ORGANIZATION
OF THE
NATIONAL RESEARCH COUNCIL

PREAMBLE

The National Academy of Sciences, under the authority conferred upon it by its charter enacted by Congress, and approved by President Lincoln on March 3, 1863, and pursuant to the request expressed in an Executive Order made by President Wilson on May 11, 1918, hereto appended, adopts the following permanent organization for the National Research Council, to replace the temporary organization under which it has operated heretofore.

ARTICLE I.—PURPOSE

It shall be the purpose of the National Research Council to promote research in the mathematical, physical, and biological sciences, and in the application of these sciences to engineering, agriculture, medicine, and other useful arts, with the object of increasing knowledge, of strengthening the national defense, and of contributing in other ways to the public welfare, as expressed in the Executive Order of May 11, 1918.

ARTICLE II.—MEMBERSHIP

Section 1. The membership of the National Research Council shall be chosen with the view of rendering the Council an effective federation of the principal research agencies in the United States concerned with the fields of science and technology named in Article I.

Section 2. The Council shall consist of

1. Representatives of national scientific and technical societies;
2. Representatives of the Government, as provided in the Executive Order;
3. Representatives of other research organizations and other persons whose aid may advance the objects of the Council.

**Article III.—Divisions**

*Section 1.* The Council shall be organized in Divisions of two classes:

A. Divisions dealing with the more general relations and activities of the Council;
B. Divisions dealing with related branches of science and technology.

*Section 2.* The initial constitution of the Divisions of the Council shall be as follows:

A. Divisions of General Relations:
   I. Government Division.
   II. Division of Foreign Relations.
   III. Division of States Relations.
   IV. Division of Educational Relations.
   V. Division of Industrial Relations.
   VI. Research Information Service.

B. Divisions of Science and Technology:
   VII. Division of Physical Sciences.
   VIII. Division of Engineering.
   IX. Division of Chemistry and Chemical Technology.
   X. Division of Geology and Geography.
   XI. Division of Medical Sciences.
   XII. Division of Biology and Agriculture.
   XIII. Division of Anthropology and Psychology.

*Section 3.* The number of divisions and the grouping of subjects in Article III, section 2, may be modified by the Executive Board of the National Research Council.

*Section 4.* The Divisions of General Relations shall be organized by the Executive Board of the National Research Council (Article IV, section 2).

*Section 5.* To secure the effective federation of the principal research agencies in the United States, provided for in Article II, a majority of the members of each of the Divisions of Science and Technology shall consist of representatives of scientific and technical societies, chosen as provided for in Article V, section 2. The other members of the Division shall be nominated by the Executive Committee of the Division, approved by the Executive Board of the National Research Council, and appointed in accordance with Article V, section 4.

*Section 6.* The Divisions of the Council, with the approval of the Executive Board, may establish sections and committees, any of which may include members chosen outside the membership of the Council.

**Article IV.—Administration**

*Section 1.* The affairs of each Division shall be administered by a Chairman, a Vice-Chairman, and an Executive Committee, of which the Chairman and the Vice-Chairman shall be ex-officio members; all of whom shall be elected annually by the Division and confirmed by the Executive Board.

*Section 2.* The affairs of the National Research Council shall be administered by an Executive Board, of which the officers of the Council, the President and Home Secretary of the National Academy of Sciences, the President of the American Association for the Advancement of Science, the Chairmen and Vice-Chairmen of the Divisions of Science and Technology, and the Chairmen of the Divisions of General Relations shall be ex-officio members. The Executive Board may elect additional members, not to exceed ten in number, who, if not already members of the National Research Council, shall be appointed thereto, in accordance with Article V, section 4.

*Section 3.* The officers of the National Research Council shall consist of a Chairman, one or more Vice-Chairmen, a
Secretary, and a Treasurer, who shall also serve as members and officers of the Executive Board of the Council.

Section 4. The officers of the National Research Council, excepting the Treasurer, shall be elected annually by the Executive Board. The Treasurer of the National Academy of Sciences shall be ex-officio Treasurer of the National Research Council.

Section 5. The duties of the officers of the Council and of the Divisions shall be fixed by the Executive Board.

Article V.—Nominations and Appointments

Section 1. The Government bureaus, civil and military, to be represented in the Government Division, and the scientific and technical societies, to be represented in the Divisions of Science and Technology of the National Research Council, shall be determined by joint action of the Council of the National Academy of Sciences and the Executive Board of the National Research Council.

Section 2. Representatives of scientific and technical societies shall be nominated by the societies, at the request of the Executive Board, and appointed by the President of the National Academy of Sciences to membership in the Council and assigned to one of its Divisions.

Section 3. The representatives of the Government shall be nominated by the President of the National Academy of Sciences after conference with the Secretaries of the Departments concerned, and the names of those nominated shall be presented to the President of the United States for designation by him for service with the National Research Council.

Section 4. Other members of the Council shall be nominated by the Executive Committees of the Divisions, approved by the Executive Board, and appointed by the President of the National Academy of Sciences to membership and assigned to one of the Divisions.

Section 5. Prior to the first annual meeting of the Council following January 1, 1919, all Divisions shall be organized by appointment of their members in accordance with Article II and Article V, sections 1 to 4.

Section 6. As far as practicable one-third of the original representatives of each scientific and technical society and approximately one-third of the other original members of each of the Divisions of Science and Technology shall serve for a term of three years; one-third for a term of two years, and one-third for a term of one year, their respective terms to be determined by lot. Each year thereafter, as the terms of members expire, their successors shall be appointed for a period of three years.

Section 7. The Government representatives shall serve for periods of three years, unless they previously retire from the Government office which they represent, in which case their successors shall be appointed for the unexpired term.

Section 8. As far as practicable a similar rotation shall be observed in the appointment of the members of the Divisions of General Relations.

Article VI.—Meetings

Section 1. The Council shall hold one stated meeting, called the annual meeting, in April of each year, in the city of Washington, on a date to be fixed by the Executive Board. Other meetings of the Council shall be held on call of the Executive Board.

Section 2. The Executive Board and each of the Divisions shall hold an annual meeting, at which officers shall be elected, at the time and place of the annual meeting of the Council, unless otherwise determined by the Executive Board, and such other meetings as may be required for the transaction of business.

Section 3. Joint meetings of the Executive Board of the National Research Council and the Council of the National Academy of Sciences shall be held from time to time, to consider special requests from the Government, the selection of
organizations to be represented in the National Research Council, and other matters which, in the judgment of the President of the National Academy, require the attention of both bodies.

**Article VII.—Publications and Reports**

*Section 1.* An annual report on the work of the National Research Council shall be presented by the Chairman to the National Academy of Sciences, for submission to Congress in connection with the annual report of the President of the Academy.

*Section 2.* Other publications of the National Research Council may include papers, bulletins, reports, and memoirs, which may appear in the Proceedings or Memoirs of the National Academy of Sciences, in the publications of other societies, in scientific and technical journals, or in a separate series of the Research Council.
NATIONAL RESEARCH COUNCIL

Executive Order Issued by the President of the
United States May 11, 1918

The National Research Council was organized in 1916 at the request of the President by the National Academy of Sciences, under its Congressional charter, as a measure of national preparedness. The work accomplished by the Council in organizing research and in securing co-operation of military and civilian agencies in the solution of military problems demonstrates its capacity for larger service. The National Academy of Sciences is therefore requested to perpetuate the National Research Council, the duties of which shall be as follows:

1. In general, to stimulate research in the mathematical, physical and biological sciences, and in the application of these sciences to engineering, agriculture, medicine and other useful arts, with the object of increasing knowledge, of strengthening the national defense, and of contributing in other ways to the public welfare.

2. To survey the larger possibilities of science, to formulate comprehensive projects of research, and to develop effective means of utilizing the scientific and technical resources of the country for dealing with these projects.

3. To promote co-operation in research, at home and abroad, in order to secure concentration of effort, minimize
duplication, and stimulate progress; but in all co-operative undertakings to give encouragement to individual initiative, as fundamentally important to the advancement of science.

4. To serve as a means of bringing American and foreign investigators into active co-operation with the scientific and technical services of the War and Navy Departments and with those of the civil branches of the Government.

5. To direct the attention of scientific and technical investigators to the present importance of military and industrial problems in connection with the war, and to aid in the solution of these problems by organizing specific researches.

6. To gather and collate scientific and technical information at home and abroad, in co-operation with Governmental and other agencies and to render such information available to duly accredited persons.

