Organizing and Financing Basic Research To Increase Food Production

Background

In February 1975, Senator Hubert Humphrey, as a member of the Technology Assessment Board, asked the Office of Technology Assessment to assess the current status of research and development in food and agriculture, Senator Humphrey's request was followed by a similar request from Representative Olin E. Teague, Chairman of the House Committee on Science and Technology. Chairman Teague asked OTA, with the help of its Food Advisory Committee, to report its findings as a supplement to the Committee's planned oversight hearings on agricultural research and development.

At the time these requests were received, a number of agencies and committees were reviewing and evaluating food, agriculture, and nutrition research:

- The General Accounting Office was engaged in a general overview study of the organization, scope, and management of publicly supported agricultural research;
- The Congressional Research Service was preparing responses to several congressional requests on aspects of the organization, priorities, and funding for publicly financed food and agriculture research and development;
- The Agricultural Research Policy Advisory Committee of the National Association of State Universities and Land-Grant Colleges and the U.S. Department of Agriculture (USDA) were organizing a National Food and Agriculture Research Users Conference to be held July 9 to 11, 1975, in Kansas City. The purpose of the conference was to inventory the wide-ranging food and agricultural research activities underway at USDA and the universities, and to establish priorities for future research funding.
- Special oversight hearings on food and agriculture research were scheduled by two subcommittees of the House Committee on Science and Technology for the summer and fall of 1975;
- The Board on Agriculture and Renewable Resources of the National Academy of Sciences had completed a report, Enhancement of Food Production in the United States, released in late 1975.
- Responding to a 1974 request from President Ford, the National Academy of Sciences (NAS) was engaged in a 2-year World Food and Nutrition Study involving 14 committees and numerous subcommittees, (The NAS issued an interim report in November 1975.)

The requests for an OTA assessment were discussed with OTA's Food Advisory Committee against the background of these activities, Chairman* Clifton Wharton, Jr,, appointed a subcommittee to confer with OTA staff, review the scope and preliminary findings of related studies, and narrow the assessment scope.

The subcommittee and staff established the following guidelines for a response to the congressional requests. The response should:

- avoid duplication of similar reports;
- be a significant and unique undertaking;
- be manageable in size;
- lead to options for congressional action; and
- be completed in time for legislative use.

Using these guidelines, OTA focused its food and agriculture research and development activities on two areas: implications of increased support of research on major food crops in developing countries, and the area addressed in this report, organizing and financing basic research to increase food production,

"Dr. Wharton, President, Michigan State University served as Chairman until June 1976.

Bask Food Production Research Inadequately Supported

Public support for research to increase food production has declined in the last two decades for a number of reasons. In the 1950's and 1960's, Congress was concerned more with the costs of storing surplus crops and maintaining farm income support programs than with food production research. Although public support has increased modestly, in recent years increases in appropriated funds have not been large enough to offset the loss in the purchasing power of the appropriations due to inflation.

Basic research in the biological sciences related to food production has historically been an undifferentiated segment of the research programs supported both by USDA, in its own Agricultural Research Service, and in the State Agricultural Experiment Stations. Under conditions of declining funds, however, increasing demands for research to solve current production problems has forced a sharp decline in the support for basic research in the biological sciences related to food production. Scientists who testified at the hearings on agricultural research and development (before the subcommittees of the House Committee on Science and Technology, September 23 through October z, 1975,) observed that recent technological advances in crop production in the United States have exhausted the previously existing backlog of basic research available to plant and animal production scientists in a number of areas and that additional basic research is needed,

Administrators of publicly supported agricultural research institutions have been successful in obtaining modest increases in funds for agricultural research in recent years. Almost all increases have been utilized to support urgently requested pest, disease control, and adaptive research, Thus with the need to tackle immediate problems, only a small amount of the additional funds have been channeled into basic research to increase food production. The Department of Agriculture does not have established procedures for financing basic research, as distinguished from adaptive or developmental research.

