U. S. Department of Agriculture
Cooperative State Experiment Station Service

Agricultural Research in Relation to Growth of Funds for Research and Development

Mr. Chairman, Dean Jackson, Director Farrell, and members of the faculty of the College of Agriculture:

I am happy to be with you for one of your seminars on research.

The Research and Graduate Study Committee is to be commended on the objectives they have outlined for your seminar series. Your careful evaluation of research policies, programs, relationships, and needs is essential for establishing an understanding of how research and educational objectives can be met most effectively.

Challenges associated with the successful accomplishment of your goals are magnified by the accelerated rate of change in the environment, both now and as we look into the future. Your 1962 summer issue of Science for the Farmer points out the need for adjustment to change; and the importance of these adjustments to all the people of your State.

The many significant contributions agricultural research and education have made to our national strength, economic growth, and physical well-being were given emphasis during 1962 as a proper part of the observance of the Land-Grant College and U. S. Department of Agriculture Centennials.

Let no monument of past accomplishments obstruct our vision of what will be demanded of each of us in the years ahead. Increased zeal and

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Presented by Deputy Administrator H. C. Knoblauch, Cooperative State Experiment Station Service, U. S. Department of Agriculture, before the Agricultural Faculty Seminar, Pennsylvania State University, University Park, Pennsylvania, February 15, 1963.

dedication to advancements in agricultural research and education are necessary if the world and we in this Nation are to move forward on the interrelated problems of agriculture for the benefit of mankind.

At times I feel we have stressed accomplishments so much that the public may feel that we do not see the problems. Considerable thought and planning should be given to the analysis and effective presentation of the State station potential for effective research.

My assignment in today's seminar is to provide information on funds from various sources for research and development.

Your program chairman will confirm my reluctance in accepting a seminar presentation wherein funds would be considered as an independent variable. There are many factors relevant to the general problem of obtaining financial support for agricultural research. Today I want to consider some of them with you.

Agricultural scientists know that the pre-eminent position of America in the world's agriculture can only be maintained by a dynamic, adequately supported program of research. Faced with old and new problems that intensify with time and require research beyond available funds from established sources, experiment station and university administrators and scientists are forced into the competitive race for dollars.

The record indicates that these efforts have been sporadic and only moderatley successful when considered in relation to the total national research and development activities. An overshadowing problem in agricultural research is that of maintaining quality, continuity, and balance while at the same time meeting the legal requirements of the several grant and contract programs.

Having worked under and participated in the administration of the pioneering Federal-grant research program provided under the Hatch Experiment Station Act, my convictions are very strong that the type of basic institutional grant provided under this Act has no equal for accomplishing agricultural research objectives and contributing to national strength.

Here at Pennsylvania State University, your leadership has shown an understanding of the facts and realities. In his address, "Reorganization for Progress," given before the 1960 Land-Grant College Meeting, President Eric Walker (1) recognized the need of Federal support for science. He outlined the advantages of the pattern of Federal support for State experiment stations established under the Hatch Act of 1887 and subsequent legislation, as reaffirmed by Congress in the amended Hatch Act of 1955. This legislation authorizes Federal payments to the State experiment stations on a formula basis with the Director determining the research to be carried on under the Federal-grant funds. He does so on the basis of his best judgment of problems, urgency of research needs, and staff capabilities in given scientific areas.

Funds for Research and Development

For background and later discussion purposes, it is desirable that certain statistical data be reviewed. These cover State station support in the past, present sources, costs of research, and indicated fund trends. The data have been assembled from a variety of related public records and statements. They will be presented primarily through the use of slides.

With regard to support for research at the State agricultural experiment stations, information will be presented on Federal, State, and industry funds received by the stations. Consideration will be given to research organization and management, to some of the relationships of the State experiment station staff, to teaching at the graduate and undergraduate levels, and to various testing and service activities. Increases in scientific manpower at the stations will be examined in relation to research growth.

Slide 1--Funds Available to the State Agricultural Experiment Stations From Federal-grant and non-Federal Sources, 1888-1962 (2)

The Hatch and other Federal-grant funds made available to the State stations constituted the main source of support in the early years. Federal-grant appropriations to the State experiment stations stimulated increases in State appropriations. The increasing rate in State funds beginning at the time of World War II and continuing down to the present is evidence of the high regard the public has for experiment station research.

At the present time the States provide, on the average, nearly $4 for every dollar received under the Hatch Experiment Station Act.

Slide 2--The Federal Research Dollar, 1940-1963

In 1940, 39¢ of each Federal dollar appropriated for research was used for agricultural research by the Department of Agriculture or as grants to the State agricultural experiment stations. In 1963, agricultural research is scheduled to receive 1.34¢ out of each Federal dollar appropriated for research and development.

Funds for research on atomic energy, space, and human health have increased far beyond any prediction that might have been made in 1940. Most of us cannot fully appreciate the immensity of these programs. We have nothing of comparable size in agriculture. For example, to place just one precision instrument in space today for use in a series of weather experiments may cost as much as $10 to $15 million.

The accomplishment of research objectives in agriculture, even though carried on for a period of several years, costs considerably less. To illustrate my point, may I refer to a few studies carried on at the State experiment stations.

Research by an Eastern State station to develop and maintain a random-bred population of white leghorns, 8 years in duration, cost $70,000. In a Midwestern State, a genetic and chemical study to obtain tomatoes of higher vitamin content, also 8 years in duration, cost $81,500.

Some beef and dairy cattle breeding or nutrition research projects have cost as much as a quarter of a million dollars at a single experiment station. Counting the cumulative expenditures in a number of States taking part in a coordinated research program, as is the case in regional research, the maximum expenditure over a 12-year period was $4.7 million.

Some of the differences between 1940 and 1963 are reflected in the following slide.

