and cents), and the exact number of pounds or the number of head of meat animals which will be forthcoming as a result of given feed prices.

In working with these problems it has been necessary to devise new advanced statistical methods—an example of the application of mathematics to agriculture. The reason that economists have not heretofore been able to express their observation quantitatively is that they have not been able to determine the conditions under which they made their observations. Unlike the natural scientists, they have not been able to take their problems into a laboratory to observe facts undisturbed by varying outside conditions. If, for example, they attempted to study the effect of the size of the domestic wheat crop on price, they were confronted by numerous complicating factors, such as the production of other grain crops, the production of wheat in foreign countries, the changes in the general commodity price level, and the fluctuations in business conditions. Now, however, by the use of correlation methods recently developed, these general factors can be isolated and their separate influences on each other measured.

The examples which I have cited, from many sciences and from many agricultural enterprises to which the results of research have been applied, merely suggest the debt which modern agriculture owes to science. It is no exaggeration to say that through the research accomplishments of recent years the average farmer to-day knows more of the science on which his industry rests and brings it into constant application than the scientist knew fifty years ago.

Yet there remains much to be done. The agricultural field is full of problems, a large proportion of which depend for their solution on the effectiveness with which underlying problems in pure science are dealt. American science, I am convinced, needs to concern itself more with fundamental research than it has done heretofore. No country in the world has made such progress in applied science, but our record in pure science is not so flattering. Since 1900, when the Nobel prizes in physics, chemistry and medicine were inaugurated, seventy-six awards have been made. Of these, twenty-four went to Germany, eleven to England, ten to France, six to the Netherlands, five to Sweden, four to the United States, three to Denmark, three to Swtizerland, two each to Austria, Canada, Italy, and Russia, and one each to Belgium and Spain. On the basis of population, the Netherlands, Denmark, Sweden and Switzerland received one to every million inhabitants; Germany one to every two and one half million; Austria one to every three million; England one to every three and a quarter million; France one to every four million; the United States, one to every twenty-nine million.

This is the situation despite the fact that we have vastly more students in colleges and universities in proportion to the population than has any other country in the world. The difficulty seems to me twofold: We are not laying enough emphasis on pure science in proportion to our emphasis on the applications of science; and we are not stimulating and training an adequate personnel in scientific research.

Indeed, superior personnel is needed in every field touching scientific work. There is grave need, as I have pointed out, for workers in pure science. There is need likewise for those who can correlate and coordinate the facts discovered.

There is demand also for those who can interpret and apply to practical problems the results obtained through scientific investigation.

The agriculture of the future will be successful in proportion to the extent to which it is shaped and guided by the basic facts revealed by scientific research, especially research in the fields of natural science, economics, engineering and business administration. If satisfactory progress is to be made in the solution of the diverse problems of the farm, to the end that agriculture may be more prosperous, the facts developed by research must be intelligently correlated and coordinated, superficials distinguished from fundamentals and the latter interpreted in the light of practical knowledge as well as scientific information.

Of supreme importance is a sufficiently numerous personnel characterized by outstanding ability, thorough professional training and unstinted devotion to the search for the truth. To the development and encouragement of such a personnel every organization concerned with science may wisely lend its hearty efforts.

W. M. JARDINE

RESEARCH IN COLLEGES AND PROFESSIONAL SCHOOLS. II

A REPORT OF SUGGESTIONS FROM THREE CONFERENCES

I SHOULD like to bring to you some of my own thoughts as to the importance of encouraging research in colleges and professional schools and the results that should follow. I am frankly optimistic as to these results if—I should like to discuss the results and the if. But it seems more appropriate, instead, to review some of the suggestions that have come from conferences and a number of consultations with leaders in research and in college work.

Among university graduates who enter upon college teaching the research death-rate is too high. Its being so high is a disadvantage (a) to the men them-

selves, (b) to the colleges and (c) their students, (d) to the progress of research and (e) to the whole community.

Ceasing their research is disadvantageous to the young doctors of philosophy, for it deprives them of the fine stimulus, the great intellectual pleasure and the self-respect that contributing activity and the contributing attitude can give them in their field of study; and it prevents their normal growth.

It is disadvantageous to the colleges to have the research of their teachers cease, for the colleges need teachers with the vital spirit that can hardly reach full development in second-hand teaching. Men of positive judgments based on some first-hand, direct contact with the materials of their fields have an attitude in teaching far more inspiring to their pupils than can readily come from teachers who rely wholly upon others for their knowledge of their own fields. The difference in tone between partly first-hand and wholly second-hand judgment of the data and their relations will be reflected in teaching. The former will give a vital quality that is rarely possible to the latter. Quality of product, not mere numbers, is what a worthy college should desire in its graduates. Fewer hours of teaching per faculty member, with more vital quality of teaching means either a larger faculty or fewer students, but in either case it should mean a more valuable output of college product.

