SCIENCE

CONTENTS

MSS. intended for publication and books, etc., intended for review should be sent to Professor J. McKeen Cattell, Garrison-on-Hudson, N. Y.

NATIONAL ACADEMIES AND THE PROGRESS OF RESEARCH

III. THE FUTURE OF THE NATIONAL ACADEMY OF SCIENCES [1]

IN previous papers of this series[2] we have traced the development of European academies and observed the powerful influence they have exercised on the advancement of research; we have watched the beginnings of scientific investigation in the United States, and their public recognition by act of Congress establishing the National Academy of Sciences; and we have followed the history of the Academy during the half century which has elapsed since its origin. In view of the great part which academies have played in the past, and the fact that the rapid development of original research in this country has carried us out of the pioneer period, the National Academy now faces an exceptional opportunity to impress its influence upon the future scientific work of the United States. But if it enjoys an opportunity, it also faces a duty, imposed upon it by its national charter and by its position as the sole representative of

[1] This paper was presented at the Baltimore meeting of the National Academy in November, 1913. By action of the council, a manuscript copy was subsequently sent by the home secretary to each member of the academy for criticism and comment. In preparing the paper for publication, the author has had the advantage of seeing these replies. Except for a few minor verbal changes, the text is printed in its original form, with the addition of new paragraphs in square brackets.

[2] I. "The Work of European Academies," SCIENCE, 38, 681, 1913. II. "The First Half Century of the National Academy of Sciences," SCIENCE, 39, 189, 1914.

America in the International Association of Academies. The history of the Academy shows that it has taken its obligations seriously, by complying with requests from the executive and legislative departments of the government for advice on scientific matters, by the use of trust funds for the advancement of research, by the award of prizes and grants for investigation, by the initiation and support of international cooperation in research, and by such other means as its limited endowment has permitted. But while the rapid growth of the scientific bureaus of the government has reduced the number of questions which would otherwise be submitted to the Academy, the enormous increase in the wealth of the country, and the expansion of its trade relations have raised new problems and advanced new opportunities. These developments, which have resulted in the multiplication of universities, observatories and laboratories, and the foundation of great endowments for research, place the Academy in a new position, and impose the question whether it can not now accomplish much more than was formerly possible. It is the purpose of this paper to open the discussion of this question, in the hope that its further consideration by other members may lead to an extension of the work and usefulness of the Academy.

Fortunately we may take advantage of the rich store of experience accumulated by the European academies during their long histories. In seeking to adapt this to our own needs, we must of course recognize the special conditions existing in the United States. The great area over which our members are distributed and the lack of any such centralization as we see in London or in Paris, will always stand in the way of weekly meetings like those of the Royal Society and the Paris Academy. But if we can not hope to see our leading investigators personally demonstrate each step in their progress before academic audiences, as Faraday and Pasteur and many another have done abroad, we can nevertheless provide for lectures and papers illustrated by experiments in connection with the semi-annual meetings of the Academy, and possibly for others of a public character, extending throughout the year, after the manner of the Royal Institution of London. The disadvantage of our members in being unable to read accounts of their latest advances before weekly meetings of their colleagues can also be largely offset by the publication of *Proceedings*, in which the first results of all new work may be adequately presented. Thus, though we lack some of the advantages of centralization, these may be largely overcome, while retaining the very great advantage of a widely distributed membership representing the scientific interests of every section of the country.

FUNCTIONS OF A NATIONAL ACADEMY

The criticism has sometimes been directed against academies covering the whole range of knowledge that their place has been sufficiently filled by the special societies devoted to particular branches of science. For more than a century the Royal Society and the Paris Academy served all the purposes of science in Great Britain and France, but toward the end of the eighteenth century special societies began to develop in England. The establishment of the Linnean Society in 1788 did not appear to give special concern to the members of the Royal Society. But when the Geological Society was instituted in 1807, Sir Joseph Banks, then President of the Royal Society, united with Sir Humphry Davy and others in a strenuous attempt to amalgamate it with the parent body. The Royal Astronomical Society was established in

1820, partly as the result of the accumulation of valuable observations too extensive for the Royal Society to publish. Sir Joseph, though he had himself aided in the establishment of the Linnean Society, was greatly perturbed at this further development. A short time later he died in the belief that the special societies had struck a severe blow at the respectability and usefulness of the Royal Society, by robbing it of many of its members and laying claim to some of its most important departments.[3] But his fears were wholly unwarranted, and the special societies continued to grow and multiply, to the advantage of science and of the Royal Society itself. Their extensive publications have not detracted from the volume or the quality of the *Philosophical Transactions* and the *Proceedings,* and each of these societies, by contributing to the development of some special field, has helped to build up that great organization of British science of which the Royal Society is the acknowledged and venerated head.