The National Science Foundation (NSF) recognizes USDA as the lead agency in agricultural research, and in the past has provided only limited support for basic research in biological sciences to increase food production, Although the need for increased research in the biological sciences related to agriculture has been recognized by groups of scientists for several years, little progress has been made in developing plans for organizing and financing increased basic research to increase food production,

There is substantial agreement among agricultural scientists that three high-priority basic research areas-photosynthesis, biological nitrogen fixation, and cell culture studies-offer unusual promise of high potential payoff over a moderate to long-term time period, To illustrate its points, OTA's assessment includes:

1. A consideration of methods for organizing and financing research in these three areas, and the application of these methods to the administration of high-priority basic research to increase food production in related areas; and
2. An examination of the costs and benefits of increased research in these three areas.

To obtain the advice of a diverse group of scientists, OTA established an n-member advisory panel that represented views from the university community, both agricultural and non-agricultural, private research organizations, and industry,

The advisory panel addressed both issues: alternatives for administering basic research to increase food production, and the costs and benefits of expanded research in the three selected areas.

This report reviews the findings of scientific groups concerned with both the need for basic research in high-priority areas and the prospective returns from additional investments in basic research to increase food production, It considers alternatives for administering such research and the implications of alternative levels of financing this research, Finally, it reviews the options open to Congress in dealing with this issue. In preparing this OTA report, the OTA staff drew upon the findings and conclusions of the advisory panel, as well as supplemental materials. The panel's detailed review of the research underway in photosynthesis, biological nitrogen fixation, and cell-culture studies and suggestions for expanding this research over a 6- to lo-year period are attached to provide technical background for the report.

Findings of Scientific Groups

In the past 10 years, four scientific groups have reviewed the agricultural research conducted by USDA and the State Agricultural Experiment Stations,

In April 1965, the Senate Committee on Appropriations requested, in Senate Report No. 156,

> ... that the Secretary of Agriculture give immediate consideration to the establishment of an appropriate research review committee comprised equally of representatives of land-grant experiment stations, Department research activities, affected producer organizations, and with appropriate industry representation, to examine fully each and every line of agricultural research conducted by the Department and by the State Experiment Stations,

A USDA-SAES task force was organized and a response to this request was issued in October 1966.[1] The task force found that USDA-SAES agricultural research activities required 10,330 scientist years in 1965, and recommended an increase to 14,250 scientist years for the year 1972, 18,170 by the year 1977.

In February 1969 Clifford M, Hardin, then Secretary of Agriculture, requested the Division of Biology and Agriculture, NAS, "To ascertain gaps in agricultural research and make such recommendations as might be appropriate ., . "

Panels were appointed by NAS to review areas of research, visit laboratories, and interview research scientists and administrators in both USDA and the universities,

An NAS committee, under the chairmanship of Dean Glenn Pound of the University of Wisconsin, issued an 80-page report of its findings and conclusions in 1972, together with a 384-page appendix consisting chiefly of the reports of the individual panels.[2] In its general summary, the committee said:

> Bold moves are called for in reshaping administrative philosophies and organizations, in establishing goals and missions, in training and management of scientists and in allocation of resources. There are too many field laboratories . . .

This underscored the report's conclusion that effective use could be made of additional funding,

With respect to level of funding, the committee recommended:

- That increases in Federal support to the SAES via formula funds be maintained at a level at least proportionately as great as for USDA in-house research.

I Association of State Universities and Land-Grant Colleges and the U.S. Department of Agriculture, A National Program of Research for Agriculture~, Washington, D. C.: U.S. Department of Agriculture. 1966

[2] Committee on Research Advisory to the U.S. Department of Agriculture, Report of the Committee on Research Advisory to the U.S. Department of Agriculture. Washington, D.C.: National Academy of Sciences, 1975.

- That the USDA seek a greatly increased level of appropriations for a competitive grants program, which should include support of basic research in the sciences-biological, physical, social—that underpin the USDA mission. These appropriations should be without commodity earmarking, although they should not exclude commodity-related research. They should be available to scientists in the USDA, in land-grant and nonland-grant public universities or colleges, and in private universities or colleges, institutes, and other research agencies.
- That this program be administered in such a way that research proposals are subjected to evaluation by peer panels of selected scientists drawn from those eligible for support, and that administration of the program be different from the administration which allocated funds for USDA in-house research.