College students need and have a right to the intellectual stimulus that comes from contact with intellectually productive men. They should develop some main intellectual interest in college, should find an intellectual hobby. Just as a man needs throughout life some pet athletic sport to keep his body fit, so each man of normal capacity and development needs a central intellectual interest as a tonic to his whole mental life. Again, each man, for the sake of his own continued self-respect, should have a contributing attitude toward his job and the community, an attitude of first-hand study of facts and conditions, of first-hand judgments upon these and of initiative and of positive contribution. There is nothing so effective for engendering such a spirit of positive individual contribution as contact with those who exemplify this spirit, and where better than in college can these contacts be had?

More recruits for research are needed. Every man engaged in research finds his studies opening vistas along many most interesting and important paths which he can not himself follow. Each piece of work entered upon opens up dozens of others. "The harvests truly are plentiful but the laborers are few." A much larger proportion of our abler college graduates should choose the life of research—a *much* larger proportion. Some men of course have to provide food and clothing for our bodies, and this army of common laborers needs executive leaders. But the problem of better adjustment of human lives to the realities in the midst of which we live demands not only, and not even chiefly, the proper application of truth as already grasped. It demands much more the search for further truth. Man needs more, and better, more nourishing, truer food for his mind and more grace and beauty to clothe his spirit. A much larger proportion of our abler college graduates might well devote their lives to the search for truth and beauty (two aspects of the same thing), to the search for sounder knowledge of the realities in the midst of which we live and to which we must relate ourselves.

But how can college students be expected to choose the life of research for truth, unless by their junior and senior years, when their life choice is usually made, they have had contact with lives devoted to research? How can such a life be presented vividly to their imagination? The spirit of devotion to truth and its fuller discovery is highly contagious. Let our college teachers be centers of such contagion.

Each individual according to his capacity needs the independent, individually productive spirit which research develops. Independent study of one's job, study of larger truth with the thought of contributing something—the individual needs this for the sake of his own fun in the game; the community needs it and has a right to ask it from each individual according to his capacity.

To furnish leaders of this type our colleges need, first, teachers imbued with the research spirit as well as the teaching urge. They need also some semi-research courses, courses using semi-research method. The two together will be a lure to lead larger numbers of the ablest college graduates to choose the productive intellectual life, the life of research.

Much encouragement, in the form of scholarships, fellowships and assistantships, is given in our universities to graduate students. A few of the ablest of the young doctors of philosophy are still further aided by fellowships, such as the National Research Council fellowships, which enable them to continue from one to three years longer in uninterrupted research. But a much larger number, including many of marked ability, go into the colleges as teachers and there in large part become swamped by too heavy teaching burden and their research purpose proves not strong enough to resist the pressure of overwork and the deadening college environment. Among these young doctors engaged in college teaching the research death-rate is disappointingly large. Can anything be done about it? Is it worthwhile to try to do anything about it?

Several conferences upon the subject that have been held between teachers and administrators from a good many colleges have unanimously said that the situation is not hopeless; that something can be done and that it's worth doing. That the situation is not hopeless, that good research and a good degree of the research spirit is possible in college, is shown by conditions that have obtained and that obtain to-day in a number of colleges. To mention but a few:

Carleton College has for years had a strong, productive department of astronomy, which has published the dignified journal, *Popular Astronomy*. The mathematics, physics and chemistry departments have also had strong research men.

In Swarthmore, also, astronomical research has long been emphasized and with it mathematics and physics.

Dr. Goodrich will tell us of Connecticut Wesleyan University, which has a long tradition of research.

Amherst has long supported research and productive scholarship in both science and literature.

Dennison had for years a highly productive department of biology.

In Oberlin all but one or perhaps two of the science faculty are engaged in worthy research, and two thirds of the other members are engaged in advanced scholarly productive study.

Lafayette was for years a center of stimulating influence in English literature.

In Princeton, for years before it became really a university for graduate training in research, there were departments strong in research.

Bryn Mawr is really a university and so is not mentioned here.

And so on. Colleges as such, in distinction from universities, have shown that they can maintain, and expose their students to, an atmosphere of research either in many or at least in some departments.

From the several conferences of college representatives upon research in colleges there have come a large number of practical suggestions as to specific needs and procedures. Let us especially emphasize a few of these:

General recognition by the whole college and its constituency of *the legitimate place of research in the college* and of its essential importance if the college is to be intellectually strong and most effective in its stimulus to its students. An atmosphere encouraging to research, a general expectation that the teachers will be engaged in research. Interest in the research that is going forward. Recognition that his research is part of the service by which the teacher justifies and earns his salary. There should be a general expectation that summer vacations be given to productive scholarship. A man in good health who customarily employs his vacations otherwise should be looked at askance. Advancement in position and in salary should be on the basis of success both in teaching and in research.