These details will not be out of place if they help to emphasize a principle which should always be respected in the work of the National Academy. The societies and journals which have been established to meet the needs of scientific progress have come to stay. It is neither necessary nor in any way desirable to usurp their functions, which are the result of a natural process of evolution. There is ample room, however, for academies devoted to the whole range of science. The rapid advance of research in a thousand ramifying fields has left much intermediate territory unexplored. The approach to these undeveloped regions may be made from more than one direction, and through the aid of more than one method. Thus nothing can be more stimulating to the progress of research than an acquaintance with the investigations and processes which are constantly being developed in fields other than one's own. Mathematics has received its principal impulses from astronomy and physics. Physical chemistry is indebted, on the one hand, to Pfeffer the botanist for the study of vegetable cells, and on the other to the mathematical and physical investigations of Willard Gibbs, Van der Waals and Arrhenius. Astrophysics came into existence through the use in astronomy of the spectroscope and other physical instruments. Every department of science sheds a luster which should illuminate, not only its particular territories, but others, near and far, occupied by other workers. The importance of recognizing and utilizing this fact must therefore increase as time goes on.

[It has been truly said that an academy can hope to accomplish large results only as it succeeds in meeting the conditions of the present rather than those of the past. What are existing conditions in science? Surely none is more striking than the contraction of the field of the average investigator. Specialization is inevitable in the maze of modern progress, and the narrowing effect of constant devotion to a single subject must become still more apparent as science ramifies further. A general academy, by insisting on the importance of large relationships, by demonstrating the unity of knowledge, by recognizing the fact that fundamental methods of research, wherever developed, are likely to be applicable in more than one department, can do much to broaden and to stimulate its members. The correlation of research should be counted as one of its prime objects, and its energies should be largely directed to this important end.]

We are thus led to the conclusion that

[3] Barrow, "Sketches of the Royal Society," pp. 10, 256; Weld, "History of the Royal Society," pp. 242, 246.

the functions of a National Academy should be of the broadest character, and that the advantage of sharing in the results of all its departments should belong to every member. Thus the policy of our National Academy of avoiding division into separate sections,[4] and of bringing papers on the most diverse subjects before the entire body, is fundamentally sound and should be maintained. Later in this paper the question will be considered whether the range of the Academy's activities should be extended so as to give increased recognition to departments of knowledge other than the physical and natural sciences.

Under the conditions now existing in the United States, there is reason to believe that the functions of a National Academy might well be multiplied so as to meet a wide variety of needs. It should stand, first of all, as a leading source and supporter of original research and as the national representative of the great body of American investigators in science. To the government it should make itself necessary by the high standard of its work, the broad range of its endeavors, and the sane and scientific spirit underlying all of its actions. To its members it should offer stimulus and encouragement in their investigations; due recognition of their advances; financial assistance and the use of instruments at critical periods in their work; the advantage of listening to papers ranging over the whole field of science, bearing suggestions of principles or methods likely to develop new ideas; contact with the greatest leaders of research from all countries and opportunities to listen to descriptions of their work; access to books and manuscripts not easily obtainable from other sources; and participation in international cooperative projects in every field of investigation. In the public mind it should rank as the national exponent of science, and as the agency best qualified to bring forward and illustrate the latest advances of its own members and of the scientific world at large. To representatives of manufactures and industries, the Academy should serve to promote the appreciation and widespread use of the scientific principles and methods which have built up the great industrial prosperity of Germany. With other societies devoted to various branches of science, it should cooperate in harmony with the best interests of American research. Toward local bodies for the encouragement of investigation and the diffusion of knowledge, it should act as an inspiring example and a reliable source of support. And in the broad field of international cooperation, it should unite with the leading academies of the world in the endeavor to perfect the organization of research and in the use of all agencies contributing to its advancement.

