Clearly, knowledge of the relative importance of different research areas is limited. To manage expenditures in animal health research in the most judicious manner possible, better methods to prioritize research areas must be developed. Specific research is needed to design a thorough, objective mechanism to set research priorities.

CSRS should appoint several ad hoc members to the Animal Health Science Research Advisory Board whose expertise encompasses quantitative measurements of animal health costs, epidemiology, statistical disease reporting, agricultural economics, technology assessment, basic computer models, and quantitative analytical systems for studying animal health disease and productivity. Computer software development, as well as the training to adapt it to animal health and disease situations, should constitute a significant portion of research dollars. CSRS must support research aimed at quantifying actual animal disease costs (both economically and socially) because this is a good way to rank animal health problems and therefore provide guidance to the advisory board.

Methods must be developed to accurately quantify disease problems, incidence, severity, cost, impacts on food supplies, impacts on foreign trade, and other factors. Broadening the focus of animal health funding from its emphasis on infectious diseases to include other areas of animal health, such as reproductive diseases, metabolic diseases, and nutritional diseases, is now warranted.

#### NEW PRIORITY AREAS

Present funding priorities strongly emphasize pathogenic infectious agents of specific species. As knowledge increases, the committee sees a need for CSRS to be flexible and to encourage the use of new approaches to solving problems in the present priority areas. Furthermore, the committee recognizes that many new opportunities exist whereby animal health and productivity can be improved. Even if no additional funds become available, new initiatives should include the following (in order of priority):

- Systems Approach to Disease Research: The committee believes that in many instances the basic mechanisms of pathogenesis of specific disease complexes are the same in a number of species. Thus, one research priority should be to increase basic knowledge of the pathogenic mechanisms of disease. This kind of systems approach could reduce the costs of solving a specific problem and also expedite control of similar diseases in various species. Furthermore, it would allow researchers to capitalize on unique model systems or research tools and reagents available in one species that are not available in

other species. Such an approach would also encourage communication and team research for interspecies studies. Areas where such an approach may prove to be cost effective include respiratory and enteric infections because for these problems both the pathogens and the disease mechanisms are similar in many species.

- Environmental and Behavioral Factors Affecting Animal Health and Productivity: Environmental conditions influence many infectious and noninfectious diseases of domesticated animals. Under favorable conditions, animals resist many infections. However, when environmental conditions deteriorate, for example if there is poor ventilation, insufficient water, accumulation of excreta, uncontrolled temperature, crowding, or the accumulation of toxins, animal resistance to disease is reduced. Most epidemiologists agree that environmental conditions influence disease susceptibility, but few studies have quantified these effects or calculated the cost effectiveness of maintaining optimum environmental conditions for domesticated animals. Environmental studies could be very fruitful in developing health maintenance programs for domesticated animals. Of additional interest is the relationship of behavior patterns of various livestock species and the effect of environmental and management conditions that restrict or inhibit normal behavior. The effects on animal well-being and on production efficiency both merit serious research investigation.

- Integrated Health Management Systems: Decreasing margins of profitability in livestock operations have made economic and production efficiency increasingly important. As a consequence, new management systems have been developed, and these have changed the incidence and type of disease problems involved in animal production. The fact that subclinical diseases may be a significant cause of animals' suboptimal performance increases the complexity of the situation.

The lack of information on disease costs under different management systems makes it difficult to devise cost-effective strategies for disease control. Such strategies require basic knowledge of the complex interactions that exist between management practices, nutrition, animal health, and production. Intensified research on these interactions is urgently needed in order to develop effective herd health management programs. The research would involve multidisciplinary investigations on the etiology of disease and suboptimal production as related to the output of the livestock production unit. Computerized programs for this purpose have been developed and could be expanded, modified, or refined.

Research in this area is also necessary to determine the true economic loss to food animal production. This will enhance the development of future research priorities for animal disease and for control strategies. It will also allow a more accurate assessment of the cost-effectiveness of disease control strategies under various management conditions. Furthermore, it will have an impact on changing the traditional delivery systems for veterinary medical care to systems that better meet the needs of the modern livestock operation.

