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ADDRESS OF THE PRESIDENT OF THE NATIONAL ACADEMY OF SCIENCES[1]

By Dr. W. W. CAMPBELL

PRESIDENT EMERITUS OF THE UNIVERSITY OF CALIFORNIA

Mr. Minister of Norway,
Members of the National Academy and esteemed Guests:

WITH one exception the several speakers of this evening will be formally introduced, and you will observe that their addresses fit into a logical plan. It will make me feel better if I exercise the privilege of telling you that I, as the one exception, am making an address at the request of the academy's council, and not upon my own initiative.

The academy's dinner of each year is attended for the first time by many of its recently elected members. It is a safe guess that those new members have an incomplete understanding of the historic reason for the academy's creation and existence. It was in the middle year of our great war between the states, the year 1863, that the United States Government, feeling the need for a definite and responsible organization of the scientists of the nation to which it could go at any time for information and advice on scientific subjects, incorporated and constituted the National Academy of Sciences, by a special Act of Congress. This act, in effect the charter of the academy, is a remarkable document; remarkable in its brevity, its clarity and in my opinion its wisdom.

The first paragraph of the congressional act consists of the statement that fifty American scientists whose names are recorded in alphabetical order, beginning appropriately with Louis Agassiz, of Harvard, on the Atlantic coast, and ending with "J. D. Whitney, California; their associates and successors

[1] Given at the annual dinner, April 23, 1935.

duly chosen, are hereby incorporated, constituted and declared to be a body corporate, by the name of the National Academy of Sciences."

The remaining fifteen lines of the printed charter contain five specifications, which I shall now quote, and briefly comment upon:

Firstly, ". . . the National Academy of Sciences shall consist of not more than fifty ordinary members." The Congress, in 1870, removed the limitation placed upon the number of ordinary members and the Academy has itself fixed the limit, for the time being, at three hundred. The actual number is now 275, of whom two are women. There are also forty-four foreign associates; that is, honorary members, eminent scientists of other nations.

Secondly, ". . . the National Academy of Sciences shall hold an annual meeting at such place in the United States as may be designated." The academy's annual meeting is held always in the city of Washington, in the month of April. The academy holds a stated meeting in the autumn of each year, always at some center of higher education or research activity other than Washington. It met last November in Cleveland. It will meet next November at the University of Virginia.

Thirdly, there is the specification which defines the purpose, apparently the sole purpose, of the Congress in establishing the academy, namely: ". . . the Academy shall, whenever called upon by any department of the Government, investigate, examine, experiment, and report upon any subject of science or art (meaning the practical arts), the actual expense of such investigations, examinations, experiments, and reports to be paid from appropriations which may be made for the purpose, but the Academy shall receive no compensation whatever for any services to the Government of the United States."

As an unwritten corollary to this specification, I may say for the special benefit of our newer members that the American citizen, the American scientist, who accepts election to membership in the academy tacitly agrees to respond to the Government's call for the study of, and report and advise upon any subject lying within his field of special interest, and without expectation of financial recompense for his services. In the 72 years of its existence the academy has complied a great many times to requests from the government for information and advice, gladly, and as promptly as practicable, on problems exhibiting a wide range of character and magnitude. The academy, naturally and in accord with the expectations of the Congress in 1863, is uniquely prepared to meet the Government's needs. To describe one recent case in illustration of that fact: When the National Planning Board, operating under the auspices of the Interior Department, on April 24 of last year, formally requested the National Academy of Sciences to advise it concerning "The Rôle of Science in National Planning," the academy's report to be made available to the board well before the close of June, I assigned the duty of conducting as comprehensive a study of the subject as the time limitation would permit, and of preparing the report, to the academy's standing Committee on Government Relations, consisting of John C. Merriam, *chairman*, the president and the vice-president of the academy, the chairman of the National Research Council, the chairman of the academy's eleven several sections, and the chairman of the Division of Federal Relations of the Research Council—a committee of sixteen members representing, very appropriately in this particular problem, every one of the principal fields in the domain of the physical and the biological sciences. At the same time advantage was taken of the academy's constitutional provision which says that "It shall be competent for the president, in special cases, to call in the aid, upon committees, of experts or men of special attainments not members of the academy," to add to the resources of the committee the valued knowledge, experience and judgment of twelve distinguished scientists not members of the academy, and also of eleven additional academy members; making a total personnel of thirty-nine. The committee's report, published in the Academy's Annual Report for 1933–34, was finished, thanks largely to the chairman's energy and executive ability, and transmitted by the academy to the Planning Board on June 18, fifty-five days after the date of the request.