A Committee on Agricultural Production Efficiency of the Board on Agriculture and Renewable Resources, NAS, was organized in 1971 to "evaluate the adequacy of the Nation's policies, knowledge, and technology relative to agriculture research and education efforts. " The committee issued a 199-page monograph in 1975, which reviewed new research and agricultural technology, the practical problems for getting improved technologies adopted by small, undercapitalized farms, and the ability of society to make wise choices when a technological change has the possibility of causing adverse environmental effects.[3] The committee's report included these statements:

- We see no way to avoid the problems of basic uncertainty about the future , .,
- A recent study by the Battelle Institute (1973) suggests that the average lead time in research is about 20 years and that it has not decreased appreciably over the years . . ,
- For major advances in the practices and technologies of agriculture, the Nation must continue to look to the research programs in public institutions and in private industry . . .
- The long-range breakthroughs in knowledge and technology that can boost our apparent productivity ceilings will require greater emphasis on basic research attuned to clearly perceived goals ., ,
- There is an urgent need for agricultural research to receive increasing-emphasis and much greater support. The future well-being of mankind could be at stake . . .

The monograph closes with the following sentence:

> The breakthrough in science and technology that must precede the long-range achievement of increased agricultural production efficiency requires additional investment in promising basic research areas such as cell fusion, photosynthesis, and biological nitrogen transformations, being ever mindful of the need to seek practical field applications of major advances in knowledge . . .

The Board on Agriculture and Renewable Resources, NAS, recommended a substantial increase in support for research directed toward the production, dependability, and quality of the food supply in its 1975 report, Enhancement of Food Production in the United States[4]:

- Financial support for such research should be increased to restore at least the 1966 buying power, and the support should be broadly distributed.
- State and Federal support, now totaling about $450 million per year, for research related to agricultural productivity should be increased immediately by 40 percent.

[3] Committee on Agricultural Production Efficiency, Agricultural Production Efficiency. Washington, D. C.: National Academy of Sciences, 1975.

[4] Board on Agriculture and Renewable Resources, Enhancement of Food Production in the United States. Washington, D. C.: National Academy of Sciences, 1975.

Regarding basic or fundamental research, the report stated:

- Fundamental research undergirding food production technology has languished for two decades.
- Ž The National Science Foundation has not focused on agriculturally related research, although it has given substantial support to botany, zoology, and plant and animal physiology and pathology.
- USDA-SAES complex has not adequately funded basic research relating to biological processes that control crop and livestock productivity and insure a greater stability of supply,

The Steering Committee, Commission on International Relations, National Research Council, repeated several of the recommendations made in the earlier report of the Board on Agriculture and Renewable Resources in its interim report, World Food and Nutrition Study, issued in November 1975. The Steering Committee stressed the potential for increasing crop productivity both through improvement in photosynthesis and nitrogen fixation and through the development and use of tissue culture techniques. The interdependence of these three research areas was emphasized as follows:

- To the extent that greater nitrogen fixation and photosynthesis can be induced by genetic changes, the prospects will be multiplied by progress in the application of cell fusion or DNA recombination techniques to genetic manipulation.[5]

Returns From Additional Investments in Basic Research to Increase Food Production

Scientific groups concerned with priorities in food and agricultural research are agreed that the returns from a long-term program of expanded basic research are likely to be great, although additional investments in a wide variety of projects are needed.

An increase in the efficiency of photosynthesis in a crop like soybeans could result in 50-percent increase in yield per acre. The annual value of increased production, reduced acreage, and/or production costs would amount to no less than $1 biIliOn, assuming this increase of only 50 percent in the yield of soybeans in the United States.