## CONCLUSION

The Cooperative State Research Service (CSRS) is an administrative office of the U.S. Department of Agriculture (USDA) and is responsible for managing and coordinating those agricultural research programs where federally mandated dollars are used in state-supported institutions. This National Research Council report is a critical evaluation of these CSRS programs, namely, the Special Research Grants Program (Section 1414), the Animal Health and Disease Research Program (Section 1433), the Hatch Program, and the Evans-Allen Program as they pertain to animal health and disease research.

These programs have an actual and potential strength beyond their size. The decentralized nature of these programs and the countless resources from which they draw throughout the nation give them unique potential unavailable from centralized federal programs, such as the Agricultural Research Service (ARS). The following paragraphs explain these special characteristics.

- The programs provide greater research yield per federal dollar spent. Federal dollars allocated to state institutions, such as experiment stations and universities, are committed primarily to actual research activity. Administrative costs, salaries, and maintenance of physical facilities are absorbed largely through the operating budgets of the state institutions. In contrast, all operating costs in the ARS system are paid for with federal dollars.

- Research dollars are awarded on a competitive basis and therefore improve the quality of research. Through the Special Research Grants Program, grants are awarded based on scientific merit, as judged by a peer review process. This ensures that those scientists best able to solve animal disease problems receive research dollars, regardless of their institutional affiliation.

- CSRS programs encourage states to commit dollars to animal disease research. The federal legislation that created the Animal Health and Disease Research Program, Section 1433, calls for states receiving these funds in excess of \$100,000 to match these research funds by state appropriation. This requirement increases the state's participation in animal health research.

- CSRS programs ensure that adequate research capabilities and facilities are maintained throughout the nation. The Hatch and Section 1433 Programs are formula programs, distributing money to the various states based on the extent of their agricultural activity and the income such activity generates. Thus, institutions in states that have sizable livestock industries receive research funds to maintain research staff and facilities. This funding increases their ability to deal with local animal health and disease problems and to maintain preparedness in the face of unexpected emergencies, such as foreign animal disease outbreaks.

- CSRS programs permit the research community to be responsive to local needs. The American livestock industry has a very regional character with different species of livestock centered in different geographic locales. By channeling federal funds through state institutions, CSRS facilitates communication between local livestock producers, the commodity groups that represent them, and the institutions that carry out research. This arrangement ensures that animal disease problems that may not be national in scope but extremely costly to certain producers are addressed and resolved by competent researchers.

- CSRS programs are the major source of research dollars for livestock diseases in veterinary schools and colleges. Veterinary medicine as a scientific discipline has a unique contribution to make to animal agriculture. It is an interdisciplinary field that combines experience in livestock production with training in the biomedical sciences. Veterinary researchers, by virtue of their training, can define animal disease research problems and offer novel solutions to these problems.

The vast majority of research dollars available to research veterinarians at schools of veterinary medicine to study livestock diseases comes from CSRS programs. Although veterinary researchers can and do compete for federal dollars through the National Institutes of Health (NIH) and other biomedical funding agencies, those dollars are rarely used to study livestock diseases.

- CSRS programs are important for training new veterinary and animal scientists. Whereas ARS funds are channeled into independent federal laboratories, CSRS program funds are channeled primarily through state universities where research is carried out in an academic setting. This facilitates the formal training of graduate students interested in careers in animal health and disease research by providing pertinent course work, degree granting programs, and research opportunities. Scientists working at large universities are more likely to interact with researchers in other disciplines, and this collaboration can facilitate the integration of new technologies into animal health research. Graduate students working with these scientists can more readily appreciate the potential applications of new technologies to solving animal health and disease research problems, and thus accelerate the process of modernizing agricultural research.