Effective prosecution of the Council’s work requires the cordial collaboration of the scientific and technical branches of the Government, both military and civil. To this end representatives of the Government, upon the nomination of the National Academy of Sciences, will be designated by the President as members of the Council, as heretofore, and the heads of the departments immediately concerned will continue to co-operate in every way that may be required.

(Signed) WOODROW WILSON

THE WHITE HOUSE
May 11, 1918
NATIONAL RESEARCH COUNCIL

RESEARCH COMMITTEES IN EDUCATIONAL INSTITUTIONS

Reprinted from the Proceedings of the National Academy of Sciences
NATIONAL RESEARCH COUNCIL

RESEARCH COMMITTEES IN EDUCATIONAL INSTITUTIONS

A very large proportion of the scientific research of the United States is conducted in the laboratories of educational institutions. It is now widely appreciated that contact with knowledge in the making is the most effective means of seizing and holding the student's attention. And it is also recognized that no greater injury can be done to the cause of science than to compel a promising investigator, fresh from the researches of his graduate years, to relinquish all hopes of further studies because of the complete absorption of his time and energy by other duties.

It is with the fullest appreciation of the difficulties which financial limitations involve, and with a sincere desire not to interfere with the just demands of the teacher's profession, that the National Research Council invites the cooperation of educational institutions in the promotion of research at this critical period in our national progress. We believe it to be feasible, without decreasing the efficiency of the university, the college, or the professional school as teaching institutions, to increase greatly their contributions to knowledge through research. Indeed, we do not hesitate to say that if a portion of the time now given to teaching were devoted to investigation, and if the courses of instruction were so altered as to take full advantage of this change, the educational efficiency of the institutions in question would be materially enhanced. In extending a request for the formation of Research Committees in educational institutions of high standards, which accord serious support to scientific research undertaken by the faculty and advanced students, we beg to call attention to some of the possibilities which lie open to committees of this character.

In view of the importance of encouraging research on the part of members of the faculties of colleges which do not undertake graduate instruction, the invitation of the Council is not limited to universities and other institutions now giving specific recognition to research. It is highly important to encourage competent men to continue the work of research begun in their university career, and a sympathetic Research Committee could help greatly in this respect. Even the existence of such a committee should serve as a valuable stimulus to men who properly look for some measure of encouragement. In small institutions, as an illustration cited below will indicate, powerful support can be given to research by a body of men who genuinely appreciate its significance.

Each Research Committee will doubtless discover its own best method of procedure, adapted to the circumstances of the case. The following suggestions, which embody the results of the discussions of the Council's Com-
mittee on Research in Educational Institutions, may nevertheless be of service in organizing the work of the committees.

(1) It will probably be advantageous to begin by preparing a survey of the research already in progress in the institution in question. This should serve to indicate the possibilities of extending existing work, and point out favorable opportunities for initiating new lines of investigation.

(2) The Research Council will shortly undertake the preparation of a National Census of Research, indicating the equipment for research, the men engaged in it, and the lines of investigation pursued in government bureaus, educational institutions, research foundations, and industrial research laboratories. The purpose of the Census is to provide data for the effective development of research in pure science and in the industries, as well as for strengthening the national defense. The various Research Committees in educational institutions can aid the Council materially in securing data for the Census, and in supplying information for annual surveys of the progress of scientific research in the United States.

(3) One of the great problems of research laboratories is to find suitably trained men to carry on their work. Nearly all of these men come from educational institutions, where every available means should be used to increase the supply. If research is encouraged on the part of faculty members, and if its national importance is frequently impressed upon the students, more of them will be impelled to follow the career of investigators. The tendency toward narrow specialization, so common at present, should be counteracted by developing more interest in science as a whole. Lectures on the history of science, and broad courses on evolution, covering its various aspects, from the constitution of matter and the evolution of stars and the earth, to the rise of man and the development of civilization, should be widely encouraged. From the purely educational viewpoint such courses may be expected to produce a more favorable influence and leave a more lasting impression than routine discussions of the minutiae of the various branches of science, though the latter are obviously essential in the training of the investigator.

(4) The Council wishes to develop a wider appreciation of the part which men of science may play in research bearing both on industrial progress and national defense, including those of ship design, aeronautics, the fixation of nitrogen, and many other subjects. Various committees of the Council will soon be prepared to furnish information regarding such research problems.

(5) The development of more general cooperation and coordination in research, within each educational institution and in alliance with other workers outside, is another important subject for consideration. It is essential to remember, however, the necessity of safeguarding the personal freedom and the individual initiative of all investigators.

(6) The interchange of research workers, especially to secure for the smaller institutions the stimulus given by leaders of research, should be strongly encouraged.

(7) The establishment of a large number of research fellowships, each yielding one thousand dollars or more annually, is very desirable. If students showing special aptitude in their work for the doctor's degree could thus be enabled to devote themselves to research for a year or more, their future career as investigators might be assured. Research fellowship may be conferred by colleges on graduates who have taken their doctor's degree elsewhere, or used to secure the services of non-graduates in research laboratories.

(8) The time is also opportune to secure the establishment of research professorships and research endowments. The present appreciation of the national importance of research, and the increasing sense of personal obligation on the state, will cause men of means to contribute more freely than ever before.

(9) Most important of all is the encouragement of the spirit of research, and the development of a sympathetic atmosphere in which the investigator can work to the best possible advantage.

Large institutions should easily be able to extend their research activities, but smaller ones may encounter greater difficulties. As a practical example of what can be done by small institutions in the promotion of the objects of the National Research Council, some results accomplished since June by Throop College of Technology, at the direct instigation of the Council, may be cited. The steps it has taken in connection with the work of the Council are as follows:

Passage by the board of trustees of a resolution endorsing the objects of the Research Council and promising cooperation and of a second resolution providing that in the event of war with a first-class power all available research men and facilities required for the solution of problems of national defense or public need may be counted upon by the Research Council.

Provision of a new fund of two hundred thousand dollars as an endowment for research in physics.

Appointment of Dr. Robert A. Millikan as Director of the Physical Laboratory (under an arrangement with the University of Chicago by which he is to spend a part of each year in Pasadena).

Organization of a cooperative attack on electron problems from the physical, chemical, and astronomical standpoints, in which the physical and chemical laboratories of Throop College and the Mount Wilson Solar Observatory will take part.

Provision of three research fellowships, yielding one thousand dollars each annually, to be awarded to men who have shown exceptional ability in their research work for the doctor's degree. (Beloit College has also established, for a period of five years, a research fellowship yielding one thousand dollars annually.)
Provision of a wind tunnel and well equipped aerodynamical laboratory for researches on the structure of aeroplanes.

Participation in a cooperative arrangement permitting the repetition at Throop College of Professor Michelson's experiment on the tides within the body of the earth, to determine the possible influence of oceanic tides, and to serve as a part of the general study of Pacific Ocean problems undertaken by a committee of the National Academy of Sciences.

CENTRAL COMMITTEES ON RESEARCH

The National Research Council, with the cooperation of the American Association for the Advancement of Science, the American Chemical Society, the American Physical Society, the American Mathematical Society, and other national scientific societies, has established a series of central committees to organize research in the various branches of science.

The purpose of these committees may be outlined as follows:

1. To join in the preparation of the National Census of Research. This will be taken by the Census Committee of the Research Council, of which the Chairmen of the various central committees are members.

2. To prepare reports embodying comprehensive surveys of the larger possibilities of research in the various departments of pure science, suggesting important problems and favorable opportunities for investigation.

3. To survey the economic and industrial problems of the United States, and report on possible means of aiding in their solution by the promotion of research in the fields represented by the various committees. (In cooperation with the Council's Committee on the Promotion of Industrial Research.)

4. To indicate how investigators in each committee's field can aid in the solution of research problems involved in strengthening the national defense. (In cooperation with the Military Committee of the National Research Council.)

5. To point out opportunities, national and international, for cooperation in research, and to assist in the coordination of the various agencies already established for this purpose.

6. To keep in touch with the Research Committees of educational institutions, and to supply research problems, suggestions, or thesis subjects when requested to do so.

7. To serve as a national clearing house of information regarding research problems in each committee's field which arise from scientific, industrial, and other sources, and are communicated to the Council by local Research Committees or other agencies.

8. To promote research by such other methods as may prove advisable, including the encouragement of such courses of instruction in educational institutions as are best adapted to develop greater breadth of view, a wider understanding of the methods of research, and a more general perception of the national importance of all forms of research, both in pure and applied science; the more effective use of existing research funds; the establishment of research fellowships, research professorships, and research endowments.

All reports of the National Research Council and of its committees are published in full in these Proceedings, through which members of the separate committees may keep in touch with the work in progress in all its various fields.