Slide 3--Federal Funds for Science for Selected Activities

In the 1940 circle on the left, when total Federal appropriations for research were $74.1 million, the Department of Agriculture received $29.1 and the Public Health Service $2.8 of the $31.9 million indicated. The

circles are drawn to scale with the 1963 circle including the Atomic Energy Commission, National Institutes of Health (which now includes the Public Health Service), National Science Foundation, and the Department of Agriculture, receiving $2.4 billion. The area indicated for agricultural research represents $171 million, which includes the $38 million in payments to the State experiment stations. Of the total for these agencies, Agriculture receives 8 percent. Please keep in mind that these figures do not represent total Federal research and development expenditures for the years indicated, but are for purposes of comparison of relative growth in support for the agencies indicated. These were selected because they represent agencies that provide funds through grants and contracts to State station scientists.

Expanding Federal Effort in Research and Development

Science progresses from advancements made in many disciplines; therefore, agricultural research employs new advancements and techniques resulting from these expanded programs. A parallelism is the substantial contribution to science made by experiment station and USDA scientists through the years. We cannot, however, look to these new sources for many of the answers needed on agricultural problems of vital importance for both the producer and the consumer.

Slide 4--Federal Funds for Research and Development, Fiscal Year 1963
(Based on figures published in Senate Document No. 94, 87th Congress (3).)

RESEARCH & DEVELOPMENT Estimated Budget Expenditures in 1963	Millions of dollars
Department of Defense (Military Functions)	$7,147
National Aeronautics & Space Administration	2,400
Atomic Energy Commission	1,408
Department of Health, Education & Welfare	680
Department of Agriculture	171

RESEARCH & DEVELOPMENT

Estimated Budget Expenditures in 1963	($ Millions)
National Science Foundation	$ 164
Other Agencies	395
	$12,365

Since the above-mentioned publication was prepared, the National Science Foundation (4) released a report on December 21, 1962, which indicates that the total estimated expenditures for research and development in 1963 will be $14.7 billion, or $2.3 billion more than the data shown in the slide.

The recent estimates show that Federal funds for research and development are 16 times greater in 1963 than in 1948. Expressed in terms of total Federal expenditures, it reflects an increase from 2.5 percent to approximately 13 percent for research and development.

Slide 5--Grants and Contracts to State Experiment Stations From Federal Sources--1954-1961

Slide 5 provides information on the amount of grants and contract funds the agricultural experiment stations received from the Atomic Energy Commission, National Institutes of Health, and National Science Foundation, in 1954 and in 1961.

Slide 5 also gives a comparison of the amounts received from these and other Federal sources. Grants from USDA are not shown.

Funds from AEC have doubled. Those from the Department of Defense have decreased slightly. Other agencies, including the Department of Commerce, Interior, and TVA, have tripled. The largest increases have come from NIH and NSF. Research funds used by the State stations from Federal sources, including the Department of Agriculture, were $2.9 million in 1954, and over $12 million in 1961. Hatch funds provided $32 million in 1961.

According to the financial reports from the State stations for fiscal year 1962, the amount of money from Federal agencies other than USDA for grants and contracts has increased to $15.5 million.

The State experiment stations received $7.2 million from industry in 1961. The amount of support from industry has remained fairly stable, ranging between $6 and $7 million over the past several years.

Slide 6--Source of Increases in Research Funds for the State Experiment Stations

Slide 6 provides an indication of the changes that have taken place during the period 1955 to 1961 in several of the sources of research funds used at the State experiment stations.

Producers, processors, and consumers, using new knowledge acquired through agricultural research, have furnished us with an abundance, experienced in no other country in the world. Problems associated with this abundance have caused some people to question the need for further research in agriculture. This fact has made it more difficult to obtain support needed for research on biological, physical, social, and economic problems of agriculture.

Increases in Hatch money in 1955 and 1961 were $5.5 and $1 million, respectively. Increases in non-Federal moneys went from $5 million in 1955 to $7.2 million in 1961. The net increase from both sources was less in 1961 than in 1955.

The competence of State station scientists has enabled them to secure funds from other Federal sources to partially overcome the slack. The increase in support to State stations from Federal agencies, other than USDA, was $3.4 million in 1961 in comparison with $600,000 in 1955.

Slide 7--Expenditures and Research Manpower

Some of the data presented previously can be misleading unless considered in relation to increasing costs of conducting research and in terms of some unit of expansion in size of the experiment station research effort. One indication of the size of the program over the years is the number of research workers employed. Slide 7 provides a part of this information. In 1940, the experiment stations employed 3,400 professional men in research, calculated on a full-time basis. By 1950, this had advanced to 4,900, and in 1960 to 5,600. The 1960 data represents a 61 percent increase over 1940.

A general measure of research growth is difficult. We know that technological advances and improved equipment have greatly increased the productivity of the farmer and the factory worker. To a degree similar reasoning can be applied to station scientists.

One guide that has been used to measure growth is the number of publications giving research results. Printed reports, bulletins, and circulars released by the experiment stations increased from 732 in 1940, to 903 in 1960, or 23.4 percent. Journal articles, a more reliable index, increased from 2,386 in 1940, to 6,672 in 1960, or 179.6 percent. Percentagewise, the increase in publications is far greater than the increase in manpower.

Slide 8--A Look Ahead

Slide 8 presents a projection to 1970 of the several sources of funds utilized by the State stations, based on amounts received during the past 8 years. Projections made on what has happened obviously are subject to limitations.

By 1970 non-Federal funds are estimated to increase $118.7 million over 1963; Hatch funds by $43.4 million. Federal agencies such as AEC, NIH, NSF, Commerce, Interior, and TVA will provide about $16.5 million over 1963 and other sources $1.5 million for an estimated increase of over $180 million from all sources in 1970.

A minimum of $133 million of the estimated increase of $180 million will be needed to meet the increased costs of doing research, based on present trends. Expressed in terms of reality, this means that all State stations and Puerto Rico will receive a net increase of only about $5 million a year from all currently available sources. The above estimates do not include grants for equipment or facilities.