## SUMMARY

Federal support for agricultural research has been a necessary, rewarding, and historically acceptable precedent in the United States. The current agricultural crisis in this country requires a continued and intensified federal commitment to support agricultural research. Improving the efficiency of agricultural production through research and development is one valuable step toward restoring profitability to American agriculture.

The American livestock industry today faces a particularly acute economic dilemma due to rising production costs and foreign competition. Significant advances can be made in improving the profit margins in livestock production by controlling clinical disease outbreaks, eliminating subclinical disease, and improving livestock management practices. Previously unimaginable improvements in production efficiency will be possible when the new technologies of computer science and molecular biology are brought to bear on animal health and disease research programs. Integrating these technologies into existing programs will take a firm commitment to increase research dollars available for animal health and disease research.

CSRS programs are a vital and dynamic component of the overall federally supported program of agricultural research. The CSRS programs are best suited to addressing national, regional, and local research problems, providing suitable training for new scientists, ensuring the performance of quality research through competition for research dollars, integrating new technologies into ongoing research, and providing the best economic value in research productivity for each federal dollar spent. These assets fully justify the continuation, as well as the expansion, of CSRS animal health and disease research programs.

## STRENGTHS, WEAKNESSES, OPPORTUNITIES, AND THREATS

Throughout the evaluation of the CSRS programs, the committee has noted the strengths, weaknesses, opportunities, and threats that are relevant to the CSRS animal health research programs. These are summarized below.

### Strengths

- The various CSRS programs complement each other, and the value of the total program is greater than the sum of the individual programs.
- CSRS grants attract high quality scientific expertise from within and outside the traditional agricultural research system and capitalize on the talent in the university system.
- The CSRS system allows problems to be addressed at national, regional, and local levels.

- CSRS funding strengthens and enhances the federal-state partnership in animal disease research.
- CSRS formula funds provide a foundation for additional support for animal health research.
- The review panels that evaluate Special Research Grants help assure high quality research.
- The Section 1433 Program provides start-up funds for new research on local disease problems, exploratory research, new facilities, upgrading of equipment needs, maintenance of research animals, and research that responds to rapidly emerging diseases.
- The Animal Health Science Research Advisory Board brings many constituencies into the advisory process to help identify and solve animal health problems.
- CSRS programs are instrumental in training animal health scientists.

#### Weaknesses

- The CSRS system lacks long-range planning.
- Inadequate funding inhibits the effectiveness of CSRS programs, and many excellent research proposals are not supported.
- Inadequate funding discourages talented animal health scientists from doing research, thereby decreasing the pool of qualified participants that will be available in the future.
- The lack of assurance of stable, continued funding threatens the continuity of programs.
- The delayed release of Section 1433 funds each year, with no procedures to carry over funds, places unrealistic constraints on research.
- There is a lack of overall communication and direction of animal health research between CSRS and other federal, state, and private sector agencies involved in animal health issues.
- CSRS lacks a systematic procedure to ensure adequate review and accountability of programs.
- CSRS provides inadequate support for the programs' administration.

#### Opportunities

- CSRS can provide leadership in national and international animal health research for the public and private sector.
- CSRS programs are well positioned to apply new technologies to animal health and disease problems by virtue of their university-based partnership.
- CSRS has many opportunities to communicate research results--helping transfer technology to education, extension, regulatory agencies, institutions, and industry.
- CSRS programs are essential for recruiting and training new scientists for animal health research.



- CSRS funds can attract diverse human and structural resources into the field of animal health.

#### Threats

- Unpredictable or eliminated support from USDA, the Office of Management and Budget, the Office of Science and Technology Policy, and Congress could limit or destroy CSRS effectiveness.
- Special interest groups could have negative impacts on CSRS programs by biasing distribution of funds.
- Competition from other USDA animal health programs, in the face of diminishing resources, could threaten the viability of CSRS programs.
- Inadequate support for administration could threaten the productivity, efficiency, and prestige of CSRS programs.