[4] Except for voting purposes.

NEEDS OF THE ACADEMY

Many of these objects have been accomplished by the National Academy in the past, but others remain for the future. The greatest aid in accomplishing its full work would be met by the provision of a suitable academy building, and an endowment sufficient to publish *Proceedings,* conduct research, provide public lectures, maintain exhibits illustrating current investigations, and to meet such additional needs as are implied by the Academy's national charter and its obligations to the scientific world and the general public. Through the courtesy of the Smithsonian Institution, extended in the year of the academy's organization, the annual meetings are held in the National Museum, in rooms ordinarily employed for other purposes. Thus the Academy does not even possess a permanent office, or a room for its library, which will

be needed in the future for its work of research. It has therefore been compelled from the outset to decline many offers of books, and thus a large and valuable collection, comprising publications offered by many of the great academies, laboratories and observatories of the world, has been lost.[5]

It is difficult to overestimate the value of a suitable building in commanding public appreciation and support for any institution. Visible evidence of the Academy's existence is a matter of no small importance, when it is remembered that the average American citizen, though well-acquainted with the name of the Paris Academy through press reports of discoveries announced there, has never heard of our own national organization. But a building used as a storehouse and occupied but once a year is not enough. The Academy must be known as a living and active body, which recognizes and fulfills its many duties to science and the public. If its headquarters were constantly employed for such purposes as are enumerated later, the Academy would soon be looked upon as the natural source of information regarding the latest developments of science, and more generally recognized as the national representative of American research.

IMPORTANCE OF PUBLISHING PROCEEDINGS

As explained in a previous paper, the name of the National Academy has never been associated with the work of its members, since the papers read at its meetings have not been published by the Academy. Thus it has not been sufficiently identified with the progress of American research, and the chief source of the reputation of the Paris Academy and the Royal Society has been lacking. But though the Academy would become more widely known by the publication of *Proceedings,* it would be foolish to take such a step merely to accomplish this purpose. The establishment of a new journal, in these days when the literature of science has become exceedingly complex, should never be undertaken without serious consideration of its probable usefulness. If it fulfills no good and lasting purpose, its life will be deservedly short. Hence we may not imitate the example of societies which established their publications before the special journals had taken the field. We must recognize, on the one hand, that the various journals devoted to particular branches of science meet a clearly defined need and should not be rivaled, even to the apparent advantage of the Academy. On the other hand, we must also remember that the members of the Academy have adopted a regular plan of publication, the interruption of which might interfere with the accessibility of their papers. Thus, if *Proceedings* are to be established, they should be so planned as to serve a useful scientific end and be distinctly advantageous, not merely to the Academy itself, but to all of its members.

I am strongly of the opinion that no step which can be taken at the present time would be so beneficial to the National Academy as the publication of *Proceedings* containing the first announcements of important advances and the chief results of American research. I believe, furthermore, that this can be done in such a way as to benefit the members and contribute to the advancement of science. In many departments of the Academy's work papers published in the special American journals of limited foreign circulation do not reach a sufficiently large group of European readers. I am told that this is

[5] The Academy has accepted some gifts of books, which are packed away (unbound) in the storerooms of the Smithsonian Institution.

particularly true in biology, where American investigators are producing a great body of results of the first importance. Thus the *Proceedings* of the Academy, if properly distributed, might be made to serve the very useful purpose of bringing the work of a large number of investigators to the attention of scholars abroad. But in order to preserve all interests, and to interfere in the least degree with present plans of publication, the *Proceedings* should not be designed to occupy such a place as the special journals adequately fill.