In 1954, AEC, NIH, and NSF accounted for 2.4 percent of the total funds used by the State stations. By 1970, it appears that they may well represent 20 to 25 percent or more of the total.

Research sponsored by these agencies by grants is generally based on specific proposals submitted by station scientists on problems of primary interest to the agency. A careful examination of many of the grants reveals that they support research on problems of concern to agriculture. In addition, some provide funds for overhead charges which are attractive to both the scientist and the administration. Similarly, some of the agencies are now making institutional grants.

Without careful planning the program of the experiment station could become extremely diverse and out of balance. The research could enter into areas that are oriented to the mission of the agency making the grant but not necessarily related to programs of the experiment station or agricultural problems of the Nation.

What needs careful review is this--there are many sources of funds attractive to station workers. Arrangements should be made so that they can be used effectively to accomplish progress on the problems of the wise use of our abundant natural resources for the good of all of our people.

Distribution of Research and Development Funds

Many of the Research and Development expenditures involved the application of technology and development of the machinery to exploit current knowledge. This strongly suggests that more effort needs to be directed to obtaining new knowledge through basic research.

Federal research and development funds to all the Land-Grant colleges and universities in 1960 amounted to $350 million. Over 70 percent of this total went to two universities--the University of California and Massachusetts Institute of Technology.

Let us priefly summarize sources of research expenditures at the Land-Grant colleges and experiment stations for the fiscal year 1961. Expenditures for all Land-Grant colleges including State appropriations, Federal-grant under the Hatch Act, grants from Federal agencies, grants from industry and other sources specifically marked research totaled $584,647,000.1/

Funds available to the experiment stations out of the above total are reflected in the following 1961 expenditures:

Federal Grant.....	$ 31,808,000
State Funds.....	118,810,000
Other Federal Grants..	11,944,000
Industry.....	6,574,000
	$169,136,000

1/ Information on total expenditures was provided by Dr. Henry S. Brunner of HEW. The Experiment Station information was obtained from our own reports.

A 1961 study by the National Science Foundation of more than 2,000 colleges and universities reported in January 1963 that only 400 of these schools employed research and development scientists and engineers. Four-fifths of all colleges and universities employed no scientists and engineers.

Graduate-level institutions accounted for 99 percent of all employed research and development engineers and scientists. The survey indicated also that colleges and universities employed a total of 176,000 scientists and engineers, which when expressed on a full-time basis is equal to 140,000. The part-time classification included about 22,000 graduate students.

The rapid expansion in Federal research and development funds and their use by colleges and universities under various arrangements has created a change in employment status for scientists and engineers. The large contract laboratory or institute has resulted in the non-faculty-status employee.

A part of the survey involving 306 graduate-level institutions showed that 40 percent were faculty members engaged in research and development. Non-faculty-status staff, including graduate students, accounted for 60 percent of the total.

Management of Research Funds

Modern, large-unit organizations supported by public funds and having public responsibility, like our Land-Grant institutions and associated experiment stations, cannot function effectively without a staff of devoted, top-level administrators. You are particularly fortunate here in Pennsylvania to have a Director who has served the cause of agricultural research in your State and the Nation in an outstanding manner.

The Land-Grant institution with the establishment of the associated experiment station under the provisions of the Hatch Act recognized the Director as the administrative officer responsible and accountable for the proper use of funds received under the Act.

With the many sources of funds for research and development made available to some institutions, problems associated with proper management and accountability can become extremely complex.

Continuity of State and Federal-grant support is important to agricultural research. This needs to be recognized at agricultural experiment stations, not only by Directors but by scientists.

Several instances in recent years indicate that some experiment station scientists and administrators take the annual increment of formula funds under the Hatch Act and allotments under Regional Research for granted. At the same time, some of them place considerable emphasis on the success of the station or an individual scientist in obtaining special Federal grants or contracts. Releases given out with respect to research findings sometimes never mention Hatch monies as a source of support. When measured in terms of continuity for quality research, Hatch funds are one of the most reliable sources. The number one question to be weighed in considering special grants is whether they can accelerate research directed at a given problem and provide information that will add to scientific knowledge. The special grants can frequently provide graduate assistance and necessary scientific equipment.

Measuring the Growth of Science

Consideration is being given to methods that might be used to measure the effect of expenditures for research and development on the growth of science in a country. National leaders are interested in the effect of research and development expenditures on the social and economic development of countries.

An article in Science (5) in 1962 presented information on the consumption of commerical energy per inhabitant as a measure of the change resulting from national expenditures for research and development. Using this as an index there is as much as a 50- to 70-year time lag between the United States, the country with the greatest consumption, and Pakistan, the country with the lowest research and development expenditure. Many countries were not included in the report. The author points out that the research potential of a country is dependent on the number of scientists engaged in research or training scientists, the equipment they use, and their productivity in terms of research results and research workers trained. The rate of growth of science in a country depends in large measure on the size of the previous generation of scientists.

Developing Research Programs

An important consideration in the development of the program of the experiment station is the choice of areas of research to be supported. Under the provisions of the Hatch Experiment Station Act, the Director has the responsibility for this choice in the use of Federal-grant funds.

The challenge for the research administrator and his staff becomes one of stimulating research planning and cooperation so that decision-

making represents the best presentation of ideas from the various scientists that can contribute to the solution of a problem.

Maintaining a research environment that will bring together the most competent scientific talents, financial resources, and research equipment on a problem requires joint formulation of research proposals.

Recognizing that ideas for research on a problem originate in the mind of the scientist, the research environment should provide opportunity for individual expression. Mutual stimulation is accomplished by scientists from several disciplines giving joint consideration to the development of research proposals. This type of approach results in cooperative research on a problem that has many of the essential features for effective research progress.