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**APPENDICES**

- A. Animal Health Science Research Advisory Board**
- B. Special Research Grants Program and the Peer Review System**
- C. Section 1433 Allocations**
- D. Special Contributors to the Committee**



## APPENDIX A

### ANIMAL HEALTH SCIENCE RESEARCH ADVISORY BOARD

The Animal Health Science Research Advisory Board was established in 1977 by P.L. 95-113, "to consult with and advise the Secretary with respect to the implementation of this subtitle and to recommend immediate priorities for the conduct of research programs authorized under this subtitle, under such rules and procedures for conducting business as the Secretary shall in the Secretary's discretion, prescribe." This mandate includes two programs authorizing extramural, federal support for animal health research--Section 1433, the Animal Health and Disease Research Program, and Section 1414(c)(1), the Animal Health Special Research Grants Program.

P.L. 95-113 prescribes that members serve on the board for a term of 5 years and that the board shall be composed of the following eleven members:

- (1) a representative of the Agricultural Research Service (ARS), U.S. Department of Agriculture (USDA);
- (2) a representative of the Cooperative State Research Service (CSRS), USDA;
- (3) a representative of the Animal and Plant Health Inspection Service (APHIS), USDA;
- (4) a representative of the Bureau of Veterinary Medicine (now the Center for Veterinary Medicine) of the Food and Drug Administration (FDA) of the Department of Health, Education and Welfare (now the Department of Health and Human Services); and
- (5) seven members appointed by the Secretary--(a) two persons representing accredited colleges of veterinary medicine, (b) two persons representing state agricultural experiment stations, and (c) three persons representing national livestock and poultry organizations.

During 1984, there were 12 members of the board. Orville G. Bentley, Assistant Secretary for Science and Education, chaired the board with Bert Hawkins, Administrator of APHIS, as Vice Chairman. Earl J. Splitter of CSRS served as executive secretary. A representative from ARS and the Center for Veterinary Medicine, FDA, were also members. Two representatives from colleges of veterinary medicine, two from state agricultural experiment stations, two from the

Farmers Home Administration and Hatch Feedyards (representing dairy and beef cattle), and one from a livestock organization filled out the membership.

The board provides CSRS with recommendations for administering the Section 1433 Program. It set the scope and priorities of eligible research, helped determine research capacity in eligible institutions, and answered other questions on program administration. Emphasis is placed on research to help solve high-priority diseases or other animal health hazards in the production of livestock, poultry, and aquaculture species.

Eligible diseases and their priorities for Special Research Grants are identified annually by the board using recommendations from national livestock and poultry commodity organizations and other groups concerned with animal health. The board also makes recommendations on the commodity distribution of funds (see Table A-1).



**TABLE A-1 Animal Health Special Research Grant Priorities and Distribution of Funds as Established by the Animal Health Science Research Advisory Board, FY 1983-FY 1985**

Commodity and Disease Priority	Percent of Total Funds			
	FY 1982	FY 1983	FY 1984	FY 1985
<b>Beef cattle</b>	42.00	41.73	41.73	41.73
Respiratory disease complex		16.69	16.69	16.69
Reproductive diseases		12.52	12.52	12.52
Enteric diseases		8.35	8.35	8.35
Parasites		4.17	4.17	4.17
<b>Dairy cattle</b>	18.00	18.27	18.27	18.27
Mastitis		6.40	6.40	6.40
Reproductive diseases		5.48	5.48	5.48
Respiratory diseases		3.65	2.74	2.74
Digestive and enteric diseases		2.74	1.83	1.83
Johne's disease	NR <sup>a</sup>	NR	NR	1.82
Foot rot	NR	NR	1.82	NR
<b>Swine</b>	18.00	18.34	18.34	18.34
Enteric diseases		5.50	4.59	4.59
Respiratory diseases		4.59	4.59	4.59
Reproductive diseases		3.67	4.58	4.58
Others	NR	NR	4.58	4.58
Parasites		2.73	NR	NR
Lameness		1.83	NR	NR
<b>Poultry</b>	12.00	12.38	12.38	12.38
Respiratory disease		4.95	4.95	4.95
Metabolic and immunologic disease	NR	NR	3.72	3.72
Enteric disorders		2.48	3.71	3.71
Skeletal problems		3.71	NR	NR
Neoplastic disease		1.24	NR	NR
<b>Sheep and goats</b>	5.00	4.64	4.64	4.64
<b>Horses</b>	3.00	3.09	3.09	3.09
<b>Aquaculture</b>	1.50	1.55	1.55	1.55