GEORGE ELLERY HALE, Chairman.
THE RELATION OF PURE SCIENCE TO INDUSTRIAL RESEARCH

It is not strange that many years ago Huxley, with his remarkable precision of thought and his admirable command of language, should have indicated his dissatisfaction with the terms "pure science" and "applied science," pointing out at the same time that what people call "applied science" is nothing but the application of pure science to particular classes of problems. The terms are still employed, possibly because, after all, they may be the best ones to use, or perhaps our ideas, to which these expressions are supposed to conform, have not yet become sufficiently definite to have called forth the right words.

It is not the purpose of this address, however, to suggest better words or expressions, but rather to direct attention to certain important relations between purely scientific research and industrial scientific research which are not yet sufficiently understood.

Because of the stupendous upheaval of the European war with its startling agencies of destruction—the product of both science and the industries—and because of the deplorable unpreparedness of our own country to defend itself against

1 President's address given at the thirty-third annual convention of the American Institute of Electrical Engineers.
attack, there has begun a great awakening of our people. By bringing to their minds the brilliant achievements of the membership of this institute in electric lighting and power and communications and by calling their attention to the manifold achievements of the members of our sister societies in mechanical and mining and civil engineering, and the accomplishments of our fellow-workers, the industrial chemists, they are being aroused to the vital importance of the products of science in the national defense.

Arising out of this agitation comes a growing appreciation of the importance of industrial scientific research, not only as an aid to military defense but as an essential part of every industry in time of peace.

Industrial research, conducted in accordance with the principles of science, is no new thing in America. The department which is under my charge, founded nearly forty years ago to develop, with the aid of scientific men, the telephone art, has grown from small beginnings with but a few workers to a great institution employing hundreds of scientists and engineers, and it is generally acknowledged that it is largely owing to the industrial research thus conducted that the telephone achievements and developments in America have so greatly exceeded those of other countries.

With the development of electric lighting and electric power and electric traction which came after the invention of the telephone, industrial scientific research laboratories were founded by some of the larger electrical manufacturing concerns and these have attained a world-wide reputation.

While vast sums are spent annually upon industrial research in these laboratories, I can say with authority that they return to the industries each year improvements in the art which, taken all together, have a value many times greater than the total cost of their production. Money expended in properly directed industrial research, conducted on scientific principles, is sure to bring to the industries a most generous return.

While many concerns in America now have well organized industrial research laboratories, particularly those engaged in metallurgy and dependent upon chemical processes, the manufacturers of our country as a whole have not yet learned of the benefits of industrial scientific research and how to avail themselves of it.

I consider that it is the high duty of our institute and of every member composing it, and that a similar duty rests upon all other engineering and scientific bodies in America, to impress upon the manufacturers of the United States the wonderful possibilities of economies in their processes and improvements in their products which are opened up by the discoveries in science. The way to realize these possibilities is through the medium of industrial research conducted in accordance with scientific principles. Once it is made clear to our manufacturers that industrial research pays, they will be sure to call to their aid men of scientific training to investigate their technical problems and to improve their processes. Those who are the first to avail themselves of the benefits of industrial research will obtain such a lead over
their competitors that we may look forward to the time when the advantages of industrial research will be recognized by all.

Industrial scientific research departments can reach their highest development in those concerns doing the largest amount of business. While instances are not wanting where the large growth of the institution is the direct result of the care which is bestowed upon industrial research at a time when it was but a small concern, nevertheless conditions to-day are such that without cooperation among themselves the small concerns can not have the full benefits of industrial research, for no one among them is sufficiently strong to maintain the necessary staff and laboratories. Once the vital importance of this subject is appreciated by the small manufacturers many solutions of the problem will promptly appear. One of these is for the manufacturer to take his problem to one of the industrial research laboratories already established for the purpose of serving those who can not afford a laboratory of their own. Other manufacturers doing the same, the financial encouragement received would enable the laboratories to extend and improve their facilities so that each of the small manufacturers who patronizes them would in course of time have the benefit of an institution similar to those maintained by our largest industrial concerns.

Thus, in accordance with the law of supply and demand, the small manufacturer may obtain the benefits of industrial research in the highest degree and the burden upon each manufacturer would be only in accordance with the use he made of it, and the entire cost of the laboratories would thus be borne by the industries as a whole, where the charge properly belongs. Many other projects are now being considered for the establishment of industrial research laboratories for those concerns which can not afford laboratories of their own, and it is in some of these cases the possible relation of these laboratories to our technical and engineering schools is being earnestly studied.

Until the manufacturers themselves are aroused to the necessity of action in the matter of industrial research there is no plan which can be devised that will result in the general establishment of research laboratories for the industries. But once their need is felt and their value appreciated and the demand for research facilities is put forth by the manufacturers themselves, research laboratories will spring up in all our great centers of industrial activity. Their number and character and size, and their method of operation and their relation to the technical and engineering schools, and the method of their working with the different industries, are all matters which involve many interesting problems—problems which I am sure will be solved as they present themselves and when their nature has been clearly apprehended.

In the present state of the world's development there is nothing which can do more to advance American industries than the adoption by our manufacturers generally of industrial research conducted on scientific principles. I am sure that if they can be made to appreciate the force of this statement, our manufacturers will rise to the
occasion with all that energy and enterprise so characteristic of America.

So much has already been said and so much remains to be said urging upon us the importance of scientific research conducted for the sake of utility and for increasing the convenience and comfort of mankind, that there is danger of losing sight of another form of research which has for its primary object none of these things. I refer to pure scientific research.

In the minds of many there is confusion between industrial scientific research and this purely scientific research, particularly as the industrial research involves the use of advanced scientific methods and calls for the highest degree of scientific attainment. The confusion is worse because the same scientific principles and methods of investigation are frequently employed in each case and even the subject-matter under investigation may sometimes be identical.

The misunderstanding arises from considering only the subject-matter of the two classes of research. The distinction is to be found not in the subject-matter of the research, but in the motive.

The electrical engineer, let us say, finding a new and unexplained difficulty in the working of electric lamps, subjects the phenomenon observed to a process of inquiry employing scientific methods, with a view to removing from the lamps an objectionable characteristic. The pure scientist at the same time investigates in precisely the same manner the same phenomenon, but with the purpose of obtaining an explanation of a physical occurrence, the nature of which can not be explained by known facts.

Although these two researches are conducted in exactly the same manner, the one nevertheless comes under the head of industrial research and the other belongs to the domain of pure science. In the last analysis the distinction between pure scientific research and industrial scientific research is one of motive. Industrial research is always conducted with the purpose of accomplishing some utilitarian end. Pure scientific research is conducted with a philosophic purpose, for the discovery of truth, and for the advancement of the boundaries of human knowledge.

The investigator in pure science may be likened to the explorer who discovers new continents or islands or hitherto unknown territory. He is continually seeking to extend the boundaries of knowledge.

The investigator in industrial research may be compared to the pioneers who survey the newly discovered territory in the endeavor to locate its mineral resources, determine the extent of its forests, and the location of its arable land, and who in other ways precede the settlers and prepare for their occupation of the new country.

The work of the pure scientists is conducted without any utilitarian motive, for, as Huxley says, "that which stirs their pulses is the love of knowledge and the joy of discovery of the causes of things sung by the old poet—the supreme delight of extending the realm of law and order ever farther towards the unattainable goals of the infinitely great and the infinitely small, between which our little race of life is run." While a single discovery in pure science when considered with reference to
any particular branch of industry may not appear to be of appreciable benefit, yet when interpreted by the industrial scientist, with whom I class the engineer and the industrial chemist, and when adapted to practical uses by them, the contributions of pure science as a whole become of incalculable value to all the industries.

I do not say this because a new incentive is necessary for the pure scientist, for in him there must be some of the divine spark and for him there is no higher motive than the search for the truth itself. But surely this motive must be intensified by the knowledge that when the search is rewarded there is sure to be found, sooner or later, in the truth which has been discovered, the seeds of future great inventions which will increase the comfort and convenience and alleviate the sufferings of mankind.

By all who study the subject, it will be found that while the discoveries of the pure scientist are of the greatest importance to the higher interests of mankind, their practical benefits, though certain, are usually indirect, intangible or remote. Pure scientific research unlike industrial scientific research can not support itself by direct pecuniary returns from its discoveries.

The practical benefits which may be immediately and directly traced to industrial research, when it is properly conducted, are so great that when their importance is more generally recognized industrial research will not lack the most generous encouragement and support. Indeed, unless industrial research abundantly supports itself it will have failed of its purpose.