Improvement in nitrogen fixation in legumes also would result in large gains. A 10 percent increase in soybean yield has been reported in the last few months where improved nitrogen-fixing bacteria have been utilized in producing the crop.[6] An even greater gain would be achieved with the development of symbiotic nitrogen fixation in corn, cereal grains, or any important crop other than legumes, Such a discovery could reduce the need for nitrogen fertilizer by millions of tons per year in the United States and throughout the world. A saving of half a billion dollars a year in the United States for nitrogen fertilizer is not an unrealistic expectation.

Cell-culture studies offer promise for developing new combinations of germ plasm and thus provide a means for genetic engineering which could lead to new strains of Rhizobium with much higher nitrogen-fixing capacity. They could also lead to new varieties of soybeans, cereals, potatoes, and other crops with substantially higher photosynthetic efficiency levels than occur in conventional plant-breeding methods. In addition, cell and tissue cultures have demonstrated their value both in freeing important cultivars of viruses and other pathogens and as a method for rapidly propagating new improved cultivars, especially those that are reproduced asex-

[5]Steering Committee, NRC Study on World Food and Nutrition, *World Food and Nutrition Study, interim Report.* Washington, D. C.: National Academy of Sciences, November *1975,* p. *28.*

[6]*New York* Times, Sept. 27, 1976.

ually. Further research with cell and tissue cultures are likely to lead to additional possibilities for plant improvement,

Scientists consulted by OTA on this project are agreed that:

- The potential for making a major breakthrough within the next 10 years in any one or all three of these high-priority areas is so great that significant expansion in research support is fully justified.
- Sustained research effort is likely to be required for the balance of the 20th century if we are to realize the gain to be made from substantially increasing and exploiting scientific knowledge.

There is a wide consensus in the scientific community that the results of additional investments in research in the areas cited above could be greater than in most other basic research areas. Groups of scientists have identified several areas in addition to photosynthesis, nitrogen fixation, and cell-culture studies which could have substantial returns from expanded research could be substantial.

Most studies of the, productivity of agricultural research indicate that investments in agricultural research in the United States since World War II have shown an annual return of 30 to 40 percent, A summary of the findings of a number of cost-benefit studies of agricultural research investments in the United States and in other countries as compiled by T.W. Arndt and V.W. Ruttan is shown below:

Summary of Direct Cost-Benefit-Type Studies of Agricultural Research Productivity*

Study	Country	Commodity	Period	Annual Rate of Return (%)
Griliches (1958)	U.S.A.	Hybrid Corn	1940-1955	35-40
Peterson (1966)	U.S.A.	Poultry	1915-1960	20-25
Ardito-Barletta (1970)	Mexico	Wheat	1943-1963	90
Ardito-Barletta (1970)	Mexico	Maize	1943-1963	35
Everson (1969)	S. Africa	Sugarcane	1945-1962	40
Ayer (1970)	Brazil	Cotton	1924-1967	77
Hertford, Ardila, Rocha, and Trujillo (1967)	Colombia	Rice	1957-1972	60-82
	Colombia	Soybean	1960-1971	79-96
	Colombia	Wheat	1953-1973	11-12
	Colombia	Cotton	1953-1972	none
Peterson and Fitzharris (1975)	U.S.A.	Aggregate	1937-1942	50
			1937-1952	51
			1957-1962	49
			1967-1972	34

*From *Allocation and Productivity in National and International Agricultural Research*, a seminar report. New York: The Agriculture Development Council, Inc., September 1975.

On the basis of these studies, it is likely that an investment of $300 to $500 million over a lo-year period in expanding basic research would yield returns over the next 20 years of $1 to $2 billion.

Institutions for Administering Basic Research for Food Production*

Basic research to increase food production is defined as those research areas 1) possessing exceptional opportunity for discovery of knowledge vital to the basic understanding of important biological processes in plants and animals, and 2) which can contribute to applied research on problems that have large impact on societal needs and urgency of implementation, They require the participation of a small group of scientists and frequently will benefit from large-scale multidisciplinary and interinstitutional cooperation.

The Federal Government might support additional basic food production research by creating new or expanding existing Federal agricultural research agencies. It could earmark funds for basic research and allocate them to the 55 State Agricultural Experiment Stations on a formula basis. Or, it could make Federal funds for basic research available through a competitive awards program administered by USDA or NSF.