The large number of areas requiring research make it necessary to establish priorities and limit the use of scientific talents and resources to those problems that can be adequately supported to make significant progress.

Research Evaluation

Different techniques are used in the review and evaluation of research at the State stations by directors and the Cooperative State Experiment Station Service. Wherever possible, a seminar type of review in which there is opportunity to present all of the work in a subject matter, department, scientific discipline, or problem area approach involving several scientists is desirable. This procedure makes it possible to evaluate each contributing part in relation to the program. Research carried on at the station or in the State in cooperation with USDA is frequently included in the review.

The essential objectives of the research review are as follows:

1. Identifying unproductive research

A necessary first step is, study of the productive history of research on the problem and the record of accomplishment of research workers assigned. Really poor research is easy to identify. Research requiring the development of new techniques or establishment of basic principles is more difficult to evaluate.

Scientists, research leaders, and administrators should formulate standards for research quality and performance. The application of high standards, used fairly, will do much to resolve problems associated with unproductive research. We can do no less than to make clear to all that research at the State stations was established on the basis of high standards and that with passing time top quality and performance is our goal.

If the individual scientist or research group shows no progress in accomplishing the objectives indicated, he or they should expect to provide an explanation of the problems encountered and what they propose to do in the future. This is to stimulate constructive thinking concentrated on the problem--not to be critical.

The ever increasing demand for scientists and engineers is resulting in considerable movement for greater opportunity, different environment, or increased financial gain. This movement of scientists will undoubtedly continue for some time in

the future. Provision should be made so that the results of research completed and in progress are summarized and publication arranged, if warranted, so research productivity is maintained.

2. Closing out or changing emphasis on research that is not getting anywhere.

If a research activity is unproductive, attempts should be made to determine whether all promising leads have been followed. If no ideas or change of emphasis are indicated, effort on the problem should be discontinued. Development of new procedures, or, later associated leads from other research, may at some future time justify reactivation.

3. Appraisal of accomplishing stated objectives.

Research projects may contain several objectives relevant to the solution of the problem. Some of the objectives may be accomplished sooner than others. Also, there are cases where accomplishment of one of the objectives requires the development of new techniques and requires cooperation with other disciplines. This cooperation should be arranged so that the project may move forward. In good planning the provision for cooperation should be made in the original proposal.

4. Evaluation of significant progress.

Significant progress and high quality work should be recognized. Recognizing major research contributions frequently has a stimulating effect on associates to put forth their best efforts to contribute in a significant way to the station research program and staff development.

Administrators should always encourage staff members to report significant progress promptly. In research, as in anything else, we attain stature by the quality of the product that comes out of our efforts. Scientists and administrators recognize that a major accomplishment cannot be forthcoming every year; but when there is one, we should have ways in which superior performance can be recognized.

5. Adequate documentation of significant findings.

For continuing projects, the greatest asset of the scientist is curiosity and creative thinking. Sometimes these virtues end in selfsatisfaction when the solution of a part of the problem is accomplished. As a part of the research--before the scientist or research team is authorized to start on a new part of the problem or related area--they should have the research finding well documented in the appropriate type of publication.

6. Completing publications and other followthrough on closed-out projects.

The progress of the research worker is closely correlated with the quality and quantity of publications. Care must be exercised not to extend undue credit to the scientist who uses the same data for several different types of publications.

When a project is closed it represents the productive record of the worker for 2, 3, 5, 10 or more years. It is, therefore, very important that publication from the research be associated with the scientist and the project.

7. Increased cooperation in research.

Every effort should be made to use all scientific disciplines that can contribute to the solution of the problem. By this I do

not mean that the team approach is the essential and only means for effective research. Certainly there are areas where we have not adequately explored the possibilities.

The advantages of increased cooperation within States should be explored. There are instances where stations could actually accomplish more from State and Federal expenditures with expanded cooperation, particularly between adjoining States or where similar environmental conditions exist.

8. Effective use of major items of scientific equipment.

Wherever possible, in departments or disciplines that need similar equipment, arrangements should be made for interdisciplinary cooperation to get maximum use out of expensive scientific equipment.

9. Most effective use of scientists.

Research requires imagination and creative thought. Sometimes a scientist makes a few dramatic contributions and thereby gains recognition. Unless he is a person of unusual intellectual balance, the possibility exists that he will thereafter become involved in too many committee assignments, public relations activities, consultantships, and the like, and thus be lost to a continued use of his talents where they are needed most, namely in research.

10. Better communication in science.

Continuing attention needs to be given to the development of more effective systems of communication between scientists on research in progress, that which is planned, and that published. For example, Senator Hubert H. Humphrey of Minnesota, Chairman

of a Subcommittee of the Senate Committee on Government Operations, has repeatedly critized the "Model T" methods used in managing scientific information, thereby contributing to unknowing duplication and "tragic and intolerable waste of men, money, and material." As recently as September 21 last, he criticized what he called "colossal waste" in the Government's science research effort. The Associated Press, on September 21, quoted him as saying that his principal criticism was "that more than a score of agencies operate as little empires, each conducting its own research program, with skimpy if any facilities for sharing the fruits of the research with other technicians or to learn what the others are doing."

In considering the availability of funds for research and the rate at which research results are published, there is need to give special attention to providing the scientist with published information related to his problem, as quickly and easily as possible For example, it has been estimated that a bench scientist receiving financial support averaging about $50,000 has support for library and reference services averaging less than 1/10 of 1 percent of that amount (6).

In hearings before the Subcommittee on Appropriations for the Department of Agriculture for 1963, a detailed statement was presented on the efforts made by State Experiment Station Directors to use Federal-grant funds efficiently. This included a report on exchange of information on current research, calling attention to the system established, whereby every station scientist has an

opportunity of knowing what is being done on Federal-grant funds by workers at every other station. Also, the statement on efficient use of grant funds for science placed special emphasis on the importance of the scientist in effective research planning and coordination. The scientist's greatest asset is his ability to think about his problem and to use all available resources that can contribute to progress in finding a solution.