But who is to support the researches of the pure scientist, and who is to furnish him with encouragement and assistance to pursue his self-sacrificing and arduous quest for that truth which is certain as time goes on to bring in its train so many blessings to mankind? Who is to furnish the laboratories, the funds for apparatus and for traveling and for foreign study?

Because of the extraordinary practical results which have been attained by scientifically trained men working in the industrial laboratories and because of the limited and narrow conditions under which many scientific investigators have sometimes been compelled to work in universities, it has been suggested that perhaps the theater of scientific research might be shifted from the university to the great industrial laboratories which have already grown up or to the even greater ones which the future is bound to bring forth. But we can dismiss this suggestion as being unworthy.

Organizations and institutions of many kinds are engaged in pure scientific research and they should receive every encouragement, but the natural home of pure science and of pure scientific research is to be found in the university, from which it can not pass. It is a high function of the universities to make advances in science, to test new scientific discoveries and to place their stamp of truth upon those which are found to be pure. In this way only can they determine what shall be taught as scientific truth to those who, relying upon their authority, come to them for knowledge and believe what they teach.
Instead of abdicating in their favor, may not our universities, stimulated by the wonderful achievements of these industrial laboratories, find a way to advance the conduct of their own pure scientific research, the grand responsibility for which rests upon them. This responsibility should now be felt more heavily than ever by our American universities, not only because the tragedy of the great war has caused the destruction of European institutions of learning, but because even a worse thing has happened. So great have been the fatalities of the war that the universities of the old world hardly dare to count their dead.

But what can the American universities do, for they, like the pure scientists, are not engaged in a lucrative occupation. Universities are not money-making institutions, and what can be done without money?

There is much that can be done without money. The most important and most fundamental factor in scientific research is the mind of a man suitably endowed by nature. Unless the scientific investigator has the proper genius for his work, no amount of financial assistance, no apparatus or laboratories, however complete, and no foreign travel and study, however extensive, will enable such a mind to discover new truths or to inspire others to do so. Judgment and appreciation and insight into character on the part of the responsible university authorities must be applied to the problem, so that when the man with the required mental attributes does appear he may be appreciated as early in his career as possible. This is a very difficult thing to do indeed. Any one can recognize such a man after his great achievements have become known to all the world, but I sometimes think that one who can select early a man who has within him the making of the scientific discoverer must have been himself fired with a little of the divine spark. Such surely was the case with Sir Humphry Davy, himself a great discoverer, who, realizing the fundamental importance of the man in scientific discovery, once said that Michael Faraday, whose genius he was prompt to recognize, constituted his greatest discovery.

I can furnish no formula for the identification of budding genius and I have no ready-made plan to lay before the universities for the advancement of pure scientific research. But as a representative of engineering and industrial research, having testified to the great value of pure scientific research, I venture to suggest that the university authorities themselves might well consider the immense debt which engineering and the industries and transportation and communications and commerce owe to pure science, and to express the hope that the importance of pure scientific research will be more fully appreciated both within the university and without, for then will come—and then only—that sympathetic appreciation and generous financial support so much needed for the advancement of pure scientific research in America.

While there are many things—and most important things—which the universities can do to aid pure science without the employment of large sums of money, there are nevertheless a great many things re-
quired in the conduct of pure scientific research which can be done only with the aid of money. The first of these I think is this:

When a master scientist does appear and has made himself known by his discoveries, then he should be provided with all of the resources and facilities and assistants that he can effectively employ, so that the range of his genius will in no way be restricted for the want of anything which money can provide.

Every reasonable and even generous provision should be made for all workers in pure science, even though their reputations have not yet become great by their discoveries, for it should be remembered that the road to great discoveries is long and discouraging and that for one great achievement in science we must expect numberless failures.

I would not restrict these workers in pure science to our great universities, for I believe that they should be located also at our technical schools, even at those with the most practical aims. In such schools the influence of a discoverer in science would serve as a balance to the practical curriculum and familiarize the student with the high ideals of the pure scientist and with his rigorous methods of investigation. Furthermore, the time has come when our technical schools must supply in largely increasing numbers men thoroughly grounded in the scientific method of investigation for the work of industrial research.

Even the engineering student, who has no thoughts of industrial research, will profit by his association with the work of the pure scientist, for if he expects ever to tread the higher walks of the engineering profession he must be qualified to investigate new problems in engineering and devise methods for their solution and for such work a knowledge of the logical processes of the pure scientist and his rigorous methods of analyzing and weighing evidence in his scrupulous search for the truth will be of the greatest value.

Furthermore, the engineering student should be taught to appreciate the ultimate great practical importance of the results of pure scientific investigation and to realize that pure science furnishes to engineering the raw material, so to speak, which he must work into useful forms. He should be taught that after graduation it will be most helpful to him and even necessary, if he is to be a leader, to watch with care the work of the pure scientist and to scrutinize the reports of new scientific discoveries to see what they may contain that can be applied to useful purposes and more particularly to problems of his own which require solution. There are many unsolved problems in applied science, to-day, which are insoluble in the present state of our knowledge, but I am sure that in the future, as has so often happened in the past, these problems will find a ready solution in the light of pure scientific discoveries yet to be made. When thus regarded the work of the pure scientist should be followed with most intense interest by all of those engaged in the application of science to industrial purposes. Acquaintance, therefore with the pure scientist, with his methods and results, is of great importance to the student of applied science. I believe that there is need of a better understand-
ing of the relations between the pure scientist and the applied scientist and that this understanding would be greatly helped by a closer association between the pure scientist and the students in the technical schools.

While I have drawn a valid distinction between the work of the two, they nevertheless have much in common. Both are concerned with the truth of things, one to discover new truths and the other to apply those truths to the uses of man. While the object of the engineer is to produce from scientific discoveries useful results, these results are for the benefit of others. They are dedicated to the use of mankind and, as is the case with the pure scientist, they should not be confused with the pecuniary compensation which the engineer himself may receive for his work for this compensation is slight, often infinitesimally so, compared with the great benefits received by others. Like the worker in pure science, the engineer finds inspiration in the desire for achievement and his real reward is found in the knowledge of the benefits which others receive from his work.

There are many other things which might be discussed concerning the conduct of pure scientific research in our universities and technical schools, but enough has been said to make it plain that I believe such work should be greatly extended in all of our American universities and technical institutions. But where are the universities to obtain the money necessary for the carrying out of a grand scheme of scientific research? It should come from those generous and public-spirited men and women who desire to dispose of their wealth in a manner well calculated to advance the welfare of mankind, and it should come from the industries themselves, which owe such a heavy debt to science. While it can not be shown that the contribution of any one manufacturer or corporation to a particular purely scientific research will bring any return to the contributor or to others, it is certain that contributions by the manufacturers in general and by the industrial corporations to pure scientific research, as a whole, will in the long run bring manifold returns through the medium of industrial research conducted in the rich and virgin territory discovered by the scientific explorer.

It was Michael Faraday, one of the greatest of the workers in pure science, who in the last century discovered the principle of the dynamo electric machine. Without a knowledge of this principle discovered by Faraday, the whole art of electrical engineering as we know it to-day could not exist, and civilization would have been deprived of those inestimable benefits which have resulted from the work of the members of this institute.

Not only Faraday in England, but Joseph Henry in our own country and scores of other workers in pure science have laid the foundations upon which the electrical engineer has reared such a magnificent structure.

What is true of the electrical art is also true of all the other arts and applied sciences. They are all based upon fundamental discoveries made by workers in pure science, who were seeking only to discover the laws of nature and extend the realm of human knowledge.
By every means in our power, therefore, let us show our appreciation of pure science and let us forward the work of the pure scientists, for they are the advance guard of civilization. They point the way which we must follow. Let us arouse the people of our country to the wonderful possibilities of scientific discovery and to the responsibility to support it which rests upon them and I am sure that they will respond generously and effectively. Then I am confident that in the future the members of this institute, together with their colleagues in all of the other branches of engineering and applied science, as well as the physician and surgeon, by utilizing the discoveries of pure science yet to be made, will develop without number marvelous new agencies for the comfort and convenience of man and for the alleviation of human suffering. These, gentlemen, are some of the considerations which have led me here in my presidential address to urge upon you the importance of a proper understanding of the relations between pure science and industrial research.