Federal funds are presently appropriated for specific agricultural research projects in USDA and for major research areas such as marketing, production and rural development at the State Agricultural Experiment Stations. The stations' funds are allocated on a formula basis, taking into account population and other factors, Most efforts to increase appropriations for agricultural research in recent years have focused on increased funding for research on pressing problems, such as pest and disease control, or on increasing funds available to State Agricultural Experiment Stations on a formula basis. These increased funds in turn being used to deal with immediate problems. The net effect has been to short change basic research whose payoff is long term.

There is a widespread agreement among both university and Federal agency scientists that creating new Federal agencies to conduct basic research to increase food production would be less cost effective than providing additional funding for institutions and scientists who now have ongoing basic research programs, There is also substantial agreement that funds for high-priority basic food production research should not be allocated on a formula basis if additional basic research funds were made available to USDA and the SAES on a formula basis, There is a high probability that the funds would continue to be utilized in many cases for adapative research and the numerous pressing problems. Further, such a distribution precludes the opportunity to obtain the needed critical mass of funds and personnel to make the kind of breakthroughs expected of basic research.

There are wide variations both in the staffing of Federal, State, and private research agencies and in their ability to provide increased basic research related to food production. For this reason, the usual project and formula basis for allocating agricultural research funds would not be cost effective in allocating high-priority basic research. The greatest progress in basic research in the near future can be achieved by increased funding for those scientists and groups of scientists who now have both ongoing basic research programs to increase food production and proven competence in the field.

Competitive Awards. There is substantial concensus among scientists that the most cost-effective way of financing increased basic research to increase food production is through a competitive awards program. Competitive grants should be available to qualified scientists in USDA research agencies, the State Agricultural Experiment Stations, public and private universities, and nonprofit research

*Some scientists perceive the term "basic research" to pertain to investigations of fundamental processes and relationships without regard to how such knowledge might be applied in a production process,

institutions, The key features of such a program would be:

1. Research proposals should be developed in detail by the principal investigators.
2. Research proposals should be reviewed and rated by peer review committees.
3. Funds should be distributed, usually in the form of grants for 3 to 5 years, according to the scientific merit of the proposals and an appraisal of past performance.

Disadvantages of Competitive Awards. Research grants made on a competitive awards basis tend to be awarded to scientists located at well-established research institutions, thus contributing to the rapid growth of these institutions relative to younger and smaller research institutions. The allocation of research grants on a competitive basis also requires that qualified scientists spend considerable time as members of peer review committees, reviewing research proposals.

The administration of high-priority basic research to increase food production could be assigned to USDA, NSF, another existing agency, or a new Federal agency. Historically, USDA has borne the responsibility for food and agricultural research. It has met these responsibilities within the limits of its funds. There is ample evidence of excellent basic research in the USDA-SAES complex. It appears that with adequate levels of funding and changes in allocation procedures, USDA could administer a first-rate program in basic research to increase food production,

An advantage to assigning the responsibility for basic research in the biological sciences to USDA is that the purpose of increasing the Nation's commitment to basic agricultural research is to provide new knowledge which will enable this Nation to significantly increase its production of food. Lines between basic research, applied research, and development of technology are not clear, but the three are interrelated. USDA and SAES scientists have demonstrated their ability to take new information in the biological and physical sciences and apply it to the production and protection of plants and animals through applied research and the development of improved technology, There is merit in supporting basic research through an agency that has the ability to followup with applied research and technological development, and both USDA and SAES have this ability.

The National Science Foundation has established an excellent record for supporting basic research, including work in the biological sciences important to agriculture. It has devised effective procedures for soliciting research proposals in the basic sciences, reviewing the proposals, and making awards to the most productive and promising scientists. The National Science Foundation is capable of handling basic agricultural research but does not have the responsibility, nor is it as well-equipped to support or to integrate the necessary applied research and the development of new technology.

