SCIENCE

VOL. 80 FRIDAY, DECEMBER 28, 1934 NO. 2087

SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. MCKEEN CATTELL and published every Friday by

THE SCIENCE PRESS

New York City: Grand Central Terminal

Lancaster, Pa. Garrison, N. Y.

Annual Subscription, $6.00 Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C.

SOME RESPONSIBILITIES OF SCIENCE WITH RELATION TO GOVERNMENT[1]

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AT this particular moment in history necessity for judgment on emergency questions has brought engineering, science and constructive work in sociology into important relation to government. Whatever views we may hold regarding the significance of scientific contributions in the present situation, this is a time in which questions touching the responsibilities of science to government can be discussed with hope that attention directed to the subject may aid ultimately in advancing understanding of this relation.

OBJECTIVES OF SCIENCE COMPARED WITH THOSE OF GOVERNMENT

Although science and the scientific method have become almost the controlling factors in certain great organized activities, as in some aspects of industry, the mode of operation of science has seemed commonly to differ sharply from that of government. Fundamentally, science relates to search for realities and principles and to their interpretation. It is the discoverer and organizer of facts. Science may also be creative, but commonly it is the inventor, engineer and artist who produce that which has not previously existed. Government is a form of organization or administration designed to make it possible for human beings to work together with mutual advantage. Its operations must be based upon realities or the truth, but their basic objective is the furnishing of means for bringing about relations among people which, according to current views of democracy, will give the maximum contribution of power or strength or wisdom for the whole group, and at the same time the

[1] Address at the General Session of the American Association for the Advancement of Science, Berkeley, California, June 20, 1934.

highest degree of individual liberty consistent with such organization.

Though fully effective government must be organized on the basis of facts and of those principles which can be demonstrated to represent the best interests of the people, often control is by brute force, by influence of money, or by many other kinds of power. Or government may be through control by types of propaganda representing ideas imposed upon thought of the people. Some of these suggestions may represent the truth, and others may be far from correct. Whether or no we recognize such government as legitimate, it may nevertheless be a foundation upon which much of human organization rests.

Again, it is necessary to realize that a government by the people will be what the people desire to have it, regardless of our specific views as to what it ought to be. Ability of leadership to accept such situations, and still in some measure furnish guidance, may be an important element, and yet be difficult to measure according to standards of scientific evaluation.

The problem of human organization or government must then be looked upon as representing a group of objectives quite different from those commonly visualized by the scientist. But in spite of this difference, it is important to emphasize the idea that ultimately in conduct of its affairs government rests upon elements which may be subject to investigation through the modes of approach used by science in search for the truth. Seen in this light, the responsibility of science may appear very large with reference to problems which relate to government.

As the term science is commonly understood, there has been much difference of opinion concerning the extent to which we may reach from this field into the region of human interests represented in government. From my own point of view, while science will deal in large part with elements which concern the natural world, it must be looked upon as representing an attitude of mind rather than the study of particular types of material. What has been called the natural history of man, illustrated in anthropology and psychology, extends into a great variety of peculiarly human problems. It expresses itself in another way in the type of historical research represented by archeology, paleontology and geology, presenting the evolution of man and his cultures. So far, then, as one can follow the study of human kind by use of methods which determine realities, and the relations between such real materials or states, we may look upon science as reaching into the investigation of human relations, even touching the field of government.

So, in the American Association for the Advancement of Science we have divisions of the organization concerned with human questions so intimately that we recognize overlap of the natural and social sciences spreading into the field of economics, and even including problems which would be called governmental.

Relation of Advance in Science to Evolution in Social and Governmental Activities

In viewing the relation of science to government from another angle, it is interesting to consider the achievements and progress in these two fields. The average estimates on rate of advance in knowledge have been assumed to indicate that science is the outstanding human activity of this time. That a wide road has been broken through boundaries which once marked the limits of knowledge regarding the natural world is clearly true. Extension of scientific thought taking us out in space to remote nebulae, into the minutiae of matter in the atom, and back in time to periods earlier than the date of man's creation, makes it impossible to avoid the view that science has entered wholly new worlds.

But great as are the achievements of science, we must realize that over long ages mankind has been moving forward in the work of constructing a stupendous and complicated organization which makes it possible for human beings to live and work together. Through this striving there has been developed in government a means for adapting individuals to each other which is perhaps the outstanding accomplishment of the human race. In spite of views which we as scientists possibly hold, government, with all its weaknesses, may represent the most important contribution of human experience up to the present time. But since government is not yet shown to be wholly scientific, and science is not yet fully adapted to government, the problem of the moment concerns means by which continuing development in forms of organization and administration essential for well-being of the community may be given the support which should come from constructive efforts through science.