J. J. Cartv
REPRINT AND CIRCULAR SERIES
OF THE
NATIONAL RESEARCH COUNCIL

SCIENCE AND THE INDUSTRIES

By John J. Carty
Vice President, American Telephone and Telegraph Company

An Address delivered under the Auspices of the National Research Council at Washington, D. C., February 6, 1920
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REPRINT AND CIRCULAR SERIES OF THE NATIONAL RESEARCH COUNCIL

NUMBER 8

SCIENCE AND THE INDUSTRIES*

By John J. Carty

Vice-President, American Telephone and Telegraph Company

Because of the stupendous upheaval of the European War with its startling agencies of destruction—the product of both science and the industries—and because of the deplorable unpreparedness of our own country to defend itself against attack, there began a great awakening of the American people. The awful shock of arms aroused them to the vital importance of the products of science in the national defense. Their minds were startled by warfare combining the scientific dreams of Jules Verne with the horrors of Armageddon. They witnessed as never before the spectacle of men warring with each other upon the earth, and under the earth, and in the air, and on the sea, and down deep in the waters of the ocean itself. Even in the very ether, scientific offensive and defensive measures were carried out in the effort to maintain or destroy communications.

Although peace has not yet come, hostilities have ceased, let us hope forever, and having concluded its work of organizing science for the war, the National Research Council now turns to its even greater purpose of encouraging and organizing scientific research in America for the advancement of scientific knowledge, and for the attainment of those immeasurable advantages which will accrue from the practical application of such knowledge to the affairs of men.

We must preach and we must prove that, great as were the achievements of science in war, they can be made incalculably greater in peace. Scientific research has proved to be an invaluable

* An address delivered under the auspices of the National Research Council at Washington, D. C., February 6, 1919.
aid to military operations in time of war. It must now be established as an essential part of every industry in time of peace.

To carry out its purpose, the Research Council has sought the aid of some of the American corporations which are in sympathy with this movement, a movement which it is hoped will result in the establishment of an industrial research department in each industrial concern large enough to support one, and in cooperative effort among the smaller concerns. The large corporations are being asked to explain the nature of their research organizations, and the advantages which are derived from them. It is believed that in this way those of our manufacturers who are not yet informed will become interested in research methods and organization and results.

The importance of scientific research to our American industries cannot be exaggerated, and while much has already been accomplished, the investigations conducted by the Research Council indicate a state of affairs in this respect far from being reassuring from the standpoint of international competition.

Most of the principal nations of the earth have research councils or their equivalents, and an International Research Council has already been formed. Enough is already known to justify me in saying that unless the manufacturers of the United States establish research departments as integral parts of their own internal organizations, our industries are bound to fall behind those of other countries.

It is in connection with this program of the National Research Council that the American Telephone and Telegraph Company, which I represent, has the honor to make an exhibit showing some of the results of industrial scientific research. Furthermore, this lecture is the first of a series, dealing with various phases of scientific research, which will continue from year to year and which, it is hoped, will frequently be accompanied by important exhibits.

The Department of Development and Research, which is under my charge, was founded about forty years ago to utilize the services of scientific men in developing the telephone art. It has grown from small beginnings with but a few workers, to a great institution employing hundreds of scientists and engineers, who devote themselves exclusively to the discovery and improvement of telephone materials, and methods, and apparatus. It is largely owing to the scientific research conducted in these laboratories that the telephone achievements and development in America have so greatly exceeded those of other countries.

The original personnel of these laboratories consisted of but two men, Alexander Graham Bell, the inventor of the telephone, and Thomas A. Watson, his associate, who constructed under Bell's direction the first telephone, and who heard through it from the lips of Bell himself the first words transmitted electrically.

At the present time the personnel, which includes graduates of a hundred American colleges and universities, consists of thirteen hundred scientists and engineers who devote their time exclusively to research and development in the telephone art.

On the table before you is one of the first products of these laboratories. It is a model of the first telephone by means of which Bell was able to communicate with Watson, but over a distance not greater than across this room. Starting with such feeble instruments, the scientific personnel of these laboratories—the successors of Bell and Watson—by persistent study, incessant experimentation and the expenditure of immense sums of money, have created an entire new art: inventing, developing and perfecting, making improvements great and small in telephone transmitter, line, cable, switchboard, and every other piece of apparatus and plant required for the transmission of speech.

As a result of this unceasing organized effort and these cumulative improvements in the art, Dr. Bell was enabled to talk once more to Mr. Watson through this original historic instrument, although they were thousands of miles apart, the one at San Francisco and the other at New York.

These two original telephones have increased marvelously in numbers and efficiency, and the first telephone line of a hundred feet in length has been expanded into a network covering the continent, until the telephone system of the United States alone comprehends thirty-one million miles of wire and thirteen million telephone stations connecting a hundred million people located everywhere throughout the country.

Pressing on to achieve still greater distances, the staff of these laboratories, by utilizing many scientific discoveries, have transmitted the human voice, without the use of wires, from Washington across the North American continent to San Francisco and even far out into the Pacific Ocean to the Hawaiian Islands, where words spoken at Washington were plainly heard. By this same apparatus and by these same scientists intelligible speech was for
the first time transmitted across the Atlantic Ocean from Arlington, Virginia, and heard at Paris.

I like to hope that the further use of the telephone in war may be forever deferred, and to contemplate its future as grand and peaceful. It will transmit speech beyond the vast extent of our own country and ultimately, I believe, to the uttermost ends of the earth, breaking down the barriers to the spoken word and preparing the way for a better understanding among men. It is not distance from one another which has produced differences of language among nations. It is lack of intercommunication. It is the failure of the spoken word to penetrate their boundaries.

I have faith that we shall some day build up a great world telephone system making necessary to all the nations the use of a common language or a common understanding of languages which will join all the peoples of the earth into one brotherhood. I have faith that the time will come, so beautifully described by the poet,

"Wherein each earth-enclosing day shall be
A Pentecost of Speech, and men shall hear,
Each in his dearest tongue, his neighbor’s voice
Tho’ separate by half the globe."

With the development of electric lights, and electric power, and electric traction, all of which came after the invention of the telephone, industrial scientific research laboratories were founded by some of the larger electrical manufacturing concerns and these have attained a world-wide reputation. While vast sums are spent annually on industrial research in these laboratories, it can be said with authority that they return to the industries, and through the industries to the public, improvements in the art which taken altogether have a value many times greater than the cost of their development. It cannot be too often asserted that money expended in properly directed industrial scientific research is sure to bring to the industries most generous returns. In the present state of the world’s development, nothing can do more to advance American industries than the adoption by our manufacturers in general of industrial research conducted on scientific principles. Our industries, our manufacturers, our railroads, our public service corporations should all be impressed with the immense savings and advantages which will come to them and to the public from the establishment within their own organizations of departments devoted to development and research.

So much has already been said and so much remains to be said urging upon us the importance of scientific research conducted for the sake of utility and for increasing the convenience and comfort of mankind, that there is danger of losing sight of another form of scientific research which has for its primary object none of these things. I refer to pure scientific research conducted for the sake of extending the boundaries of knowledge.

Pure scientific research is conducted with a philosophic purpose, for the discovery of the truth, and for the advancement of learning. The investigators in pure science may be likened to explorers who discover new continents or islands, or hitherto unknown territory. They are continually seeking to push forward the frontiers of knowledge. The work of the pure scientists is conducted without any utilitarian motive, for as Huxley says, “that which stirs their pulses is the love of knowledge and the joy of discovery of the causes of things—the supreme delight of extending the realm of law and order ever farther toward the unattainable goals of the infinitely great and the infinitely small, between which our little race of life is run.”

The pure scientists are the advance guard of civilization. By their discoveries, they furnish to the engineer and industrial chemist and other applied scientists the raw material to be elaborated into manifold agencies for the amelioration of the condition of mankind. Unless the work of the pure scientist is continued and pushed forward with ever increasing energy, the achievements of the industrial scientist will diminish and degenerate. Many practical problems now confronting mankind cannot be solved by the industrial scientist alone, but must await further fundamental discoveries and new scientific generalizations.

When considered with reference to a single branch of industry, no particular discovery in pure science appears as a rule to be of appreciable benefit. When, however, the total contributions of pure science are reviewed with regard to the industries as a whole, it is found that they have become of incalculable value through adaptation to practical uses by the industrial scientist, with whom I class the engineer and the industrial chemist.

I do not say this because a new incentive is necessary for the pure scientist, for in him there must be something of the divine spark and for him there is no higher motive than the search for the truth itself. But his motive will be intensified by the knowledge that, when his search is rewarded, there is sure to be found contained
in the truth which has been discovered the seeds of future great
inventions.

While the discoveries of the pure scientists are of the greatest
importance to the higher interests of mankind, the practical
benefits flowing from them, though certain, are usually indirect,
intangible, or remote. From its very nature pure science cannot
support itself. Nevertheless it must be conducted regardless of
its lack of pecuniary returns.