While increased funding for basic research to increase food production could be administered by NSF, it appears that a more efficient and less costly way to proceed would be to assign the responsibility to USDA.

Administering Agencies within USDA. A number of agencies within USDA could administer basic research. Any agency selected would require an experienced administrative officer with high standards of performance in research. The person in charge of administration should be a recognized authority in an important area of basic agricultural research.

If a new office for awarding grants for basic research to increase food production were established, it would not need a large staff. The staff should be sufficient to solicit and acknowledge receipt of research proposals, organize and assist peer-review panels, allocate and administer grants, organize and sponsor special symposia, and prepare annual reports and budgets. In addition to his or her

other responsibilities, the person in charge of the administration of grants for basic research to increase food production should have liaison with other agencies supporting or conducting agricultural research and be a member of the interagency Federal Coordinating Council for Science, Engineering, and Technology, and other such relevant groups as may be established.

An advisory board of 12 to 15 rotating members, appointed by the Secretary of Agriculture and representing a variety of disciplines, regions of the county, and Federal, State, and private organizations, may be needed to oversee the program, If such a board were established, it could assist the administrator in the development of proposals and in the selection of areas of research which should be given priority.

The board could also periodically or annually review the areas of basic research to increase food production which should be given priority. It would be the board's responsibility to recommend to the administrator of the program, as conditions change, and to the Secretary of Agriculture the designation of additional basic research areas to be given priority funding,

In establishing operating and review procedures, the administrator and the advisory board should be guided by current practices in the National Institutes of Health (NIH) and by the recommendations in National Science Foundation Peer Review, Volume I, January 1976.

USDA **Has Competitive Grants Authority.** Under Public Law 89-106, the Secretary of Agriculture now has authority to make research grants on a competitive basis for a period not to exceed 5 years for any one grant. Scientists in Federal agencies, however, are not eligible for grants under Public Law 89-106. This authority has been delegated to the Administrator of the Cooperative State Research Service. Congress appropriated funds for FY 1977 for research grants totaling $4.5 million to be awarded on a competitive basis in 11 specified areas.

Administration of grants for basic research to increase food production could be assigned to the Administrator of the Cooperative State Research Service (CSRS). He or she would be responsible for administering all research grants.

There would be a number of advantages in making such an arrangement, as CSRS has experience in administering grants awarded on a competitive basis. Congressional concern could be minimized, overhead costs reduced, and continuity provided. There are also disadvantages to such an arrangement, since CSRS is primarily concerned with activities of the State Agricultural Experiment Stations. Current CSRS programs require increasing amounts of funds and might prevent programs in basic research from receiving the attention and funds they need. The Secretary of Agriculture would have to see to it that participation in the program is open to all qualified scientists, whether they are at State Agricultural Experiment Stations, publicly or privately endowed universities, or at nonprofit research agencies.

An alternative would be to establish an Office of Basic Research Grants as a separate USDA agency, This would provide a high visibility within USDA, assure program integrity, and it would not disrupt operations. It would prevent domination of research grants by a single agency and prevent confusion with other competitive grants. The major disadvantage of this arrangement is that a separate agency would require a separate accounting staff and other administrative services; such services are available in other research agencies in USDA, Since it would be a leading office, its future budget might be restricted despite its small size.

Alternative number 3 is a variation on number 2, It would establish an Office of Basic Research Grants as a separate USDA agency, However, it would have a pass-

through provision for funding other agencies which support or conduct basic research to increase food production, such as NSF. This arrangement would recognize USDA as the leading Government agency for food and nutrition research, but would assure the entire scientific community access to funds supporting basic research, Coordination of research funding activities in USDA, NSF, and other agencies concerned with funding basic research would be improved, The scientific community might have greater confidence in the new funding program under such an administrative arrangement.

The significant disadvantage is that it reduces the leadership role of USDA as the agency to promote basic research to increase food production, and increases the costs of administering the grant funds.