<sup>a</sup>NR - no recommendation.

SOURCE: Adapted from USDA Animal Health Science Research Advisory Board Annual Reports 1982, 1983a, 1984a, and 1985a.

## APPENDIX B

### SPECIAL RESEARCH GRANTS PROGRAM AND THE PEER REVIEW SYSTEM

In response to a Federal Register Notice of Availability of Funds for Animal Health Grants, proposals are received by the Cooperative State Research Service (CSRS) from eligible institutions. Eligible institutions are defined as land-grant colleges and universities, research foundations established by land-grant colleges and universities, state agricultural experiment stations, and all colleges having a demonstrated capacity in food and agricultural research.

Proposals are sought for fundamental and innovative approaches to resolving problem areas. The specific areas of inquiry and availability of funds for 1985 as set by the Animal Health Science Research Advisory Board are listed in Table B-1.

During FY 1985, CSRS received 447 proposals and assigned each to one of six review panels. The panels and the number of proposals assigned are listed in Table B-2.

Each panel is composed of seven or eight scientists appointed for a 3-year term and a CSRS panel manager. The panel members are selected by the following criteria: (1) one member from each region, (2) one member from a federal agency, and (3) one member from a nonacademic setting (industry). Minority representatives and women are also given consideration in the selection of panel members.

Each panel member acts as a primary reviewer for 10 to 15 proposals; however, the full panel decides the merits of each proposal. If a proposal is submitted by a panel member, or if there is no expertise on the panel to review a proposal, three or more ad hoc outside reviews are solicited.

The proposals are evaluated, weighted, and selected by six criteria (see Table B-3) set forth in the Federal Register.

The panel can recommend full requested funding of the proposal or can reduce funding by cutting out some of the objectives, reducing the time period, equipment, supplies, or graduate student wages. Proposals receiving the highest scores within each program problem area are recommended for funding. Actual funding is determined by the administrator of CSRS and is based on the availability of funds.

**TABLE B-1 Research Areas with Available Funds, 1985**

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<b>Program Problem Area</b>	<b>Percent of Total Funds Established</b>
<b>Beef cattle</b>	
Respiratory disease complex	17
Reproductive diseases	12
Enteric diseases	8
Parasites	4
<b>Dairy cattle</b>	
Mastitis	6
Reproductive diseases	5
Respiratory diseases	3
Digestive and enteric diseases	2
Johne's disease	2
<b>Swine</b>	
Enteric diseases	5
Respiratory diseases	5
Reproductive diseases	4
Other swine diseases	4
<b>Poultry</b>	
Respiratory diseases	6
Metabolic and immunologic diseases	4
Enteric disorders	3
<b>Sheep and goat</b>	
Bluetongue, foot rot, chlamydia, polyarthritis, gastrointestinal, parasites, caseous lymphadenitis, pneumonia, mastitis, bacterial scours, ram epididymitis, and predator control	5
<b>Horses</b>	
Respiratory, enteric, reproductive, and musculoskeletal diseases	3
<b>Aquaculture</b>	
Infectious diseases and parasites	2

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TABLE B-2 CSRS Peer Review Panels, FY 1985

Panels	Number of Proposals
Bovine reproductive disease	13
Bovine respiratory diseases	55
Cattle, other disease (enteric, metabolic, parasites, and Johne's disease)	115
Poultry and horse diseases	102
Swine, sheep, and goats	96
Aquaculture	86