Service and Testing Work

Many experiment station programs could be made more effective by limiting activities of staff members to research. Programs involving tests, demonstrations, and control work are time-consuming and contribute little to a better understanding of research. Increased cooperation between research and extension helps to relieve this load and serves to bring about a desirable relationship for evaluating problems needing research.

The Research Approach

Many of you know that the project system of outlining research wasn't something that was developed in Washington. It represents years of effort on the part of Directors, research workers, and the office that I represent, in formulating a system that would indicate clearly to each other the research that is planned. The project system has strong points as well as certain weaknesses. I will mention only a few essentials and leave time at the end of my comments for discussion of any questions you may have in mind on developing proposals for research.

The two most important points in developing a statement of planned

research are a clear outline of the problem and presentation of evidence that the worker is familiar with past and current work. A good research outline does not require a lot of words, but it does require clear thinking. With increasing need for basic research, we must be sure that project requirements do not hamper creative effort. Having too rigid requirements on procedures to be used could restrict the worker in following promising leads.

Number of Research Projects of the State Stations

Careful consideration needs to be given by State station scientists and administrators to the current inventory of Federal-grant and non-Federal projects. These now total over 13,000--6,400 Federal-grant and 7,000 non-Federal. Many of the projects carry small allocations of funds and may be on the books with little significant progress.

We might well ask whether the 13,000 projects provide the best framework needed to approach the interdisciplinary problems facing agriculture today. Careful analysis shows that we can delineate the problems needing research in larger segments. Once these are identified, steps can be taken to bring about closer coordination of research. If we keep aming at the stated objective as the continuing target, team-work and cooperation can improve both quality and research output. This type of approach requires careful evaluation of department structure in the station and its parent institution.

Research and Teaching Relationships

In the early days following passage of the Hatch Act, there was frequent argument as to the relationship between teaching and research.

As a matter of fact, failure to resolve this issue almost caused a break between the State stations and the colleges.

One of the early and eloquent spokesmen for the colleges was President G. W. Atherton (7) of Pennsylvania State College. In his 1889 presidential address before the Association of American Agricultural Colleges and Experiment Stations, he said: (I quote)

> "Let the college investigate that it may teach well, and the station teach that it may investigate, and this two-fold cord shall not easily be broken."

A careful review of the record will reveal that President Atherton was more interested in the scientist because of what the latter could contribute to teaching rather than what the research would contribute to the advancement of knowledge.

Another Pennsylvanian who took part in the early deliberations on teaching and research relationships was Dr. H. P. Armsby (8). He drew a sharp and distinct line between teaching and research and challenged every feature of President Atherton's philosophy which worked to the disadvantage of the experiment stations. Armsby pointed out that the developers of the Hatch Act recognized the station as an educational institution, a part of the university, meeting the responsibility of seeking knowledge as well as teaching it.

The following is a quotation from a statement Dr. Armsby made in 1899: (I quote)

> "I look confidently to the time when the agricultural college as we now know it will be but the capstone of a great system.... But what shall all of these people, young and old be taught, and who shall teach it to them.... We shall find it precisely where it was found in all systems of education--in that first hand knowledge and familiarity with the subject which is gained by independent, original investigation--that is, we shall find it in the experiment station."

The wisdom in Armsby's statement was affirmed by the late President C. A. Elvehjem (9) of the University of Wisconsin over 60 years later, when he pointed out that the Land-Grant institutions have been recognized as being extremely successful in graduate work. President Elvehjem said: (I quote)

> "Why they have been so successful is not as obvious.
>
> "Generally, it is conceded that the emphasis they have given to research is fundamental to their leadership. For graduate teaching is research, and research was given great emphasis by the establishment of the agricultural experiment stations which formalized and recognized research in our institutions for more than three-quarters of a century.
>
> "But I believe that the recognition of research--particularly the applied sort of research which was implied in the name Experiment Station--was not as important in the development of quality graduate programs as was the early recognition in these institutions of the fact that basic research must underlie the applications."

Graduate Students Currently Associated With State Experiment Station Programs

The State experiment stations provide opportunities to students to participate in research in intimate association with competent scientist-teachers on the station staff. In 1962, The Cooperative State Experiment Station Service, with the cooperation of the State agricultural experiment stations, conducted a survey of graduate students doing research on approved Hatch projects under the direction of experiment station scientists. Information was obtained also on the total number of graduate students associated with experiment station programs.

Preliminary anslysis of the information shows that 1,787 graduate students are working on Hatch-supported research projects, and that 8,931 graduate students are directly associated with experiment station

programs in the college of agriculture. These figures include graduate students in veterinary medicine, home economics, and other departments closely related to agriculture.

The greatest number of graduate students in any one discipline, as such disciplines are defined by the National Science Foundation, is 578 in agricultural economics. Following closely are biochemistry with 545, entomology--488, and soil science--475. About 70 percent of the State stations reported graduate students in each of these disciplines associated with station scientists.

Disciplines with a comparatively small number of graduate students are: plant physiology with 41, hydrology--25, rural sociology--162, and soil physics--60.

As might be expected, there is a wide range in the number of graduate students at the various institutions. The maximum reported by any one State as being associated with station scientists was 857. Two reported having no graduate students associated directly with the agricultural experiment station.

Certainly, the station research--graduate assistant relationship--represents a great potential. Here we can bring about improvements in quality of both research and education by insisting on high standards of excellence for graduate students in these areas.

An analysis of graduate degrees awarded by Land-Grant colleges and universities by the Office of Education showed that both the Masters and Doctors degrees were higher in 1958-59 than in 1949 and 1950. From 1954-55, in comparison with 1958-59, there was a decrease in number of both degrees awarded by Land-Grant colleges. Unless there are careful

plans to emphasize graduate work there may be further decline. Certainly the need exists and ways must be found to meet the need.