[The chief advantage of the *Proceedings* would not be the same in all departments of science. In mathematics, where the existing journals are greatly overcrowded, prompt publication of the condensed results of new research would be heartily welcomed. The same thing is true in botany and in many other subjects. In fact, improved means of prompt publication would be generally appreciated by Academy members. In biology, as already remarked, the great number of special journals prevents many of them from reaching European laboratories, where American research is frequently overlooked as a consequence. In astronomy and astrophysics, which have fewer journals, the circulation of the chief American journals is large, and their contents reach all investigators abroad. But the practise of publishing separate series of circulars or bulletins, which has been adopted by many American observatories, confines the circulation of their papers to the limited number of astronomers and observatories on their mailing lists. If brief accounts of the broader aspects of these investigations were printed by the Academy, they would be useful to astronomers making a general survey of progress in their own field. But they would be even more serviceable to the mathematician, physicist, meteorologist, chemist, geologist or other investigator who may find information of direct or suggestive value in the results of astronomical research. Conversely, even those astronomers who keep in touch with progress in mathematics or physics can not also examine the numerous journals of chemistry, geology and other subjects which contain results applicable in their own work. It will thus be seen that the Academy could perform an important service in its special province of correlating knowledge by publishing papers covering the whole range of science.

The value of the *Proceedings* in strengthening the position of American science at home and abroad should not be overlooked. The rapid progress of American research in a single field may be known to the European specialist, but he may not realize that similar advances in other departments have raised American science to a new level. Recognition of this fact is desirable, not for the gratification of national pride, but because the international influence of America in science will grow with its prestige. The combination of effort which the *Proceedings* would represent, and the demonstration they would afford of American activity in research, are factors of real significance in securing that recognition and standing, both at home and abroad, which is needed to accelerate future progress.]

To accomplish the desired result, it would seem that the *Proceedings* should be intermediate in character between the *Comptes Rendus* of the Paris Academy and the *Proceedings* of the Royal Society. Papers read before the Paris Academy on Monday are printed and issued in the *Comptes Rendus* on the following Saturday—a record for speed which we should not expect to rival. Such accelerated publication, while it doubtless possesses certain advantages, renders impossible that more leisurely

editorial examination which most journals demand. The *Proceedings* of the Royal Society, on the other hand, appear at irregular intervals, and frequently contain long and detailed papers, which with us might better find a place in the special journals. In the case of the National Academy it is doubtful whether publication at shorter intervals than one month is necessary, but the possible advantages of fortnightly publication should be carefully considered.

It goes without saying that papers for the *Proceedings,* while comparatively brief (perhaps averaging from three to five pages), should not be hasty announcements based on inadequate data. On the contrary, the dignity of the National Academy and the best interests of its members demand that only carefully matured conclusions, resulting from prolonged observational or theoretical research, should appear under the Academy's imprint. Measures and other exact data needed to establish these conclusions would be a necessary part of such papers, though long numerical tables, profuse illustrations, and detailed accounts of minor topics should be reserved for publication in the special journals, to which members would continue to contribute as before. The Academy *Proceedings* would thus serve for the first announcement of discoveries and of the more important contributions to research, illustrated by line cuts and occasional halftones in the text, when essential to clearness, but free from unnecessary detail and extensive numerical data. Non-members, as well as members, should be invited to contribute, with the understanding that their papers are to be presented by a member of the Academy, as in the case of the Paris Academy and the Royal Society.[6]

[6] The *Proceedings* should be so planned as to interfere in the least possible degree with the *Journal* of the Washington Academy of Sciences, which is a publication similar in character to the one here proposed. As the *Journal* is devoted mainly to work done in Washington, or presented before the various Washington societies (other than the National Academy), no important overlapping of the two publications need be anticipated, especially as members of this Academy have rarely contributed to the *Journal.*

The constitution of the National Academy already provides for the issue of *Proceedings,* as well as *Memoirs* and *Annual Reports.* In fact, as explained in a previous paper, three volumes of *Proceedings* were published, though they did not contain papers presented to the Academy. There is therefore no need of any radical departure requiring amendment of the constitution. In other words, if sufficient funds are available, this very important step toward the development of the Academy can be taken by simple affirmative vote.[7]

The annual volumes of the *Proceedings,* bringing together for the first time the best product of American research, would place the Academy in a clearer light before the academic world. *Annual Reports* and infrequent volumes of *Memoirs* receive scant attention, except from a few specialists, in the libraries of our contemporary societies. But the *Proceedings,* published at regular intervals, and containing a standing notice of the Academy's publications, would aid in making them better known. The quarto *Memoirs,* eleven volumes of which have already appeared, afford an excellent place for extended publication, when the necessity for lengthy tables, numerous plates, or long discussions of data places the manuscript beyond the reach of the special journals. The publication of the *Proceedings* might serve to disclose

[7] [The Academy voted, at its meeting of November, 1913, to begin the publication of *Proceedings* as soon as arrangements could be perfected. The first number will appear in January, 1915.]

much material worthy of use in the *Memoirs,* and the editorial board should be constantly on the watch for opportunities to extend the *Memoirs* and to render them more serviceable to science.