Alternative Levels of Financing High-Priority Bask Research To increase Food Production

A comprehensive statement concerning the additional research needed on the more important problems relating to food was prepared by an ad hoc work group of the Agricultural Research Policy Advisory Committee,[7] This group reviewed the adequacy of current research for each of 134 of the most important problem areas identified at the 1975 Kansas City Conference on Research to Meet U.S. and World Food Needs and, in its 1975 report, by the NAS Board on Agriculture and Renewable Resources.

The ad hoc working group of the committee concluded that research should be increased on 117 of the problems. The increases recommended for all 117 problems would require 2,031 scientist years and cost $215 million over a period of 4 years.

The amount of labor expressed in scientist years and the recommended increases over a 4-year period in each of three broad subject areas is shown below:

	Current Scientist Years	Recommended Increase in Scientist Years	Percent
Human Needs for Food, Including Nutrient Requirement, Food Technology, and Food Safety.	**622**	**305**	**49**
Organization of Resources to provide Public Policy,, Finance, and international Development.	582	**191**	**33**
Management of Resources to Provide Food, Including Land Water, Crop, and Livestock Production	4702	1535-	33
Total	**5906**	**2031**	**35**

No comparable analysis has been made for the number of scientist years and necessary increases in basic research to increase food production.

The OTA advisory panel was asked to direct its attention to the more limited subject of needed increase in basic research in photosynthesis, nitrogen fixation, and cell-culture studies, Their analysis indicates that current research funding through all public and private sources amounts to about $15,6 million annually for the three areas. About 290 USDA-SAES scientists are engaged in the three areas of research. In addition, approximately 75 scientists are at other universities, nonprofit organizations, and in private industry. (Table 1.)

[7] Report of Ad Hoc Work Group on Most Important Problems, U.S. Food Research. Washington, D. C.: U.S. Department of Agriculture, May 1976 (duplicated).

The advisory panel estimated that in the first year of an expanded basic research program in the three areas of photosynthesis, biological nitrogen fixation, and cell-culture studies, research funding requests of merit would total $12.25 million. Additional funds would be needed for administering the program of grants to be awarded on a competitive basis.

The advisory panel emphasized the close relationship among the three areas of research and urged maximum flexibility in allocating them any increased funding. The panel's technical analysis and discussion is included in their attached "Supplementary Technical Analysis."

The first objective of an expanded basic research program should be the provision of more adequate support for scientists now doing high-quality research in these areas. After their needs have been met, the panel recommends annual increases in funds for a 6-year period in order to increase the number of scientists working in these high-priority areas by 40 to 50 percent,

The minimum expansion program for the three research areas would start at $12.45

Table 1. **Estimated** Annual Expenditures and Scientist Yews for Research on Photosynthesis, Nitrogen Fixation and Cell Studies

(Expenditures in $1000)

	Current Research Information System[1]							NSF[4]
	CSRS Admin./ USDA Approp.	Other Federal	Non-Federal[a]	Total	No. Res. Projects	Number of Scientists Scientists	Years[3]	
Photosynthesis	$2,497	$633	$2,849	$5,979	140	182	77	$3,723
Nitrogen Fixation	867	415	920	2,202	54	71	30	1,285
Cell Studies	451	58	601	1,110	28	37	16	612
Totals	$3,815	$1,106	$4,370	$9,291	222	290	123	$5,620

[1] Analysis of Juno 1976 CRIS data by W. K. Kennedy.

[2] Agricultural Research and Development Special Oversight Hearings, Part II, before Subcommittee on Science, Research, and Technology and the Subcommittee on Domestic and International Scientific Planning and Analysis of the Committee on Science and Technology, U.S. House of Representatives, No. 51, U.S. Government Printing Office, 1976, Pages 1126 and 1127.

[3] *Note*: Scientist years indicates the number of full-time scientist equivalents. A somewhat greater number of scientists are engaged in the designated areas of research, since those at the universities hove teaching os well os research responsibilities.