At the undergraduate teaching level, our experience over the years indicates that in dual assignments of teaching and research, poor research productivity is associated with most assignments requiring 50 percent or more of the time for teaching. This is particularly true where the teaching assignment continues throughout the academic year. A more productive procedure from the research standpoint is to have a semester or term where full time is devoted to research with a continuing opportunity throughout the year to carry on some research.

The same principles do not apply at the graduate level, particularly for a senior scientist supervising the work of Ph.D. candidates. Several outstanding scientists can use as many as 8-12 graduate students effectively on their program of research. In other cases, there could be a question if one or two would not be too many because the scientist is not able to properly stimulate the thought processes in the student in relation to the research approach.

The special Federal grants can be used in a most effective manner for research assistants, particularly Ph.D. candidates and post-doctoral assistants.

Summary

The State agricultural experiment stations and Land-Grant colleges have a group of the most competent scientific minds in the country. They are pursuing a program of research primarily directed toward agriculture but obviously covering a broad spectrum of biological, physical, social, and economic research interests. The Land-Grant colleges have

as a major responsibility the molding and training of a large group of future agricultural scientists, teachers and technicians of high quality. This requires competence, time, effort, and money.

I have tried to provide you with information on a number of Federal sources of funds available to scientists. Experiment station workers should make use of these sources, with the recognition of the relationship to station research objectives. There must be authority and responsibility within the experiment station to evaluate all requests for outside support made by station scientists. There is also a responsibility that both scientist and administrator be aware of the need for accountability of fund use.

Future Possibilities

The Land-Grant colleges and associated experiment stations have contributed much to our national strength. The future offers a challenge of major proportions, both at home and abroad.

With the positive determination and high degree of dedication characteristic of scientists and educators at our Land-Grant colleges and universities, we may be sure that these institutions will, in the future as in the past, stand for the highest degree of excellence.

Dean Jackson, I am honored to participate in this seminar series dedicated to you. May I express my personal greetings and best wishes.

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PLANNING AND EVALUATING EXPERIMENT STATION RESEARCH 1/

By H. C. Knoblauch, Associate Administrator
Cooperative State Research Service, U.S.D.A.

It is a pleasure to take part in your seminar and to consider with you how agricultural experiment station research can help West Virginia University improve its services to the people of the State. Also, in a larger framework, to contribute knowledge useful to the State, the Nation, and the world.

Seminars like yours today and tomorrow, which include participation by research, teaching, and extension members of the faculty, can do much to periodically evaluate and vitalize the services of a land-grant institution to people of the State.

I recall the national seminar in which Dr. Paul A. Miller, your President here at West Virginia University, took part in November 1961, in an "Evaluation of the Division of Agriculture." It was during the opening of the Land-Grant Centennial year. They foresaw many changes for the future, many of which are now emerging. I might mention the present trend to establish international program centers at land-grant colleges.

Over the past several years many States have undertaken major changes in their College of Agriculture organizations. Surveys for others are under way.

We all realize that change simply for the sake of change can do more harm than good. But in a forward-moving civilization, there is constant reason for periodic re-examination of needs and possible adjustment to new facts. If we expect improved organizational and program changes to come out of an appraisal, then it is desirable that each component unit involved take an active part in the appraisal.

Identifying the Elements of Change

The ever increasing pace of change is a reality of which today's generation is well aware. Changes and participating in them have become a fact of our work and life. This makes it necessary that we recognize the varied elements of change and seek ways of making contributions either as individuals or in a cooperative effort that will bring about desirable change.

Since my first visit to Morgantown in 1941, I have been here and at other places in your State frequently. Each time I have seen changes. In the physical appearance of the campus and in the organizational pattern of the university. The results of the changes, both on your campus and over the State, are expressed in many different ways. Current programs of teaching, research, and extension should be integral components of these changes. How responsive as scientists and teachers have you been in determining your most effective role in making a constructive contribution to these changes?

The excellent new agricultural science and engineering buildings, like many other new facilities, are examples of physical expansion of plant for improving

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1/ Summary of remarks during a faculty seminar, College of Agriculture, Forestry, and Home Economics, The Agricultural Experiment Station, and The Agricultural Extension Service of West Virginia University, Morgantown, W. Va., January 26, 1965.

research and teaching and for providing increased service. The competence of research workers here today, like many who have gone before you, plus contributions then and now, are significant factors that provided substance for the progress experienced in many areas of agriculture.

Opportunities and responsibilities in research, teaching, and extension work are as great now as ever. And in the years ahead they will increase at an even more rapid rate than in the past.

Much has been accomplished in agriculture through scientific advancements and new techniques. Our Nation can honestly claim to have attained the highest level of farm production efficiency. Great challenges, however, still face us in many areas, including education and effective use of human and natural resources. I sincerely believe that the many problems of critical concern today can best be solved through the united effort of many research disciplines. Also basic to the approach and vital to success is the requirement to perfect the best system of cooperation you can between agricultural research, teaching, and extension.

We face the reality that problems now are much more complex and interrelated. Only a generation ago, which might be considered as the comfortable past, we were frequently able to make an easier choice--in developing proposed research based on an analysis of a problem. Research workers could select a segment of, or at times an entire problem that seemed solvable, and proceed with their work, with some confidence that after a few years of effort a contribution of merit would result.