Who, therefore, is to support the researches of the pure scientist
and who is to furnish him with encouragement and assistance to
pursue his self-sacrificing and arduous quest for that truth which is
certain, as time goes on, to bring in its train so many blessings to
mankind? Who is to furnish the laboratories, the funds for appar-
atus, for travel, and for foreign study?

Because of the extraordinary practical results which have been
attained by scientifically trained men working in industrial
laboratories, and because of the restricted conditions under which
many scientific investigators in universities are so often compelled
to work, it has been suggested that perhaps the theatre of scientific
research might be shifted from the universities to the
great industrial laboratories which have grown up, or to the even
greater ones which the future must bring forth.

But we may dismiss this suggestion as being unworthy. Instead
of abdicating in their favor, may not our universities, stimu-
lated by the notable achievements of the industrial laboratories,
find a way to advance the conduct of their pure scientific research,
the responsibility for which rests so heavily upon them.

Various organizations and institutions, not connected with
universities, are also engaged in pure scientific research and they
are achieving most remarkable results. They should receive every
encouragement and their number should be increased, but a home
for pure science must always be found in the university.

In matters of science the function of the university is two-fold—
the discovery of the unknown, and the teaching of the known.
It is a high function of the universities to make advances in pure
science, to test reported new scientific discoveries and to place
upon those which are found to be true the stamp of their approval.
In this way they can determine what shall be taught as scientific
truth to those who, relying upon their authority, come to them for
knowledge and believe what they teach.

In my Presidential address before the American Institute of
Electrical Engineers delivered at Cleveland in 1916, speaking as a
representative of engineering and industrial research. I testified
to the great value of pure scientific research in universities, and
ventured to suggest to the university authorities that they consider
the immense debt which engineering, the industries, transportation,
communications and commerce owe to them and to pure science.
I expressed the hope that the importance of pure scientific re-
search would be more fully appreciated, both within the university
and without, since with that appreciation there would come the
sympathy and generous financial support so much needed for the
advancement of pure scientific research in America.

The time has now come when the universities, aroused by the
experience of the war to the ever-increasing importance of science
in the public welfare, are striving as never before to fulfill their
function of promoting new scientific discoveries. They are asking
where they are to obtain the necessary money, particularly when it is
impossible for them to maintain adequately the staffs required for
teaching those scientific truths which have already been discovered.
So great has been the economic disorder created by the war that
many of the scientific teachers and others in the universities are
compelled to seek other occupations in order that they may support
their families. A critical situation confronts our institutions of
learning, and unless we come to their rescue, our progress in science
will suffer. For the necessary pecuniary aid we must appeal to
those generous and public-spirited men and women who desire
to dispose of their wealth in a manner best calculated to advance
the welfare of mankind, and we must also appeal to the industries
themselves which owe such a heavy debt to science.

It is certain that contributions by our manufacturers and by the
industrial corporations generally to pure scientific research will
in the long run bring manifold returns to them and to the public
whom they serve. These returns will come through the medium
of industrial research conducted in the rich territory discovered
by the scientific investigators of the universities and the other
institutions devoted to the cause of science.

In England during the last century Michael Faraday, one of the
greatest workers in pure science, discovered the principle of the
dynamo-electric machine. Independently of him, and at about
the same time, the same principle was discovered by Joseph Henry,
teacher at the Albany Academy; professor at Princeton, the first Secretary of the Smithsonian Institution, and President of the National Academy of Sciences. No controversy arose between Faraday and Henry as to the credit for the discovery, but with that generosity of spirit which characterized them both, each gave a full measure of credit to the other. Indeed, this discovery tended to form a bond of union and became the source of a permanent friendship between them. By agreement among the scientists of all the nations, one of the fundamental electrical units is called the "farad," in honor of Faraday, and another is called the "henry" in honor of Henry. Both of these men devoted their lives to the discovery of new scientific truths, and to the teaching of science.

To them, as to all workers in pure science, "What use is it?" is not the vital question, but rather, "What message does it bring? What truth does it reveal? What law does it establish?"

An experiment in science is but a question put to nature. She will answer truthfully every question that we ask. She will make known to us all her secrets if we have but the skill properly to frame our questions and the wit to appreciate the answers.

An English statesman before whom Faraday performed his fundamental experiment in electromagnetism asked the forbidden question "What use is it?" Faraday replied, "Some day it may be developed so that you can tax it."

Faraday was a good prophet, for upon his fundamental discovery and that of Henry, if I may but include one or two others of a similar fundamental character, there has been erected the entire art of electrical engineering, as it exists throughout the world today. Truly this discovery has been developed. To-day mankind is in possession of electrical property valued at twenty billions of dollars and evidence is not lacking that other statesmen besides Faraday's are busy taxing it.

It is my great privilege to have here the identical apparatus employed by Henry, and with this to perform before you to-night the experiment illustrating the fundamental principle in electromagnetism discovered by Faraday and Henry. In this experiment, an electromagnet (see Fig. 1) is made to generate a current of electricity in a coil of wire, as is proven by the deflection of the galvanometer (see Fig. 2). The principle thus discovered is the fundamental one upon which all dynamo-electric machines are built.

The coils of these magnets and this galvanometer were...
wound by Henry himself. Even the very wire was insulated with his own hands. Insulated electrical wire, which now seems so common to us that we may perhaps fancy it has always existed, was not an article of manufacture in Henry's time. In fact, it appears that to Henry belongs the credit of having first thought of applying an insulated covering to the wire used for winding electromagnets. Earlier electromagnets had all consisted of a varnished iron core wound about with a few turns of bare wire. Electromagnets with many turns of insulated wire, such as are used in every telephone and telegraph instrument and form part of every dynamo and motor, were first devised and their superiority demonstrated to the scientific world by Joseph Henry.

These historic relics are valued possessions of Princeton University, where for years they have been carefully guarded by Henry's scientific successors. Because of their very great desire to assist the Research Council in its work, the authorities of the University have generously permitted me to bring this apparatus to Washington to perform this experiment before you.

At the time this experiment in natural philosophy was performed by Henry, no one could dream of the wonderful possibilities which it was destined to open to us. The value of this discovery is not to be measured merely by the billions of dollars worth of electrical property which it has made possible. This property has now become such a fundamental part of the mechanism of modern civilization that, if it were suddenly withdrawn from use, the world's industries would become deranged, its communications paralyzed, and transportation would become so disorganized that millions would starve and disorder inconceivable supervene.

That such remarkable results should have followed from this simple experiment conducted by a philosopher seeking only for the truth, surely no one could have foretold. For any practical purpose these old magnets never had a value greater than so much junk, but in the hands of the philosopher they have brought endless advantages which will continue to accrue to the benefit of mankind as long as civilization endures.

In order to encourage those engaged in the industries and in the practical arts and in commerce to make contributions to the support of scientific discovery in the universities and other institutions, and more particularly in order to justify them from a business standpoint in so doing, it is necessary to demonstrate the pecuniary value of
science. I have endeavored to combat the unappreciative views so often held concerning pure science in the universities, and at the same time I have urged the great practical usefulness and profit to be derived from scientific research conducted within the industries. Above all it has been my purpose to show that our future progress in the industries, in commerce, in medicine and in surgery, and in all the practical arts and sciences depends upon fundamental discoveries yet to be made by workers in pure science in our universities and other scientific institutions.

For many years friends of the Albany Academy have tried in vain to raise the few thousand dollars necessary to erect at Albany, where Henry did his early work, a monument to his memory. Once the American people have been made to understand the marvelous contribution which their scientist made to human welfare, their sense of duty and their unfailing generosity will stir them to action. Then, I am sure, they will erect a worthy memorial through which American art will express to American science the gratitude of our people for the discoveries of Henry.

Also, through their generosity, through their gratitude and their feeling of enlightened self-interest, they will relieve the necessities of Princeton, which lacks only pecuniary aid to enable the successors of Joseph Henry there, to carry out in a worthy manner the high traditions which he established at that university.

Even at the Smithsonian, where Henry its first Secretary labored so successfully, many of the wonderful scientific projects of his distinguished successor, Dr. Walcott, are sadly impeded for lack of funds. In this case also, when the truth is known, I am sure that the generosity of our people will not fail.

For these institutions, forever associated with the name of our great American scientist, and for all the universities and other organizations devoted to science, these old magnets wound by the patient hands of Henry himself, have come to speak. Here at the Smithsonian, in the capital of the Nation, the scene of his many triumphs, these venerable relics speak to the American people and plead the cause of science.

The message which they bear expresses much more than the indebtedness of the electrical industry to Henry and Faraday, vast though that is; it expresses the debt of every industry to all laborers in scientific fields. Every age and nation has had its Henrys and its Faradays who have devoted themselves to the quest for truth; and the fruits of their endeavors when called to testify, could speak as eloquently as these old magnets of the immense practical benefits accruing to the world from what have often seemed to the uninitiated to be trivial scientific investigations.