TABLE B-3 Evaluation Criteria for CSRS Research Proposals

Selection Criteria	Score 1-10	Weighting Factor	Score x Weighting Factor	Comments
Scientific and technical quality of the idea		8		
Scientific and technological quality of the approach		8		
Relevance and importance of proposed research to solution of specific area of inquiry		5		
Feasibility of attaining objectives during life of proposed research		5		
Adequacy of professional training or research experience of research team in essential disciplines needed to conduct the proposed research		5		
Adequacy of facilities, equipment, and professional and technical staffing		5		

SOURCE: Federal Register, Vol. 50, No. 5, Tuesday, January 8, 1985.

**APPENDIX C**

**DISBURSEMENTS FROM ANIMAL HEALTH AND  
DISEASE RESEARCH PROGRAM: SECTION 1433**



**TABLE C-1 Animal Health (Section 1433) Fund Allocations to 50 States and Puerto Rico--FY 1979 to 1985**

Fund Recipient <sup>a</sup>	1979 (\$)	1980 (\$)	1981 (\$)	1982 (\$)	1983 (\$)	1984 (\$)	1985 (\$)
<b>Alabama</b>							
AES, Auburn Univ.	85,549	104,005	108,063	89,645	88,463	84,301	86,828
SVM, Auburn Univ.	14,681	27,320	23,668	21,560	21,006	22,931	29,764
SVM, Tuskegee Univ.	30,054	24,325	26,886	20,435	21,103	16,454	10,988
<b>Alaska</b>							
AES, Univ. of Alaska	8,016	9,602	11,589	12,503	15,053	13,924	9,318
<b>Arizona</b>							
AES, Univ. of Arizona	54,156	66,874	73,426	60,007	59,239	54,686	57,164
<b>Arkansas</b>							
AES, Univ. of Arkansas	68,868	83,340	91,359	81,957	81,621	79,011	78,085
<b>California</b>							
AES, Univ. of California, Berkeley	187,777	218,204	232,257	203,790	212,367	226,345	245,028
SVM, Univ. of California, Davis	84,359	85,821	160,537	177,166	199,317	188,341	196,346
<b>Colorado</b>							
AES, Colorado State Univ.							
SVM, Colorado State Univ.	*124,800 <sup>b</sup>	*232,980	*260,767	*276,285	*260,477	*262,454	*230,633
<b>Connecticut</b>							
AES, Univ. of Connecticut, Storrs	11,928	16,840	17,924	20,041	22,256	24,065	23,806
<b>Delaware</b>							
AES, Univ. of Delaware	11,148	14,901	16,814	17,041	16,776	16,187	14,830
<b>Florida</b>							
AES, Univ. of Florida	76,232	94,598	98,792	82,307	81,509	79,028	82,855
SVM, Univ. of Florida	12,052	14,011	15,811	15,821	23,915	34,538	49,013
<b>Georgia</b>							
AES, Univ. of Georgia	43,330	46,979	49,398	40,281	37,903	33,989	29,647
SVM, Univ. of Georgia	111,302	130,171	137,082	124,516	130,479	136,986	143,203