SCIENCE AND THE PUBLIC

The circulation of the *Proceedings* would necessarily be limited to scholars and scholarly institutions—they could not be expected to reach the general public. Here a difficulty remains to be overcome, since the results of original investigations should certainly be made more generally known and more clearly understood than they are at the present time. The average man of science, after sad experience with the daily press, is usually forced to the conclusion that newspaper publication is synonymous with rank sensationalism. Repeatedly told, and not without justice, that his cloistered wisdom should reach a wider world, he sometimes yields to the persistent demands of a reporter. The outcome is too well known to require telling. Even in the case of a really intelligent and conscientious reporter, who does not distort or exaggerate, the "headline man" may be depended upon to provide a grotesque disguise. A few experiences of this sort suffice for most investigators. They are soon forced to shut out the reporter, and are well pleased when they succeed. Yet they recognize that the exclusion of the public from all contact with their work is neither fair nor desirable. Some way should be found of bridging the gap.

A plan followed in England by the Royal Society, of circulating brief abstracts on the day when a paper is read, which are afterwards published in *Nature* (sometimes in condensed form), is one which we might advantageously imitate. When a paper is accepted by the editorial board for publication in the *Proceedings,* a brief abstract, preferably prepared by the author, should be sent to Science (and perhaps also to *Nature*). At the same time this abstract, or a briefer one in less technical language, might be communicated to the Associated Press. It goes without saying that papers for the *Proceedings* would differ widely in their availability for popular treatment. Probably only a comparatively small proportion of them would contain results suitable for use by the Associated Press, but all would doubtless be published in abstract by Science. Through the Associated Press, and also through certain conservative newspapers and magazines, the Academy could thus bring before the public the actual results of scientific research, as distinguished from the false and distorted conceptions of science which most of our newspapers now disseminate.

LECTURES ON RESEARCH

The plan of publication outlined above is but one of several methods by which the Academy may enlarge its usefulness. Public lectures should also be instituted, primarily for the benefit of the Academy members, but also with the expectation of reaching a larger circle. Here the Academy would do well to study and imitate the Royal Institution of London, where original research and the diffusion of knowledge are combined in a very effective manner. In brilliant addresses, illustrated by lantern slides and experiments, a long line of illustrious speakers, best typified by Faraday, have charmed and enlightened the most distinguished audiences. Many of these speakers, including Davy, Faraday, Tyndall, Dewar, Rayleigh and Thomson, have been drawn from the staff of the Royal Institution. But their English contemporaries, as well as scientific men from all parts of Europe and the United States,

have also been invited to describe their latest advances. The speaker at a "Friday Evening Discourse" is faced by the leaders of English thought and action in many fields. Privileged to select from the large collection of historic instruments accumulated during a century, and even to illustrate his points with the apparatus of Faraday himself, he feels an inspiration that no other platform affords. In such an atmosphere he learns to appreciate the dignity of popular science at its best, and to perceive how the busiest and most successful of present-day physicists can find time to deliver elaborate courses of Christmas lectures to a juvenile audience. These lectures, instituted by Faraday, are now in their eighty-seventh season. Under such topics as "The Chemistry of Flame" they have afforded him and his followers an opportunity to show how simply and beautifully the principles of science can be made to appeal even to young children.[8] The art of the popular lecture should be developed in the United States by the National Academy. Under its auspices, and with the example of the Royal Institution behind him, the lecturer need not fear for his dignity. The Academy would soon find its reward in the increasing appreciation of its work and purposes, the spread of scientific knowledge, and ultimately in larger endowments for research.