Recalling that the academy's members number about 275, and that they represent in reasonably normal proportions the several physical sciences and biological sciences, including medicine, psychology and anthropology, a modest application of arithmetical division suggests that the academy could, in case of emergency call, constitute a full score of committees composed of a dozen academy members each, without any overlappings of personnel, and without requisitioning its aged members. This is an imaginary "set-up" of committees: it will probably never occur in fact. The academy's collective membership represents uniquely in the United States a great reservoir of knowledge, experience and tested judgment on scientific subjects; and much can be said as to the wisdom of the Congressional plan that "any department of the Government" may call upon the academy for information and advice upon questions in any division of the physical sciences and the biological sciences. Academy committees can be, and always have been, constituted each in excellent accord with the nature of the problem involved.

It is a universally recognized fact that governments may count upon obtaining the most dependable advice, in general, from institutions which are independent of political considerations and relationships, and whose members have no political interests except those possessed by all good citizens, and no financial or other material concern with the outcome of studies conducted for the government. I do not know of any other group of citizens of the republic who are so universally contented with their present lot as are the members of this academy. Using some ponderous language, I may proudly say that they are all interested in the eternal verities! They have been seeking the truth, as represented by scientific facts and principles, and they have been fairly successful in their quests; otherwise they would not be members of the academy. Looking in the opposite direction, I regard it as essential to the welfare of the academy, through the decades and centuries which lie before it, that the academy be at all times completely free of political elements in its organic and administrative relationships. I think the Congress of 1863, perhaps in response to the advices of some of the wise men who were prospective charter members of the academy, must have realized the importance of this condition, for,

Fourthly, there is a specification in the academy's congressional charter which says that the "corporation (*i.e.*, the National Academy of Sciences) hereby constituted shall have power to make its own organization, including its constitution, by-laws, and rules and regulations; to fill all vacancies created by death, resignation, or otherwise; to provide for the election of foreign and domestic members, the division into classes, and all other matters needful or usual in such institution, and"

Fifthly, the specification that the academy "report the same to Congress."

The charter conditions that the academy govern itself in all things, and that the academy receive no compensation whatever for any services to the Government of the United States, are precisely as they should be, as both the fundamental purposes of our institution and the traditions and experiences of similar institutions in the capital cities of other nations clearly proclaim. In confirmation of these facts, I can not do better than to quote from the annual address delivered by the president of the Royal Society of London, Sir William Huggins, in the year 1904: The Royal Society

> asks for no endowment from the State, for it could not tolerate the control from without which follows the acceptance of public money, nor permit of that interference with its internal affairs which, as is seen in some foreign Academies, is associated with State endowment. . . . The financial independence of the Royal Society, neither receiving nor wishing to accept State aid for its own private purposes, has enabled the Society to give advice and assistance which, both with the Government and with Parliament, have the weight and finality of a wholly disinterested opinion. I (the President of the Royal Society) may quote here the words of a recent letter from His Majesty's Treasury: Their Lordships have deemed themselves in the past very fortunate in being able to rely, in dealing with scientific questions, upon the aid of the Royal Society, which commands not only the confidence of the scientific world, but also of Parliament.

The Royal Society received its royal charter in the year 1662, and it was therefore 242 years old when President Huggins thus spoke. The Royal Society has had long experience, and it is very wise.

I have regarded the charter of the acedemy, received by gift of the Congress, as a trust closely approaching the sacred, to be violated or disregarded at the academy's peril. In accordance with the specific command of its charter from the Congress, the academy reports annually to the Congress.

The charter contains one clause which, speaking in a familiar manner, may be interpreted as a blanket provision conferring unspecified powers: "the National Academy of Sciences shall . . . have power . . . to provide for . . . all other matters needful or usual in such institution." It is thereby permitted, and may have been intended by its founders, that the academy shall be active in encouraging the extension of knowledge in the domain of the physical and the biological sciences, through research and discovery: firstly, by making a high degree of success in this field of endeavor the principal and essential criterion for election to membership in the academy; secondly, by the description and the interpretation of research results achieved by its members and other invited scientists, through the medium of papers presented at the academy's meetings; thirdly, by awarding medals and honoraria to members and non-members in recognition of notable research achievements, or for applications of science to the public welfare; fourthly, by making grants of money to members and non-members for the support of definite and promising research plans from funds which will have come to the academy by gifts and bequests; and in yet other ways. These things the National Academy has done with commendable success, as have also the leading academies of sciences in other nations.