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TABLE C-1 Continued

Fund Recipient <sup>a</sup>	1979 (\$)	1980 (\$)	1981 (\$)	1982 (\$)	1983 (\$)	1984 (\$)	1985 (\$)
<b>Hawaii</b>							
AES, Univ. of Hawaii	7,752	8,481	9,156	8,341	8,458	8,314	7,943
<b>Idaho</b>							
AES, Univ. of Idaho	58,175	73,323				71,230	64,687
SVM, Univ. of Idaho	23,845	27,517	*104,670	*85,447	*82,667	13,487	15,638
<b>Illinois</b>							
AES, Univ. of Illinois	56,076						
SVM, Univ. of Illinois	124,620	*200,909	*200,150	*167,905	*164,312	*171,958	*179,934
<b>Indiana</b>							
AES, Univ. of Indiana	8,381						
SVM, Univ. of Indiana	104,695	*131,077	*141,379	*120,908	*123,647	*123,794	*123,252
<b>Iowa</b>							
AES, Iowa State Univ.	30,634	35,405	42,338	51,691	64,009	70,018	67,881
SVM, Iowa State Univ.	250,322	311,942	326,415	280,350	261,622	254,464	258,524
<b>Kansas</b>							
AES, Kansas State Univ.							
SVM, Kansas State Univ.	*157,716	*194,993	*206,457	*185,103	*186,541	*190,193	*184,651
<b>Kentucky</b>							
AES, Univ. of Kentucky	91,668	107,071	109,265	93,303	98,340	98,166	98,092
<b>Louisiana</b>							
AES, Louisiana State Univ.	87,973	101,978	110,564	94,090	89,607	84,321	80,562
SVM, Louisiana State Univ.	4,127	11,486	15,512	17,501	25,013	30,105	30,042
<b>Maine</b>							
AES, Univ. of Maine	17,316	23,455	25,046	24,622	22,675	20,012	18,102
<b>Maryland</b>							
AES, Univ. of Maryland	56,469	64,442	68,862	54,976	57,058	50,065	48,548
Johns Hopkins Univ.	14,499	15,787	15,584	10,449	0	0	0

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<b>Massachusetts</b>								
AES, Univ. of Massachusetts	19,440	23,705	21,738	16,945	15,670	12,126	10,620	
SVM, Tufts Univ.	0	0	28,052	36,068	36,849	56,192	51,016	
<b>Michigan</b>								
AES, Michigan State Univ.			91,310	68,783				
SVM, Michigan State Univ.	*138,120	*148,301	51,366	47,294	*110,149	*107,814	*103,969	
<b>Minnesota</b>								
AES, Univ. of Minnesota	44,062	81,970	84,055	76,364	70,268	74,718	82,115	
SVM, Univ. of Minnesota	123,770	125,357	144,017	124,668	132,156	123,487	111,182	
<b>Mississippi</b>								
AES, Mississippi State Univ.								
SVM, Mississippi State Univ.	*56,712	*75,867	*81,045	*76,879	*69,523	*62,566	*52,007	
<b>Missouri</b>								
AES, Univ. of Missouri		75,175	66,293	45,869	42,073	61,934	73,452	
SVM, Univ. of Missouri	*130,920	87,841	121,398	123,728	121,225	93,589	67,853	
<b>Montana</b>								
AES, Montana State Univ.	91,956	106,421	111,624	89,650	83,889	77,041	77,156	
<b>Nebraska</b>								
AES, Univ. of Nebraska	147,648	180,942	203,947	184,801	190,134	191,682	193,987	
<b>Nevada</b>								
AES, Univ. of Nevada	28,620	30,751	30,547	23,947	21,672	18,647	17,365	
<b>New Hampshire</b>								
AES, Univ. of New Hampshire	16,512	16,872	16,206	12,753	12,482	11,678	11,190	
<b>New Jersey</b>								
AES, Rutgers Univ.	26,004	31,407	32,008	27,466	28,707	26,715	26,978	
<b>New Mexico</b>								
AES, New Mexico State Univ.	39,264	49,104	50,407	43,831	39,689	38,421	41,159	
<b>New York</b>								
AES, Cornell Univ.	24,734	24,621	38,475	43,554	51,701	50,473	51,250	
SVM, Cornell Univ.	181,522	203,053	223,216	188,889	199,730	206,594	221,233	
<b>North Carolina</b>								
AES, North Carolina State Univ.	117,576							
SVM, North Carolina State Univ.	0	*125,158	*126,026	*101,339	*97,640	*96,193	*100,061	