If it were attempted to appraise the value of science in dollars or to express it in amounts of taxable property, the figures would be inconceivably large. But science can best be measured in terms of human achievement, the mastery of the forces of nature, the elimination of poverty and disease, the prolongation of life, the advancement of learning, the growth of right living and sound thinking, and of good understanding among men.

I have now a message to deliver. Filled with courage and promise and hope, it is addressed to all of those who labor and are burdened with toil. It tells them that the possibilities of science are boundless and that the resources of nature are without number. They are asked no longer to interpret life as a struggle among men for a limited store, where one man's gain must be another man's loss. They are bidden to pay heed to the voice of the scientist and under his leadership join with their fellowmen, all working together in controlling and utilizing the bountiful forces of nature.

They are told that they are pioneers in a new land. They are asked to endure the temporary hardships of the present day as did the early settlers in our own country, who were buoyed up with that vision of vast natural resources which unfolded itself before their eyes. They are told to look about them through the eyes of modern science and they will see that they too are pioneers, and in a world of wonders filled with boundless promise which will be realized by their children and their children's children and all of their generations in increasing measure.

Great as are the scientific accomplishments of our day, they are small indeed compared to the possibilities of the future with which Nature awaits the call of the scientist. Two centuries ago, Sir Isaac Newton, the discoverer of the law of gravitation, who ranks perhaps as the foremost scientist the world has had, expressed his faith in the infinite possibilities of science in the following words:

"I seem to have been only like a boy playing on the seashore, and directing myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me."
All the wonderful scientific developments since the time of Newton so strikingly confirm the vision of the great philosopher expressed in the words just quoted, that I can predict with a feeling of certainty that the discoveries of the future, if science is properly supported, will be enormously great in comparison to those of our own time. I believe, indeed, that they will be so great that the people of that coming day will look back upon our knowledge of the forces of Nature as we now look back upon that of the North American Indian who, cold and shivering, was ignorant of the coal at his feet with its stores of warmth and power.

For all of the benefits which she has conferred upon us, science asks only that we provide her faithful workers with an opportunity to multiply their efforts in our behalf. Pointing to the past, she holds forth with certainty the promise of further great truths. She tells us that from these truths the engineers and chemists, the physicians and surgeons, the agriculturists and all the other applied scientists trained in our universities, will develop without number marvelous new agencies for the comfort and convenience of man and for the alleviation of human suffering.
NATIONAL RESEARCH COUNCIL

PRELIMINARY REPORT OF THE ORGANIZING COMMITTEE TO THE
PRESIDENT OF THE ACADEMY

By George E. Hale, Chairman

On April 19, 1916, at the closing session of the annual meeting, the Academy voted unanimously to offer its services to the President of the United States in the interest of national preparedness. The Council of the Academy was authorized to execute the work in the event of the President's acceptance.

On April 26 the President of the Academy, accompanied by Messrs. Conklin, Hale, Walcott, and Woodward, was received at the White House by the President of the United States. In presenting the resolution adopted at the annual meeting, it was suggested that the Academy might advantageously organize the scientific resources of educational and research institutions in the interest of national security and welfare. The President accepted this offer, and requested the Academy to proceed at once to carry it into effect.

Immediately following this visit, the President of the Academy, in harmony with resolutions adopted by the Council on April 19, appointed the following Organizing Committee: Messrs. Edwin G. Conklin, Simon Flexner, Robert A. Millikan, Arthur A. Noyes, and George E. Hale (Chairman).

At a meeting of the Council of the Academy, held in New York on June 19, the Organizing Committee presented the following statement of work accomplished up to that date.

Much time was devoted during the first five weeks to the organization of committees to meet immediate needs, including those on Nitrile Acid Supply (A. A. Noyes, Chairman), in co-operation with the American Chemical Society; Preventive Medicine (Simon Flexner, Chairman), in co-operation with the Committee of Physicians and Surgeons, and Synthetic Organic Chemistry (M. T. Bogert, Chairman), in co-operation with the American Chemical Society. Special attention was also given to arrangements for co-operation with the scientific Bureaus of the Government, the Committee of Physicians and Surgeons, the Naval Consulting Board, the national societies devoted to branches of science in which committees were immediately needed, the national engineering societies, the larger research foundations, certain universities and schools of technology, and the leading investigators in many fields of research, both on the industrial and the educational side. The hearty encouragement received from all of these men and institutions leaves no doubt that, as soon as a general request for co-operation is sent out, it will meet with universal acceptance.

During this preliminary period a more comprehensive plan of organization was developed, and finally embodied in the form indicated below. It was recognized from the outset that the activities of the committee should not be confined to the promotion of researches bearing directly upon military problems, but that true preparedness would best result from the encouragement of every form of investigation, whether for military and industrial ap-
plication, or for the advancement of knowledge without regard to its immediate practical bearing. The scheme of organization must be broad enough to secure the co-operation of all important agencies in accomplishing this result.

After considering a variety of plans the Organizing Committee presented to the Council of the Academy the following recommendations:

"(3) The promotion of co-operation in research, with the object of securing increased efficiency; but with careful avoidance of any hampering control or interference with individual freedom and initiative.

"(4) Co-operation with educational institutions, by supporting their efforts to secure larger funds and more favorable conditions for the pursuit of research and for the training of students in the methods and spirit of investigation.

"(5) Co-operation with research foundations and other agencies desiring to secure a more effective use of funds available for investigation.

"(6) The encouragement in co-operating laboratories of research designed to strengthen the national defense and to render the United States independent of foreign sources of supply liable to be affected by war."

The Council of the Academy voted to accept the proposals of the Organizing Committee, and instructed it to proceed with the formation of the National Research Council in accordance with the plan recommended by the committee.

In consultation with the presidents of the various societies already mentioned, most of the members of the Council have now been chosen. The endorsement of the President of the United States and the authority to secure the appointment of government representatives, is conveyed in the following letter to the President of the Academy:

WILLIAM H. Welch,
President of the National Academy of Sciences, Baltimore, Maryland.

My Dear Mr. Welch:

I want to tell you what gratification I have received the preliminary report of the National Research Council, which was formed at my request under the National Academy of Sciences. The outline of work there set forth and the evidence of remarkable progress towards the accomplishment of the object of the Council are indeed gratifying. May I not take this occasion to say that the Departments of the Government are ready to co-operate in every way that may be required, and that the heads of the Departments most immediately concerned are now, at my request, actively engaged in considering the best methods of co-operation?

Representatives of Government Bureaus will be appointed as members of the Research Council as the Council desires.

Cordially and sincerely yours,


Under this authority, the appointment of representatives of the Army, Navy and various scientific Bureaus of the Government will now be arranged with the members of the Cabinet. It is expected that the first meeting of the Council will be held in September.

It has already been stated that cordial desire to co-operate has been encountered in every hand. Special reference may now be made to certain striking cases. The first of these illustrates how the Council, taking advan-
tage of the increased appreciation of the value of science and the spirit of
national service which have resulted from the war, may obtain the co-opera-
tion of educational institutions and assist them in adding to their endow-
ments for scientific research. Throop College of Technology, in Pasadena,
California, is a small institution of high standards which gives special attention
to research. President Scherer, hearing of the plans of the Research Council,
offered the assistance and co-operation of the recently endowed Research
Laboratory of Chemistry and secured at once an additional endowment of
one hundred thousand dollars for scientific research. Under somewhat
similar circumstances, a gift of $500,000 has been made to the endowment of
the Massachusetts Institute of Technology, with the expectation that much
of the income will be used for research at that Institution.

Another illustration of friendly co-operation, of special importance because
it assures the support of the National Engineering Societies, is afforded by
the following resolution of the Engineering Foundation of New York, adopted
at the annual meeting of the Foundation, on June 21, 1916:

"Whereas, the National Academy of Sciences of the United States of Amer-
ica has taken the initiative in bringing into co-operation existing governmental,
educational, industrial, and other research organizations with the object of
couraging the investigation of natural phenomena, the application of
scientific principles in American industries, the employment of science in
the national defense, and such other objects as will promote the national
welfare, and

"Whereas, these objects are among the objects for which the Engineering
Foundation was created,

"Now, Therefore, be it Resolved, that the Engineering Foundation hereby
registers its approval of the co-ordination and federation of the research
agencies of the country undertaken by the National Academy of Sciences and
expresses its willingness to join with and assist the National Academy in
accomplishing the above federation."