As a first step in this direction, the children of the late William Ellery Hale have established a course of lectures in memory of their father. Their object in doing so is twofold. In the first place, it is hoped that the lectures may add to the attractiveness of the Academy meetings, both to the members and the public. Again, it is believed that by a suitable choice of lecturers and topics, the inter-relationship of the various fields of research represented in the Academy, and the light thrown by the methods of investigation or of interpretation employed in one field upon those of another, may be illustrated in an effective way. Moreover, the lectures will afford an opportunity of testing whether the Academy may not further assist in increasing public appreciation of the cultural and the industrial value of science.

[8] The last course of Christmas Juvenile Lectures, on "Alchemy," "Atoms," "Light," "Clouds," "Meteorites" and "Frozen Worlds," was given by Sir James Dewar.

SCIENCE IN EDUCATION

In the Academy of Plato and the Alexandrian Museum the functions of an academy and a university were united, and the work of instruction went hand in hand with the development of new knowledge. The growth of the modern university has now removed from national academies their former work of teaching a body of students, but their opportunity to exert a favorable influence on the educational methods of the nation remains. The Institute of France, as planned by Talleyrand and Condorcet,[9] was to control public instruction and offer courses to advanced students. This was not carried out, but an instance of the same sort is afforded by the Academy of Munich, which has charge of the public instruction of Bavaria.

There is no apparent reason why our own National Academy should have a formal connection with educational institutions. But in harmony with its purpose to advance knowledge in the United States, it should contribute toward the development of the science of education and take advantage of the possibility of increasing public appreciation of the educational value of science.

In a presidential address which excited

[9] See Hippeau, "L'instruction publique en France pendant la révolution," Vol. 1, pp. 115, 228.

great public interest in England, Sir William Huggins emphasized before the Royal Society the importance of science in education.[10] We need not dwell upon his arguments regarding the value of scientific training in developing the power of accurate observation and the habit of correct and cautious reasoning. But a more neglected phase of science in education—its power of awakening and expanding the imaginative faculty—may be referred to in his own words:

> Surely the master-creations of poetry, music, sculpture and painting, alike in mystery and grandeur, can not surpass the natural epics and scenes of the heavens above and of the earth beneath, in their power of firing the imagination, which indeed has taken its most daring and enduring flights under the earlier and simpler conditions of human life, when men lived in closer contact with Nature, and in greater quiet, free from the deadening rush of modern society. Of supreme value is the exercise of the imagination, that lofty faculty of creating and weaving imagery in the mind, and of giving subjective reality to its own creations, which is the source of the initial impulses to human progress and development, to all inspiration in the arts, and to discovery in science.

Of all the teachings of science, the principle of evolution makes by far the strongest appeal to the imagination. Isolated phenomena, however remarkable, acquire a new meaning when seen in its light. Minute details of structure in animals or plants, slight differences of the relative intensity of lines in the spectra of stars, may become of intense interest even to the elementary student if explained as steps in a great process of development. But, after all that has been said and written since the time of Darwin, we fail to take full advantage of our opportunity. Properly presented, a picture of evolution in its broadest aspects would serve better than any other agency to stimulate the imagination, to awaken interest in science, and to demonstrate that its cultural value is in no wise inferior to that of the humanities. To the average student, even physics and chemistry are distinct branches of science, each occupied with its own problems. Astronomy, he knows, concerns itself with the heavenly bodies, botany with plants, zoology with animals. But if he studies these subjects at all, he almost invariably fails to realize their relationship, because no binding principle, like that of evolution, is brought prominently to his attention or, at the best, is restricted in its application to some single organic or inorganic field.

When Humboldt wrote "Cosmos" and Huxley lectured on "A Piece of Chalk" and other subjects, they showed what might be accomplished in picturing the problems of science in a broad way. The National Academy is better qualified than any other body in America to demonstrate what can be done in the same direction with the rich store of knowledge acquired since their time. A course of lectures on evolution, beginning with an account of the constitution of matter, the transformation of the elements, and the electron theory; picturing the heavenly bodies and the structure of the universe, the evolution of stars and planets, and the origin of the earth; outlining the various stages of the earth's history, the formation and changes of its surface features, the beginning and development of plant and animal life; explaining modern biological problems, the study of variation and mutation, and the various theories of organic evolution; summarizing our knowledge of earliest man, his first differentiation from anthropoid ancestors, and the crude origins of civilization; and connecting with our own day by an account of early Oriental peoples, the rise of the Egyptian dynasties, and their influence on modern

[10] Huggins, "The Royal Society," p. 109.

progress: such a course, free from technicalities and unnecessary details, richly illustrated by lantern slides and experiments, and woven together into a clear and homogeneous whole, would serve to give the average student a far broader view of evolution than he now obtains, and leave no doubt in the hearer's mind as to the cultural and imaginative value of science.