TABLE C-1 Continued

Fund Recipient <sup>a</sup>	1979 (\$)	1980 (\$)	1981 (\$)	1982 (\$)	1983 (\$)	1984 (\$)	1985 (\$)
<b>North Dakota</b>							
AES, North Dakota State Univ.	58,764	67,213	69,565	57,879	56,734	57,644	58,502
<b>Ohio</b>							
Agriculture R&D Center, Ohio State Univ.	86,789	98,576	89,550	65,621	61,952	64,874	70,716
SVM, Ohio State Univ.	56,227	51,921	60,966	69,974	70,324	70,147	53,379
<b>Oklahoma</b>							
AES, Oklahoma State Univ.	130,158	148,637	157,722				
SVM, Oklahoma State Univ.	4,002	6,145	5,066	*130,813	*129,962	*123,764	*125,298
<b>Oregon</b>							
AES, Oregon State Univ.	44,287	58,795	66,998	63,963	68,444	62,117	53,015
SVM, Oregon State Univ.	47,045	54,244	59,314	50,978	40,850	37,633	42,804
<b>Pennsylvania</b>							
AES, Univ. of Pennsylvania	60,428	67,793	64,985	55,225	52,832	52,447	52,337
SVM, Univ. of Pennsylvania	62,399	74,501	97,406	105,426	117,555	119,387	108,886
Lehigh Univ.	2,549	2,791	0	0	0	0	0
<b>Puerto Rico</b>							
AES, Univ. of Puerto Rico	7,164	19,280	16,935	16,008	16,418	15,292	14,543
<b>Rhode Island</b>							
AES, Univ. of Rhode Island	12,684	12,199	15,231	12,658	13,549	14,402	14,910
<b>South Carolina</b>							
AES, Clemson Univ.	28,704	28,671	28,397	23,241	23,012	23,754	23,555
<b>South Dakota</b>							
AES, South Dakota State Univ.	101,676	118,702	125,871	109,615	105,878	101,127	96,112
<b>Tennessee</b>							
AES, Univ. of Tennessee							
SVM, Univ. of Tennessee	*64,812	*73,301	*82,137	*73,990	*76,904	*74,629	*70,441

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<b>Texas</b>							
AES, Texas A&M Univ.							
SVM, Texas A&M Univ.	*362,604	*425,692	*436,027	*343,157	*319,658	*331,193	*346,564
<b>Utah</b>							
AES, Utah State Univ.	34,476	52,768	60,889	61,031	61,301	60,935	57,344
<b>Vermont</b>							
AES, Univ. of Vermont	16,752	19,305	19,674	17,148	18,253	18,977	18,298
<b>Virginia</b>							
AES, Virginia Polytechnic Institute and State Univ.							
SVM, Virginia Polytechnic Institute and State Univ.	*70,956	*85,377	*95,619	86,636	90,487	84,512	90,624
<b>Washington</b>							
AES, Washington State Univ.	39,975	37,457	35,524	28,038	27,741	30,950	34,631
SVM, Washington State Univ.	71,557	94,349	115,483	110,128	115,258	111,666	116,010
<b>West Virginia</b>							
AES, West Virginia Univ.	17,652	21,579	23,531	18,317	17,463	16,035	16,267
<b>Wisconsin</b>							
AES, Univ. of Wisconsin	176,148	225,816	239,723	215,841			
SVM, Univ. of Wisconsin	0	0	0	0	*212,814	*213,497	*208,846
<b>Wyoming</b>							
AES, Univ. of Wyoming	43,812	50,106	51,986	43,044	42,162	42,203	43,265
<b>TOTAL</b>	<b>\$4,807,000</b>	<b>\$5,759,600</b>	<b>\$6,240,100</b>	<b>\$5,529,600</b>	<b>\$5,518,541</b>	<b>\$5,496,422</b>	<b>\$5,474,304</b>

<sup>a</sup>AES = agricultural experiment station; SVM = schools and colleges of veterinary medicine.  
<sup>b</sup>Asterisk (\*) denotes AES and SVM combined.

SOURCES: Animal Health Science Research Advisory Board, Sept. 18, 1985 (minutes).

## APPENDIX D

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