Some Evaluations

The recent publication, AGRICULTURAL COLLEGES IN NEW ENGLAND, by Ayers Brinser and Lee R. Martin, presents findings of a study of opportunities facing land-grant agricultural colleges in New England. Reviewing the implications of their findings, the authors point out that major questions facing rural New England are those of making adjustments to expanding urban society. They see the need for more research and extension programs that deal with problems of recreation, water supply, costs of government, the interaction of economic and social means and ends, transportation, education, and shrinking space. Not only do they recommend research on the physical aspects of these problems, but also social science research that will help people understand and choose alternatives in action programs. They feel that, accompanying the research there should be required training of extension workers to carry the research findings to the people "and to bring back to the researchers knowledge of the real world and of the relevant problems toward which research should be directed." In addition, they see a growing need for training many more resource managers such as land managers, watershed technicians, recreation specialists, designers of land use patterns, program planners, and policymakers.

I am sure you will find other sections of the Brinser-Martin report worthy of additional thought in relation to some of the problems here in West Virginia. I would not wish to imply that the situations are entirely comparable. In fact, some of the evaluations by the authors were somewhat different from mine as to the contributions from the New England colleges to the area and to

the Nation. For example, the publication might direct more attention to adjustments that have been made in teaching, research, and extension programs in some of the New England States. The fact remains, however, that whether in New England or in other areas the possibilities are great for formulating new approaches to current problems through studies that include the program and organizational pattern of an institution.

Another recent study in which you may be interested is the evaluation of the present and potential structure and functions of the Ohio Cooperative Extension Service. It was done for the Agriculture and Allied Interest Study Committee by the Battelle Institute.

A Region Apart

The introduction, A Region Apart, of the report, APPALACHIA, gives a summary of the social and economic changes over time and puts into focus a complex of problems where research, teaching, and extension should find common denominators for a total cooperative approach. Research programs here at West Virginia University have contributed factual information on the nature and extent of some of the changes taking place. Recommendations have come out of this research that have been helpful to agriculture and to the people.

Looking back on the efforts in agricultural research, teaching, and extension, some may feel that these programs have not involved adequate planning. Some of this criticism is justified. This kind of hindsight should not overlook the factors other than agriculture involved in the economy and well-being of the people of this State and of the Nation.

The kind of reflective evaluation and resolve that should cover our thoughts of the past is to remember the wisdom contained in the words of Santayana, "Those who cannot remember the past are condemned to repeat it."

Assuming that the above characterizes some of our problems of mutual interest, I would like to outline for your consideration: (1) A suggested plan for evaluation of agricultural research; (2) research and extension relationships; (3) opportunities in the light of the past; and (4) some future challenges.

REVIEW OF STATION PROGRAMS

In May of this year we will request heads of research departments through the Experiment Station Director in West Virginia to cooperate in preparing for a research program review and evaluation that will take place sometime in September. The essential points to be covered are as follows: (1) Appraise the present research program of the department; (2) identify factors limiting progress of research; (3) opportunities for more effective use of scientific manpower and other resources; and (4) project research needs for the future, including means by which these might be met.

From the standpoint of the Cooperative State Research Service, research program reviews provide overall knowledge of the research program under way at the station, department by department. The review should become a valuable complement to the subject-matter reviews and the annual progress reports for research projects.

We expect that the research program reviews involving all departments of the station will be held at intervals of about 2 years. Currently, subject-matter reviews, involving a detailed review of the research projects of a department, are held every 3 to 4 years. The experiment station directors will be requested to cooperate in the development of a schedule that would cover the review of all projects by subject matter or commodity once every 4 years.

The questions and related information which follow are important considerations which departments should apply to all research from time to time. During a department program review a CSRS representative welcomes the opportunity to evaluate with department heads the problem that he and the Experiment Station Director consider pertinent.

We find that the best possible use of the time available for the review of the individual department is accomplished when its head prepares: (1) A brief summary table of the department's research program showing projects, research time, and financial support by principal problem areas; (2) a list of major lines of current research in each problem area; and (3) a concise narrative statement covering the significant points under the headings 1 to 6 of a guide that is proposed for their use.

The Director's office is asked to provide the summary of funds assigned to departments. The above reports provide the basis for discussions. We request that the written statement covering items 1 to 6 for each department be brief, not exceed 6 pages. Examples of each of the reports are provided to the Director before the review.

1. Problem Identification and Research Planning

Because effective research planning must be a continuing process, all departments should have certain long-range plans with regard to specific aspects of their program. An essential beginning point hinges on the identification of major problem areas and the criteria used in assigning priorities to alternative lines of research. Some related key questions for consideration are: What factors have contributed to the major areas of research activity and strength of the present research program? What are the principal research resources of the department in terms of staff, specialized facilities, equipment, etc.? How have these influenced the choice of problems for investigation?

2. Research Organization and Management

Is all research in the department conducted under an organized project, regardless of source of funds? What system of review for project outlines and work plans is used in the department and by the station Director?

Administrators and research workers frequently state that pressures from many directions lead to the initiation of too many projects, with resulting dissipation of effort--including over-emphasis on emergency holding action and a relative neglect of a fundamental approach to problems. Is this a problem? If so, do you have suggestions for improving the situation? What would improve the organization and management of research in your department?

3. Research Coordination and Cooperation

Indicate nature and extent of cooperation in your department's research program: Among individuals in your own department; with corresponding departments in other stations (regional projects, et al); with other departments in the West Virginia station; other colleges on campus; USDA; and others. Is there need for more effective coordination of research and extension programs?

To what extent are the services of a statistical laboratory, automatic data processing center, station statistician, chemical analytical laboratory and others available and utilized?

4. Prospective Research Program 5 to 10 Years in the Future

A. Assuming Present Level of Support.

A dynamic research program should be modified from time to time to meet the needs of a period of rapid technological and social change. Are there current or emerging problems of major importance which will dictate the changes in emphasis in your program?

Are there areas of research endeavor which need to be initiated to strengthen the research of your department? Are there additional areas in which your department plans to develop research competence and leadership? Do you foresee changes in the relative emphasis on basic and applied research? Is the research that is currently supported of higher priority than any proposed new research?

B. Assuming a Substantial Increase in Support.

If research funds could be increased, what program changes or recommendations would you make? Indicate which current lines of work would be strengthened and what areas of new work would be undertaken. Where would cooperation be increased?