In the first three decades of this century, and earlier, there was wide-spread recognition of the obvious fact that scientific discoveries and their applications were contributing enormously to the physical comforts and the material well-being of the peoples who dwell in what we may call the scientific nations:

scientific discovery, directly and indirectly, was responsible, above all other influences combined, for the raising of the standards of living and the lengthening of the average span of human life, in the astonishing degrees we are all aware of. Within the past three or four years, however, scientific discoveries, and especially the accelerated speed with which such discoveries had recently been made, have been under some degree of suspicion as to their resultant values to the human race. People in great and unaccustomed numbers have been suffering privations, both physical and spiritual, and they have been looking for the sources of their misfortunes. Scientific discoveries, coming too rapidly, have been blamed. However, the accusations have been made more or less irresponsibly, and apparently without basis of serious and comprehensive thought, or verified fact; for discoveries in science are but truth uncovered, truth which had been existing and operating a long, long time, though we didn't know it; and we have suffered no harm in suddenly learning about it.

It is doubtless true that advances of knowledge in the fields of the various sciences have, through their applications to the affairs of the world, subtracted from the demands for human labor in some of the older industries, but it should be remembered that these applications have to their credit the creation and development of new activities, many and on relatively large scales, which have undoubtedly given employment to greater numbers of both men and women than had been displaced from the earlier activities.

What is quite another thing, the applications of labor-saving machinery in factory and mill, on the farm and elsewhere, have with apparent reason been blamed for some of the ills of the world. Early in June, 1928, full sixteen months before the financial slump of October, 1929, I heard an able and well-informed man quote to a small but distinguished audience in New York City the indisputable evidence that in the few years then just passed, a great many thousands of workmen, both skilled and unskilled, in mills and factories had been displaced by labor-saving machines; displaced so rapidly that they failed in large measure to secure other positions; and that already there was much suffering in consequence. The speaker, whom many of you know very well, said in substance to the men before him, many of whose names are as household words to you: "If these conditions can develop and exist in the period of greatest manufacturing activity ever experienced in our country, what will happen when years of economic depression arrive? I ask and urge," said the speaker, "that you men of large affairs and wide experience give thought to the great problem which seems to lie ahead of us."

The predicted problem of unemployment and its dire consequences has certainly been with us, through the past five years. However, the labor-saving machinery under suspicion had but little relation, and much of it absolutely no relation to recent discoveries in science. For example, we have all seen labor-saving machinery at work in the construction of modern highways, and on the farms which certainly had no relation to recent discoveries in science![2] Rather were the offending machines, with relatively few exceptions, the products of mechanical engineers' and electrical engineers' inventive genius, aroused by the urge of the great war's abnormal demands and later by the urge of competition perhaps due in some measure to low wages in other lands and relatively high wages and other conditions at home. I do not pursue the subject further because, in my opinion, it lies almost wholly within the immense and important domain of economics and the social sciences.

There is one superlatively important consequence of discoveries and developments in the physical and the biological sciences which seldom gets any description or discussion in books and newspapers read by people in general. In preceding paragraphs I have been treating of science chiefly in its "bread and butter" aspects. I here refer to the profound influence of scientific discovery, through the decades and the centuries, upon our modes of thought, upon our freedom of speech and freedom of search for the truth, upon our ways of looking at life and life's affairs. The subject is a most tempting one, and if time were abundant, as it is not, I should have liked to develop it; but I must limit myself to a few more or less disconnected illustrations and statements.

Nearly forty years ago, while on a scientific mission in central India, I camped in a region whose people were suffering from their second year of famine. I could not induce any of the emaciated millions of Hindus around us to accept a slice of bread or a can of peaches because, for reasons attaching to their caste system, all our food, from their point of view, was unclean in the theological sense, and to eat it would destroy their chances of happiness in the world to come.