The William Ellery Hale lectures will open with a series on evolution, so designed as to be of interest to members of the academy, and at the same time to be intelligible and attractive to the public. At each meeting two lectures will be given by a distinguished European or American investigator, chosen because of his competence to deal with some branch of the subject. The first course of lectures, to be given by Sir Ernest Rutherford at the annual meeting in April, 1914, will deal with the constitution of matter and the evolution of the elements.[11] At the conclusion of this series, which will extend through several years, it is hoped that the lectures may be brought together, in a homogeneous and perhaps somewhat simplified form, into a small volume suitable for use in schools.

The course above outlined will serve to test the question whether the Academy may advantageously enter more extensively into the lecture field. So far as the members of the Academy are concerned, it seems probable that lectures by able American and European investigators would add to the interest of the meetings. But the value of the lectures to the general public can only be determined by experiment. If a suitable building can be obtained, and the success of these lectures is sufficient to warrant it, the foremost investigators, American and foreign, might be invited from time to time throughout the year to describe and illustrate their advances in the lecture-hall of the Academy. This plan is already followed by various American institutions, but the Academy, because of its national character, would be better able to attract the best men and to give their lectures more than local significance. Ample facilities for experimental illustration would also go far toward enhancing the value of the lectures. In short, the example of the Royal Institution should be followed as closely as possible.[12]

[11] [The second course was given at the autumn meeting by Dr. William Wallace Campbell on "Stellar Evolution and the Formation of the Earth."]

INDUSTRIAL RESEARCH

The value of science to the American manufacturer, though no new theme, is capable of wide development at the hands of the National Academy. In a presidential address delivered before the Royal Society in 1902, Sir William Huggins dwelt on the "Supreme Importance of Science to the Industries of the Country, which can be secured only through making Science an Essential Part of all Education." He saw the fruits of English discoveries passing into the hands of Germany, whose universities have so long fostered and spread abroad the spirit of research, and wondered at the apathy of the average British manufacturer toward scientific methods. Huggins, speaking in plain language, pointed to the chief source of weakness—"the too close adherence of our older universities, and through them of our public schools, and all other schools in the country downward, to the traditional methods of teaching of medieval times."[13]

In this country, where the classics do

[12] [It has been suggested by several members that these lectures might be repeated in two or three large cities, in cooperation with local scientific institutions.]

[13] "The Royal Society," p. 29.

not dominate the university system, the task of arousing an adequate appreciation of the enormous benefits which science can render is a far easier one. We must have, first of all, a widespread interest in science and some comprehension of its problems and methods. A general course on evolution, given to all college students, should be of great service as an entering wedge. More students might thus be led to take science courses, while those who specialize in the humanities could gain a better conception of what science means. The rapid development of research in our universities and technical schools promises to influence the faculties of our colleges, where a man's success as a teacher will be materially enhanced if he is also a producer of new knowledge. Thus the future is promising in the educational field.

On the side of our manufacturers, who are eager to adopt the most efficient methods, the outlook is equally favorable, as President Little of the American Chemical Society showed so effectively in his address on "Industrial Research in America."[14] Many great firms are establishing large research laboratories, where problems of all kinds are under investigation. The development within the past few years of Taylor's efficiency system is another indication that the advantages of scientific methods are being grasped and applied in the arts. But the opportunities in this direction are almost endless, and the National Academy would do well to devise ways and means of convincing not only the large manufacturers, but the small manufacturers as well, of the industrial importance of scientific research. Lectures on recent advances in engineering, by European and American leaders, should have a powerful influence if carefully planned and effectively illustrated. Parsons on the steam turbine,[15] Marconi on wireless telegraphy,[15] Goethals on the Panama Canal, would attract large audiences and appeal in published form to a wide public.