The second great need recognized is release of part of the *teacher's time and energy for research*. Every college should have a clerical staff sufficient to relieve teachers of clerical work. It is a waste of money and, far worse, a waste of men, to use teachers for work that clerks can do. A reasonable teaching schedule should be adopted and not exceeded. Two full courses for one semester and one for another semester has been suggested. The half-semester free, plus the summer vacation, gives the teacher about half of his whole year's time for research. In this connection small classes and enough teachers were urged.

Changes in these directions involve additional *expense*. Generous contributions to aid colleges to put all teachers of proven capacity (and only such are best worth having) on a part-time research basis and to relieve all teachers of clerical work and of too heavy teaching schedule may be necessary before all that is desirable can be accomplished, but all who have discussed the matter at our conferences are convinced that much can be done without greatly increased cost if its desirability and importance is clearly recognized in the colleges themselves.

A list of numerous suggestions was published in *School and Society*, November 20, 1926. Of these some may be mentioned here. This will involve my overstepping a little the time limit accepted by the other speakers, but it seems appropriate to give more than fifteen minutes to a report of suggestions from over ninety men who gave careful consideration to the whole matter.

I

Cooperation between universities and research institutions, on the one hand, and colleges, on the other hand

(A) Consultation trips by college men to the research centers for advice and conference and reading.

(B) Exchange of teachers between universities and colleges (and perhaps exchange of research men between industry and the colleges).

(C) Loan of equipment and books.

II

Cooperation between colleges

(A) Consultation trips for men interested in related problems to confer for mutual aid.

(B) Loan of equipment and books.

(C) Exchange of faculty members for a year or for a semester or for a lecture course.

(D) Joining in securing visits from leading scholars, combining on special lecture plans, etc.

III

Within the individual college

Give promotion of research a place in faculty meetings on a parity with teaching problems.

Give research, as a matter of course, recognition in the budget of each department of study; grants for apparatus, literature, research assistants, etc.

Have special research fund for special grants, this to be administered by the research committee. This emphasizes the dignity and importance of this committee.

Give stenographic and clerical assistance to faculty members to conserve their time and energy for teaching and research.

Cut down hours of teaching—a maximum of two full courses (5 hours each) one semester and one the other semester suggested as a standard, the remaining time *to be used for research,* summer vacations included.

Large faculties, small classes.

Leaves of absence, on salary, *for intensive study.*

Assistance toward expense of attending professional society meetings.

Special honors to men successful in research:

(A) Research as well as teaching success recognized as a basis for promotion.

(B) Special professorships for those markedly successful in both research and teaching, with added time and assistance for research, and additional salary.

(C) Occasional appointment for a limited period to research positions with full time for research. These research appointees might naturally be chosen from the members of the faculty.

(D) Invitation to give college lectures, and publication of these lectures, with allowance of time for preparation.

Encouragement of research for the M.A. degree; also special stipends for M.A. students who shall assist professors in their research.

Research scholarships for outgoing seniors and for recent graduates to study in research institutions.

Develop the library for assistance to research as well as for teaching.

SOME GENERAL POLICIES

Have no upper limit in rule or practice for aid to the able man when discovered.

Encourage research in all fields, not over-emphasizing any subject or group of subjects. Fear has been expressed lest other than scientific subjects be neglected.

Emphasize the fact that there are many problems of interest and importance, for research, within the immediate environment of each college, and that aid and cooperation in their study may often be secured from local organizations and institutions, including chambers of commerce, clubs, schools, historical societies, etc.

SUGGESTIONS OF POSSIBLE ORGANIZATION TO PROMOTE RESEARCH IN COLLEGES

A *Research Committee* in each college, appointed or elected on such plan as the institution thinks best, but it was suggested that the inclusion of representatives from faculty, administration and trustees would be valuable.

A *Liaison Member* from each local committee for consultation with similar members from the committees in other colleges.

In time there may develop need for a small *Executive Committee,* elected by the liaison members to act for them in aiding in every possible way research in the colleges, with such *Officers* as the executive committee shall recommend and the liaison members approve. Possibly ultimately a central *Office* with staff might be found necessary.

FUNCTIONS OF LOCAL RESEARCH COMMITTEE

Promote appreciation of importance of research on the part of all members of the college community, including trustees, administrative officers, faculty, students and donors.

Survey and list the researches in progress in the institution.

List the more important researches published in the past from the college.

Gather and classify information in regard to the entrance of graduates upon research, and list the ablest research men among the past graduates of the college.

Learn, classify and list the assistance needed for (A) researches in progress; (B) researches it is desired to undertake. Assist in plans for securing such aid.

Publish all these items for circulation in the college community.

Publish an annual report for circulation in the college.