The Hindus and the Mohammedans and the other "fatalistic" peoples, with relatively few exceptions, have been falling far behind with respect to what we make bold to call world progress, not because they

[2] After this address was finished, I learned from *Time* for April 22, pages 36–38, that a machine for picking cotton, in replacement of human labor, has been invented and subjected to successful test. *Time* says that "In seven and a half hours it gathers as much cotton as a diligent hand-picker gathers in an eleven-week season." I doubt if it bears intimate relation to any recent discovery in science, but the subject might easily become one of vast importance, economically and politically.

have been retrograding in the absolute sense, but because the other peoples have relatively forged ahead. Their disadvantages have lain less in their failure to profit from the material benefits of applied science than in their holding to the mystical philosophies of old, which are "fatal" to progress. The essence of the philosophy of science is the cause-and-effect principle. The tenets of the scientific spirit tell us, whenever we are dealing with really serious matters, to "Prove all things; hold fast that which is good."

The year 1859, three quarters of a century ago, marked an astonishing epoch in the intellectual history of the world; in no previous year had so much been done to liberate the spirit of man. In that year was published the "Origin of Species"; in that year were discovered the principles of spectroscopy. It is true that many of the ideas on evolution antedated Darwin; but Darwin's systematized and fortified ideas took root, and thenceforward there developed rapidly the hypothesis, and I might almost say the conviction, that the principles of evolution are applicable to nearly all—perhaps all—things: to our ideas on almost any subject; certainly to the religions and the theologies of the earth's peoples; to the earth, in that it is not only very old, and the result of evolutionary processes, but that the earth's surface features and all things upon the earth are changing, more or less slowly evolving, in orderly manner, with the passing of time. Some of the revelations of the spectroscope antedated Kirchhoff; but with the ability to interpret spectroscopic observations of the sun, of the other stars, of the nebulae, there came rapidly a realization of the unity of the great universe. The earth is not only not flat; it is not the center of the universe; it is just one of the sun's smaller children; our sun itself is just a humble star among the billions of stars in our own stellar system; and there are, at the least, many tens of millions of other stellar systems. These are facts, established at the cost of great labor, and they have influenced and modified our ideas and attitudes most profoundly. No longer do we repeat the old dicta, "We shall never be able to know the chemical composition of the stars"; "The conditions existing in the deep interior of the earth must forever remain unknown"; and many similar beliefs of the last century and earlier.

The dread malady, diphtheria, now comes to a very low percentage of families, but with every comprehending family there resides an inspiring appreciation of the values beyond price which reside in the antitoxin made available by scientific research. Relatively few families have members or friends at sea, but every intelligent family finds mental and spiritual comfort in the knowledge that wireless telegraphy is ever alert to rob the oceans of their most cruel terrors. Our physicists have not yet learned what electricity really is, but I think they hold to the expectation that they or their successors will some day find out what it is. Their discoveries about the constitution of the atoms and the ways of their constituent parts promise to be as marvelous as the modern developments of astronomical knowledge. At any rate, the physicists know much more about electricity than the astronomers do about gravitation. We know something of what gravitation is doing, and of what it will do, but we seem to know nothing about the mechanism of its action, nothing of the technical reason why it exists. Of all the forces known to man, gravitation is marvelous beyond compare. The velocity of light and of electricity, 186,000 miles a second, seems to be a snail's pace in contrast with the effective speed of gravitational action. Pulses of light, emitted by the sun, require 500 seconds for their journey to the earth, whereas the sun's gravitational pull upon the earth, compelling the earth to travel in its elliptic orbit, seems to act instantaneously across the gap of 93 millions of miles. At any rate, the tests of that hypothesis have been many, and not one of them has given or suggested an answer to the contrary. The gravitational action of two bodies upon each other seems not to be affected or modified by the placing or presence of other bodies, no matter how massive, between them: a pebble at my foot at midnight and the farthermost atom of calcium on the far side of the sun are thought to attract each other precisely as they would if the entire body of the earth, save that one pebble, and the entire body of the sun, save that one calcium atom, were annihilated and non-existent. The strength of the mutual gravitational pull of two bodies seems not to depend upon their temperatures, their magnetic states or any other known conditions.