Would your greatest need be for (a) additional staff, (b) additional graduate assistants or technical help, (c) research equipment, (d) space, (e) operating funds? What distinction is being made between short-term and long-range needs?

5. Extent and Nature of Outside Grants and Their Relationship to Publicly Financed Programs

Indicate to what extent outside grants and other funds provide support for your research. How do you use these funds in your department? Are there administrative or program problems involved in the use of other funds?

6. Major Research Accomplishments

The department head is requested to summarize briefly the major research accomplishments in the department during the past 2 years. Two or three of the best examples should be given. The nature of the problem, the research

results, and the interpretation of their significance should be a part of the presentation of each example.

Publication

The results of research should be presented in a publication that will serve as a means of communication to the user. Also, the kind and frequency of publication is a significant measure of scientific productivity. Research workers as public servants have a major responsibility in the periodic summary of the results of their investigations and publication so that progress may be evaluated and the future course of the investigation determined. The Cooperative State Research Service recently made a study of publications by the various State Agricultural Experiment Stations.

Planning Relationships

The States and the Federal Government need to give added emphasis to research planning at state, regional, and national levels. Many examples could be cited from experience wherein requests for needed support were not adequately presented from the standpoint of current and needed future research activity.

In the past 8 to 10 weeks many of you have devoted considerable effort to an analysis of the current meat animal research program in West Virginia. This request originated with the Senate Appropriations Committee during hearings on the Department of Agriculture and Related Agencies Appropriations Bill, 1965, which includes the following item under the section on cost-of-production research:

> "Under the heading of meat animal research the (appropriations) committee has included $25,000 for a feasibility study and report on meat animal research. . . . The committee strongly supports livestock research as is evidenced by the large appropriation already devoted to this general purpose, but believes it should be much better informed . . . as to the entire program of research--present and proposed--for livestock by the departmental agencies and by the States.
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> "The committee has provided $25,000 under Section 32 funds to enable the Department to make this study and review of the present research program and the development of clear and concrete recommendations to the committee as to specific needs for the future, by objective, and by location."

It is reasonable to expect that there will be additional requests for summary and evaluation of current and projected research needs, by commodities or subject-matter areas. We must not only be aware of the problems but must be able to present a plan of attack that will show full cooperation among the States and between the States and the Federal Government.

I have deliberately avoided an attempt to define or evaluate research needs in certain areas. Likewise, I have not made comparisons of the importance of basic versus applied research. The complexity of the problems that we

have considered should show clearly that there is need for both basic and applied research.

My concept of need for creative thinking on the problems of today is reflected in the statement of John Dewey, "Theory is, in the end, the most practical of all things."

It has been said that experiment station research, with the increasing emphasis on basic research, is leaving a bigger and bigger gap between research and extension programs. Since both programs are different phases of a closely linked public responsibility for cooperative solution of interrelated problems, it is up to both to contribute to the needed mutuality of approach. You have much at stake: the conservation and effective use of the natural resources of your State, the fullest development of human resources, and the assurance of a continued free and productive society.

You have already recognized that the University of West Virginia and its component parts have a unique opportunity to contribute to progress on the complex problems of your State. The experiment station with its various field research locations can investigate and develop more effective natural resource management practices. At these locations research and extension leadership could evaluate practices and combinations of practices that will be used by the people to obtain for them the greatest economic return.

Dr. Bennett S. White, Jr., and Dr. Glenn R. Smith from the Cooperative State Research Service in the cooperative review and evaluation of the programs of research in Agricultural Economics and Rural Sociology of the West Virginia station last May again directed attention to the two West Virginias in the following statement:

> "First-hand observation as well as the inspection of the above and related data indicate that one might properly speak of two West Virginias. There is one economy of high productivity, employment, profits, and wages, resting mainly on the highly mechanized basic industries of coal, steel, chemicals, utilities, and transportation. There is the second economy of the unemployed and underemployed, many of whom have been displaced by the machines which make possible the high wages in the first economy. The second economy also includes the aged, the infirm and the school dropouts; those who cannot be effective producers in their home communities and in many cases are indisposed or ill-equipped to migrate to opportunities in other locations; and the small farmer whose rugged land and lack of capital and technical know-how do not enable him to earn an adequate income under present conditions."

Ultimate success will only be achieved after a full partnership of education and science is formed with our most vital resource, the people. As sponsors of this partnership, you have both a great responsibility and a great opportunity.

The Use of Science

In the past decade or so we have seen tremendous progress in science. Some of this has been brought about through bringing into closer working relationship the research findings in biology and in the behavioral and other social sciences.

Research in genetics and biophysics on what determines heredity has revealed exciting new information. For example, Dr. LeRoy Augenstein, Professor and Chairman of Biophysics, Michigan State University, in an address last September reviewed some of the developments.

> "How many of you know, for example," he asked, "that one out of twenty individuals, maybe one out of twenty-five, who ever lived on this earth, are alive right now? At the moment our population is increasing at the rate of about 1.2 percent per year. At that rate, we will double our population in 60 years. In 600 years, there will be one square yard per person. In 1,700 years, at the same rate, the mass of people will exceed the mass of the earth."

Dr. Augenstein's paper summarized other startling findings of the past year or two. He asked fundamental questions about their implications.

> "Those who would presume to make decisions in these areas," he emphasized, ". . . must know what science is all about, what they can expect science to do and what science cannot do, and also they must know from the other side of the fence, how has man tried to answer these questions in the past and why has he been unable to answer them?"

The future of mankind depends on continuing progress in the advancement of knowledge in the sciences, the arts, the humanities--in the development of excellence whatever the field. These are the activities that represent the continuing challenges of our universities.

As scientists, as teachers, as extension workers, all of you have a responsibility in helping West Virginia University measure up toward building a better future.

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