But while the advantages resulting from ingenuity and invention and the best practise of engineering should certainly be brought out in the course of lectures I now have in mind, the improvement of manufactured products by research methods, and the potential industrial value of pure science are the points which should be emphasized. We have a long way to go before any single manufacturing firm employs seven hundred qualified chemists, as the combined chemical factories of Elberfeld, Ludwigshafen and Treptow do. The supremacy in this field of Germany, which produced chemicals valued at $3,750,000,000 in 1907, is directly due to the carefully directed research of an army of chemists, who learned the methods of investigation in the universities and technical schools.[16] The Berlin Academy of Sciences has also contributed in an important way to this result, through van't Hoff's investigations of the Stassfurth salt deposits. The recent rapid development of our own chemical industries leads us to hope that similar advances may soon be achieved in the United States. In electrical engineering, at least, we are already making comparable progress.

But the average man of business is much better able to appreciate the value of research directly applied to the improvement of manufactures than to comprehend the more fundamental importance of pure science. We must show how the investigations of Faraday, pursued for the pure love

[14] SCIENCE, 38, pp. 643–656, 1913.

[15] Lectures before the Royal Institution, 1911.

[16] In 1910 the Nobel prize for chemistry went to Germany for the sixth time, thus giving to a single country sixty per cent. of all the Nobel prizes for chemistry awarded up to that date.

of truth and apparently of no commercial value, nevertheless laid the foundations of electrical engineering. If we can disseminate such knowledge, which is capable of the easiest demonstration and the most striking illustration, we can multiply the friends of pure science and secure new and larger endowments for physics, chemistry and other fundamental subjects.

[While there can be no doubt of the importance of emphasizing the value of industrial research, the necessity of vigilance in the interests of pure science is shown by the opposite tendency of several recent writers, who measure science solely in terms of its applicability in the arts.

The stimulus of commercial rivalry is doubtless a factor in the rapid progress of our great industrial laboratories, but I doubt if their directors would maintain that all chemical research should be of the industrial kind. Immediate commercial value as a criterion of success will not often point the way to the discovery of fundamental laws, though these are by far the richest source of ultimate achievement, practical as well as theoretical. Modern electrical engineers do not forget the investigations of Faraday and Hertz in pure science, nor do leading industrial chemists overlook the researches of Gibbs, van't Hoff, and others, which brought them no practical returns, but rendered many modern industries possible. Exclusive attention to industrial research means nothing more or less than the growth of the superstructure at the expense of the foundations. Industrial laboratories are able to offer large salaries and other tempting promises of material advantages, and thus to draw the most promising men from the universities. But while these laboratories should be strongly encouraged, and multiplied to the point where every small manufacturer will realize the value of research methods, this should not be done at the serious expense of pure science. Germany's success on the industrial side is primarily due to her still greater achievements in the university laboratories. The National Academy, by helping to maintain the two phases of American research in stable equilibrium, can perform a service which the truest advocates of applied science will recognize as essential to sound progress.]

GEORGE ELLERY HALE
THE MOUNT WILSON
SOLAR OBSERVATORY

(To be continued)

UNIVERSITY REGISTRATION STATISTICS

THE registration returns for November 1, 1914, of thirty of the universities of the country will be found tabulated on a following page. These statistics show *only* the registration in the universities considered. There is no intention to convey the idea that these universities are the thirty largest universities in the country, nor that they are necessarily the leading institutions.

The largest gains in terms of student units, including the summer attendance, but making due allowance by deduction for the summer-session students who returned for instruction in the fall, were registered by Columbia (1,365), California (1,109), Pittsburgh (1,069), Ohio State (832), Wisconsin (806), Harvard (784), New York University (634), Minnesota (552), Pennsylvania (536), Illinois (405), Nebraska (349), Cornell (327), Cincinnati (319) and Michigan (311).

Last year there was none that showed a gain of more than 1,000 against four this year, and ten institutions showed gains of more than 300 against fourteen of this year. They were: New York University, Illinois, Columbia, Wisconsin, Pennsylvania, California, Iowa, Ohio State, Chicago and Michigan. There is a theory that universities and colleges have larger increases than usual when national economic conditions are bad, that is during