I have mentioned these well-known facts not at all for the information of any single member of this intelligent audience, but to link a few of the many marvelous accomplishments of the past with some of the outstanding mysteries of the present, in illustration of the spirit of science which says that research will proceed in the hope and expectation that with the passing of the centuries and the millennia the greatest of mysteries in our surroundings on the earth and in the universe will one by one be resolved. Why should we not have confidence that many children of to-day will live to see all the infectious and contagious diseases, including infantile paralysis, banished from the earth, through the discoveries of medical science and the administrations of public health services? Why should not man aim at an ever more complete comprehension of the universe in which he is living and working? I think we are all in accord with the thesis that the vast body of known truth about our surroundings, as revealed by the ways and the means of the physical and the biological sciences, is incomparably more wonderful and inspiring than the fiction of the most lively imagination and, being idealistic and non-materialistic in character, is of the imperishable treasures of the human race.

MEDALS OF THE NATIONAL ACADEMY OF SCIENCES

PRESENTATION OF THE AGASSIZ MEDAL FOR 1934 TO HAAKON HASBERG GRAN

WHETHER we ourselves be physicists, chemists or biologists, I think we will all agree, as living beings, that no question of sea science is more intriguing than how the inhabitants of the waters manage to survive in the waste of waters. And if we follow the life chain backward far enough we come at last to the question: What it is that governs the productivity of the sea for the microscopic floating vegetation which serves as eventual sustenance for all the animals of the sea? If all flesh be grass, it is as nearly true that all fish be diatoms. It is in this most significant field that Haakon Gran has delved, until his name and fame are as familiar to students of marine biology as is his genial countenance to many of us here.

Gran's earliest scientific papers were along somewhat other lines, for he opened his productive career as a student of the taxonomy and distribution of diatoms, a field in which he soon attained high eminence. He commenced his scientific authorship in the last years of the past century; in 1902 came his famous monograph on the plankton of the Norwegian sea, where he traced for the first time the relationship that the communities of floating plants bear to the various water masses through the seasons for so extensive an area. By 1908 he had produced his well-known handbook of the marine planktonic diatoms. In 1912 there followed what still remains the best-rounded account of the vegetable plankton of high seas that has appeared, based on his own field studies on the transatlantic expedition of the *Michael Sars*. And he has ever since continued adding to our factual knowledge of the microscopic plants of the oceans, far and wide.

All this, however, expresses but one side of Gran's scientific life. Even in his earliest papers, while a young student, we see him concerned with the sudden and spectacular increases and decreases in the amount of planktonic vegetation in northern seas, and with the wide variations that may exist in this respect within short distances, the occurrence of which was already well known, but for which no explanation had previously been suggested. Influenced, perhaps, by the Norwegian oceanographers Nansen and Helland-Hansen, he early saw that advances here, as in the physics of the sea, awaited the development of a precise quantitative technique. Experience followed with the centrifuge method, introduced shortly previous by Lohman, with such rich results. By 1912 Gran had combined this procedure with a satisfactory technique for preservation, and provided his fellow students with a tool, by means of which the whole water mass, top to bottom, can be as precisely examined for its content of microscopic plankton as for its temperature or for its salinity. Use of this tool far and wide, from seaside laboratory and deep-sea expedition, has vastly enlarged our knowledge of the quantitative distribution of planktonic organisms, and Gran has himself introduced it to American waters.

By that date Brandt's theoretic application, to the sea, of Liebig's law of the minimum, had been widely accepted as a working hypothesis, while Nathanson's suggestion that updrafts of chemically rich water from the deeps bring fertility to the surface zone where plants can live was exciting attention. These threads Gran drew together, showing that the seasonal cycle of plankton production in North-European seas is explicable only on the assumptions that variability in the chemical fertility of the water is in fact a controlling factor; that different water masses and depths do differ in this respect, and that the fertility of the surface waters alters from season to season.

Evidence for his far-reaching concept had so far been indirect, no adequate methods having been available for measuring the richness of the water in the substances presumably concerned. But the introduction by Atkins and Harvey of improved chemical technique brought ample confirmation for studies of the relationship between plankton and chemistry of the water, at many hands (including Gran's own), in different seas, it was soon proved that the picture outlined earlier by Gran and his associates was essentially correct; or, as Gran puts it, that "most of the differences in the productivity of various areas in the sea can be explained from the distribution of the nitrates and phosphates." So close, in fact, was the parallelism found between the ups and downs of the planktonic plants and of the nutrient substance most easily measured, and so attractive to the human mind is simplicity to account for complexity, that many of us were tempted to think we had found the uni-