The Foundation also offered to devote its entire income for the coming
year (including a special gift of $5000 for this purpose from its founder,
Mr. Ambrose Swasey) toward the expenses of organization, and to provide
a New York office for the Council in the Engineers Building.

The Presidents of the American Philosophical Society, of the American
Association of University Professors, and of Yale University have already
expressed their intention of proposing the adoption of similar resolutions by
the institutions which they represent and of recommending the appointment
of committees to co-operate with the National Research Council; and it is ex-
pected that other societies and educational institutions will take similar action.

Respectfully submitted by the Organizing Committee,

George E. Hale (Chairman),
Edwin G. Conklin,
Simon Flexner,
Robert A. Millikan,
Arthur A. Noyes.
NATIONAL RESEARCH COUNCIL

PRELIMINARY REPORT OF THE ORGANIZING COMMITTEE
TO THE PRESIDENT OF THE ACADEMY

BY

GEORGE E. HALE, Chairman

REPRINTED FROM
THE PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES
Vol. 2, p. 507, August, 1916
NATIONAL RESEARCH COUNCIL

NATIONAL RESEARCH FELLOWSHIPS IN PHYSICS AND CHEMISTRY

Supported by the Rockefeller Foundation

General Statement.—The National Research Council has been entrusted by the Rockefeller Foundation with the expenditure of an appropriation of $500,000 within a period of five years for promoting fundamental research in physics and chemistry primarily in educational institutions of the United States.

The primary feature of the plan is the initiation and maintenance of a system of National Research Fellowships, which are to be awarded by the National Research Council to persons who have demonstrated a high order of ability in research, for the purpose of enabling them to conduct investigations at educational institutions which make adequate provision for effective prosecution of research in physics or chemistry. The plan will include such supplementary features as may promote its broad purpose and increase its efficiency.

Purposes in View.—Among the important results which are expected to follow from the execution of the plan may be mentioned:

(1) Opening of a scientific career to a larger number of able investigators and their more thorough training in research, thus meeting an urgent need of our universities and industries.
(2) Increase of knowledge relating to the fundamental principles of physics and chemistry, upon which the progress of all the sciences and the development of industry depend.

(3) Creation of more favorable conditions for research in the educational institutions of this country.

Administration.—The plan will be administered by the Research Fellowship Board of the National Research Council. This Board consists of six members appointed for terms of five years, and of the chairman ex-officio of the Division of Physical Science and the Division of Chemistry and Chemical Technology of the National Research Council. The members of the Board are:

Henry A. Bowditch, Professor of Physics, Yale University.
Simon Flexner, Director of Laboratories, Rockefeller Institution for Medical Research.
George E. Hale, Director of Mount Wilson Observatory.
E. S. K. Kuschke, Professor of Chemistry, Harvard University.
Robert A. Millikan, Professor of Physics, University of Chicago.
Arthur A. Noyes, Director of the Research Laboratory of Physical Chemistry, Massachusetts Institute of Technology.
Wilder D. Bancroft, Professor of Physical Chemistry, Cornell University, Chairman of the Division of Chemistry and Chemical Technology.

Cooperation of Educational Institutions.—National Research Fellows will be permitted to conduct their investigations at institutions that will cooperate in meeting their needs. These needs differ widely from those of students seeking only instruction. Able investigators, actively engaged in productive research, are needed to inspire and guide the work of the Fellows. Research laboratories, adequately manned with assistants and mechanicians, and amply supplied with instruments, machine tools, and other facilities, are indispensable; and funds to provide supplies and to satisfy the constantly recurrent demands of research must be available. Above all, there must exist the stimulating atmosphere found only in institutions that have brought together a group of men devoted to the advancement of science through pursuit of research.

The Research Fellowship Board expects to make arrangements by which educational institutions will associate the Research Fellows with their graduate departments and offer the most favorable conditions for the prosecution of their researches.

The applicant will indicate one or more institutions at which, in his opinion, his research work can be conducted to the best advantage.

Fellowship Appointments.—The appointments of National Research Fellows will be made only after careful consideration of the scientific attainments of all candidates, not only of those who apply on their own initiative, but also of those who are brought to the attention of the Fellowship Board by professors in educational institutions and by other investigators throughout the country. In making the appointments much weight will also be given to the judgment shown by the applicant in selecting and planning his proposed research.

The Research Fellowships will for the most part be awarded to American citizens who have had training equivalent to that represented by the Doctor's degree. The salary will ordinarily be $1,500 for the first year. The Research Fellowship Board will not, however, be bound by rigid rules of procedure. Thus it may offer larger salaries to those of exceptional attainment or wider experience, and may give appointment to competent investigators who have had training other than that represented by the Doctor's degree. The Research Fellows will be appointed for one year; but they will be eligible for successive reappointments, ordinarily with increase of salary.

Fellowship Regulations.—Research Fellows are expected to devote their entire time to research, except that during the college year they may at their option give not more than one-fifth of their time (outside preparation included) to teaching of educational value to themselves, or to attendance on advanced courses of study. They may associate graduate students with their researches. They shall not engage in
work for remuneration during the term of their appointment. Fellows who have not received the Doctor's degree may, with the approval of the institution, offer their research work in partial fulfillment of the requirements for that degree.

Fellows are expected to submit to the Board shortly before the first of April of each year a detailed report on the progress of their researches. They must also present an account of their researches in form for publication before withdrawing from the Fellowship; and final salary payments will be deferred until this condition is fulfilled. It is understood that all results of investigation by the Fellows shall be made available to the public without restriction.

Fellowship appointments are subject to the condition that after they are accepted by the applicant, they will not be vacated within the year without consent of the Research Fellowship Board.

_Fellowship Applications._—It is expected that fifteen to twenty Research Fellowships will be available during the coming year, and that the number will be increased in subsequent years. Applications for these Fellowships should be made on the form provided for the purpose, and should be sent to the Secretary of the Research Fellowship Board, National Research Council, 1023 Sixteenth Street, Washington, D. C., to whom all other correspondence should also be addressed. Applications will be received up to September 1, 1919 for Fellowships available during the next academic year; but a limited number of appointments will be made on the basis of the applications received before April 20, 1919.

_Washington, D. C., March 29, 1919._
The President reports to the Board of Trustees the following appointments to Fellowships of the National Research Council:

In Physics
  Jared Kirtland Morse
  Melvin Mooney
  Tracy Yerkes Thomas
  Herman Zanstra

In Chemistry
  Marschelle Harnly Power

In Medicine
  Edward Julius Stieglitz

In Physiology
  Margarete Meta Hedwig Junde
  Gerald Watson Hamilton

In Zoology
  Leigh Hoadley
Dear Dean Tufts:

As near as I can find out, the following hold National Research Council Fellowships:

In Physics:
  Jared Kirtland Morse
  Tracy Yerkes Thomas
  Herman Zanstra

In Chemistry:
  Marschelle Harnly Power

In Medicine:
  Edward Julius Stieglitz

In Physiology:
  Margarete Merta Hedwig Kunde
  Gerald Watson Hamilton

In Zoology:
  Leigh Headley

Very truly yours,

Henry G. Gale

Dean James H. Tufts
University of Chicago

Nov. 8, 1925
Dear Dean Tufts:

As near as I can find out, the following hold National Research Council Fellowships:

In Physics:
  Jared Kirtland Morse
  Tracy Yerkes Thomas
  Herman Zanstra

In Chemistry:
  Marschelle Harnly Power

In Medicine:
  Edward Julius Stieglitz

In Physiology:
  Margarete Meta Hedwig Kunde
  Gerald Watson Hamilton

In Zoology:
  Leigh Hoadley

Very truly yours,

Henry G. Gale

HGG:

Dean James H. Tufts
University of Chicago

Nov 8, 1925
Memorandum to the President:

Concerning National Research Fellows.

I find that we have had several National Research Fellows in the Departments of Physics and Chemistry, who have been placed upon the list of officers of instruction of the departmental staff as printed in the Register. Unless I am mistaken I spoke with you about this last spring and you authorized the appointment of Dr. Leigh Hoadley, on Professor Lillie's recommendation. I wrote to Mr. Dickerson the attached letter and you will note his suggestion. I have said to him in reply that it seemed to me that the board would prefer not to have additional matters of detail of this character presented to it unless this were considered necessary. Mr. Dickerson said he would be governed entirely by your judgment.

It occurs to me that if you considered it necessary the board might be asked to authorize such recognition by authority of the President (since there is no financial obligation created except that of furnishing laboratory opportunities), but that you might as a matter of proper congratulation like to recite to the board from time to time such appointments since they are an honor to the University.

T.S