Assist in securing cooperation between faculty members in research.

Study and suggest possible correlations between researches under way in the college.

Consider publication of research results—perhaps advisable, especially for studies of local environment. Publication assistance is especially needed in the so-called "humanities." Avoid encouraging publication of unworthy papers.

Secure a liberal research fund, grants from which shall be administered by the research committee.

Exchange with local committees in other colleges information as to methods and success in promotion of research.

Encourage teachers to present their subjects from the standpoint of their development through research, both the past development thus accomplished and the need of further studies to fill gaps in present knowledge and to extend it. All college work should be from the standpoint of growth of knowledge.

Arrange for presentation to the students, by men from the several departments and from outside the college, of the life devoted to research, and present newer phases of progress in knowledge, discussing also the men through whose research mankind have made great advance. Encourage establishment of societies and fraternities which cultivate research.

Encourage work by semi-research methods in the curriculum, putting some of this work as early as the Freshman or at least the Sophomore year, so that its tonic effect may be felt in later work. All college work may well be more by the research method than is now the case.

Present research to community by lectures and exhibits.

Urge value of administrative assistants to relieve faculty members of detailed committee work.

At Smith College attempt is made to put each teacher's classes at one end of the week, leaving study and research time freer from conflict with classroom duties.

FUNCTIONS OF INTERCOLLEGIATE EXECUTIVE COMMITTEE AND OFFICERS

Study problem of encouraging research in colleges and serve as a clearing-house for exchange of suggestions as to methods of promoting research:

(A) by publication of data and discussion,

(B) by correspondence,

(C) by promotion of regional and national conferences discussing promotion of research in the colleges and its relation to successful teaching. Research promotion should have a place on college association programs.

Serve as an agency to bring together in thought and action the colleges and the several organizations interested in the promotion of research in the colleges. Numerous learned societies and other organizations have committees on this subject.

Survey the colleges as to research status, teaching demands upon the time of the faculty members, etc. Perhaps publish results of such survey.

Study sources of aid for research, in and outside the colleges.

Assist individual colleges, or the colleges as a whole, to give and obtain aid for research.

Assist individuals to obtain help, financial and other, in their research.

Study the relation of college work in the past to the stimuli which led men into the life of research.

Develop recognition of the importance of research in the colleges—especially on the part of boards of trustees, administrative officers and those determining college policies.

Help secure for less experienced workers advice from leading scholars in choosing and directing research.

Aid in promoting cooperative research by bringing into contact advisers, workers and supporters in such work.

Aid in exchange of teachers between colleges, and between colleges and universities, also perhaps between industry and colleges there might be exchange of research men.

Assist in securing and arranging lecture courses, and more extended periods of resident work, by leading scholars, several colleges cooperating.

Aid in forming regional societies for cooperation and stimulus in scholarly interests. Neighboring institutions might form interinstitutional groups in different subjects of study for mutual stimulus.

Publish, at least annually, reports upon research in the colleges and its promotion.

MAYNARD M. METCALF
THE JOHNS HOPKINS UNIVERSITY

RESEARCH EXPERIENCES AND PROBLEMS IN A SMALL COLLEGE

THIS paper is prepared by request to present the conditions that have made and are making original work possible in a small college. It has been expected that statements should be definite and explicit and therefore I ask your indulgence when it seems to me necessary to refer to names and events connected with the history of a single college which is here represented.

Wesleyan University was established in 1831. Some think that a certain liberal outlook of its founders had bearing upon its later history. I will, however, pass over those considerations and mention at once an important period. We are familiar with the change in American universities leading to a greater recognition of scholarly work of which the founding of Johns Hopkins University in 1876 is often taken as a convenient landmark. By virtue of certain fortunate circumstances Wesleyan University was able to participate in this change. In 1873 the curriculum was revised, allowing more free election and bringing in new subjects for study. This necessitated an increase in the faculty student ratio. Previously it had been of the order of one teacher to eighteen students. After this it climbed rapidly to the neighborhood of one teacher to eleven students. In the accompanying chart (Fig. 1) a comparison is made between the number of students and faculty throughout the history of the college. (Line A is a graph of the number of students divided by 10 and line B shows the number of the faculty exclusive of the president and administrative officers.) Here may be noted the change in faculty student ratio occurring between 1873 and 1888. This revision of the curriculum giving broader interests and requiring a larger teaching force was the work of John Monroe Van Vleck and William North Rice. These two men also realized the value of research and by their counsel in the selection of new members of the faculty greatly aided in the introduction of this new element into the life of the college. In 1873 Wilbur O. Atwater became a member of the faculty. With the coming of Atwater, we find the first record of graduate work and the first beginnings of any continuous scientific investigation. His enthusiasm carried him outside of the college in search of financial support. This was received from private donors and later from the state, from the national government and from the