[4] *Note*: At least o portion of the support provided by NSF for research on photosynthesis and nitrogen fixation may be included in the other federal funds listed under CRIS. Hence the total for photosynthesis may be about $9.2 million and for nitrogen fixation about $3.1 million. The total level of annual research support for these three high. priority areas moy be about $13.4 million through USDA, NSF, and SAES.

million the first year, increasing to about $50 million in the tenth year. The advisory panel believed that such an expansion program should be considered a minimum effort. The provision of funds for an even greater expansion was recommended, permitting a 60 to 70 percent increase in the number of scientists engaged in basic research in photosynthesis, biological nitrogen fixation, and cell-culture studies over a lo-year period.

A complete review of basic research in the three areas and a proposed lo-year expansion program is developed in detail in the advisory panel's attached "Supplementary Technical Analysis, "

Bask Research in Other Areas

Expansion programs for basic research to increase food production in other areas, such as management and breeding of plants to minimize environmental stress, plant growth regulators, or more effective and less dangerous pesticides, would merit perhaps roughly comparable funding.

The NAS World Food and Nutrition Study issued in June 1977 proposes a first-year increase in Federal funds for food and nutrition research of $l20 million to be divided equally between (1) USDA in-house research and Hatch formula allocations, and (z) a new grants award program. The study proposes that after the first-year research funds be increased 10 percent per year for a 5-year period. Such a program of increases would raise USDA research support from $522 million to nearly $1 billion annually.[8] Although the scientists in this study emphasize the need for increased basic research to increase food production, they do not indicate how the funds for competitive grant programs should be allocated between basic and applied research. It is probable that fully half to two-thirds of the funds made available in the next 5 to 10 years for expanded food and nutrition research under a competitive grants program should be allocated for basic research.

[8]Steering Committee, NRC Study on World Food and Nutrition. World Food and Nutrition Study, final report, Washington, D.C., National Academy of Sciences, June 1977, p. 19.

Summary

Available studies and discussions with informed agricultural scientists point to an urgent need for additional basic research directed toward increasing food production. The three highest priority areas, from the standpoint of prospective payoff, appear to be those discussed in this report—photosynthesis, biological nitrogen fixation, and cell-culture studies. A minimum expansion program in these three areas should start at $12.45 million and increase several million dollars a year for a 6-year period, An even larger program would be needed to fully use the potential opportunities for an accelerated program of basic research in five or six important basic research areas.

Congressional Options

The past 10 years have been years of rapidly growing research programs in health, space explorations, energy, environmental protection, and related fields, but years of declining research programs for the enhancement of food production. Scientists have been drawn from basic food and nutrition research into these other fields. The sharp inflationary price increases in the past 5 years have not been matched by comparable increases in Federal funds for food and agriculture research. Federal appropriations for research in USDA and the State Agricultural Experiment Stations totaled $522,284,000 for FY 1977. However, appropriations of $570,584,000 would have been required to provide the same level of research support as in 1966. Federal appropriations for USDA-SAES research for FY 1977 lack $48.3 million of equal purchasing power of the 1966 appropriations for research.

The issue for Congress is what priority to place on an expansion in basic research to

enhance food production. If Congress desires more public funds invested in such basic research, it appears that funds will have to be earmarked for this purpose. Otherwise, as research funds are now administered both in USDA and in the State Agricultural Experiment Stations, there is no assurance that additional funds will be utilized for these specific purposes. Thus option number one for Congress is to continue the status quo. However, if changes are desired, option number two would be to earmark funds allocated under a competitive grants program utilizing a peer review system. This appears to be the most satisfactory means of assuring that such funds will be utilized effectively in expanding high-priority basic research. Additional legislation is not required for the administration of such funds. Without additional directives the Secretary of Agriculture would have discretion, as provided in Public Law 89-106, to delegate the administration of such funds to any member of his administrative staff, Legislation may be required, however, to authorize the Agricultural Research Service to participate in competitive grants programs,

The third option for Congress would be to pass legislation setting up a USDA Office of Basic Research Grants, with or without a pass-through provision. The legislation could provide for a 5- to lo-year or longer term program at either minimum or higher funding levels,

A fourth option for Congress would be to authorize and fund an NSF program of expanded basic research to increase food production.