In consideration of this particular question it is desirable to ask whether the contributions of science toward solution of social, economic and governmental questions may aid in opening the way for new types of advance in governmental organization. May we expect further movement in the fields of human research corresponding to that widening of vision and deepening of thought which were made possible in the natural sciences through construction of the microscope, telescope and theories like those expressed in the developmental or evolutionary view of life?

The almost infinite complexity of human affairs as compared with situations in most problems of natural science indicates that a restatement or reorganization or redevelopment of social, economic and governmen-

tal science comparable to what has occurred in natural science will probably take place only through effort vastly greater than that which made modern scientific advance possible.

Further development of government will show, among other critical features, that we need to consider human attitudes as they are encountered, though we may not justify them on the basis of scientific judgment. In examination of the factors involved in many great human problems there must be recognition of states of being and points of view for what they are, even if the conditions do not seem to fit completely into categories set up on the basis of facts and logic as we have catalogued and interpreted them in natural science. The emotional features of human beings and their individual independence increase the difficulty greatly. And yet it seems within the bounds of possibility that further great advances in evolution of government may occur, corresponding to those in our knowledge of the natural world around us. It is a part of the responsibility of science to consider the extent to which cooperation with investigators devoted to problems of government may facilitate such advance.

Education in Science as Related to Development of Initiative and to Quality of Judgment on Fundamental Problems of Government

One of the most critical questions touching the value of science in its relation to public affairs concerns the possible influence of the scientific attitude upon development of initiative and upon the quality of judgments required in solution of many new types of problems fundamental in government.

Future students of our political organization may be able to determine the extent to which ability to obtain and to maintain political power is correlated with capacity for solving great questions of the commonwealth. The natural development of government will presumably bring us increasingly close correlation between these two kinds of ability. The modification may come through bettered education of the people. Over the centuries the ultimate effectiveness of any government of the type which we support depends upon the capacity, the interest in critical questions and the point of view of the citizens. Though great leaders arise, in general the judgment of an educated citizenry will determine the nature of authority of government and the levels which it may reach.

While attempting to develop a governmental organization giving advantages of strength for the whole group, we endeavor to maintain freedom of thought and initiative. Whatever else is controlled, our religious views, our ideals and the opportunities for constructive work must be free from domination by central authority.

In development of the highest type of citizenship, inquiry and initiative are essential. This attitude represents precisely the point of view taken by science and research, which must rest upon and grow out of inquiry and initiative. Through the field of education, scientific subjects should have large ultimate influence upon the manner of thought of the people, and therefore upon government. Development of the attitude of mind which they illustrate is essential in maintenance of a democracy. If democracy represents the people, its roots must be in the people, and this involves ideas and attitudes as well as other things assumed to be more clearly defined.

As science, research and constructive thinking have developed in America, much of great significance has arisen within departments set up by the government. It is to be hoped that governmental policies will lean toward even greater extension of aid both to fundamental research and to its application. And yet, we must expect in the future, as in the past, that the sources of scientific initiative, like the sources of governmental authority, will arise from the people under a great variety of conditions and in institutions and localities as widely spread as are the boundaries of the country.

Non-governmental agencies representing a broad range of public interests, such as the Commonwealth Club, of San Francisco, are critically important sources of initiation and development of thought. Especially is this true of social and governmental questions. The research activities in organizations of this and of very many other types have a fundamental and far-reaching influence on the development of inquiry and initiative, and ultimately upon public judgment.

Fundamental Science in Governmental Programs

In study of great problems with which the government may concern itself, as in development of the present soil erosion program, or of study on land use, or in many other comparable questions, it is necessary to distinguish those elements which have to do with basic scientific factors from others which have been defined in terms of social, business or administrative values. Continuing development in our understanding of these major scientific questions will depend upon increasing knowledge of underlying principles. It is the responsibility of science to give its clearest thought and strongest effort to definition of these principles and to their intensive study.

It is necessary also to appreciate the fact that in contrast to what have been recognized as scientific elements, no program of this nature can be carried forward unless there is clear recognition of the interests and desires or aspirations of the people concerned. For example, adequate land use is dependent upon what the people of the country or the world desire to do. If, as illustration, it is believed that primitive natural beauty has an important place in development of the ideals and interests of mankind, then it is essential that there be clear definition of the purposes involved and that provision be made for protection and use of such features or areas. If it is believed that mankind should outgrow the influence of that natural beauty which existed in the world as it was made, and develop into what might be considered a higher state of living, then primitive nature should be disregarded.

In study of great problems clearly of national interest, such as weather prediction, basic scientific research will continue to be one of the most important contributing elements. The information may be related to extent of variation in radiation from the sun, or the nature of physical phenomena involved in atmospheric movements. Or the necessary scientific data may concern the form of the earth and the influence of land features upon movements of air and water. There is no case which seems to indicate greater need for correlation and integration of results derived from many sources than in that touching acquaintance with the climate and weather, and prediction of their moods or changes. For investigation of such questions it is important that science give its fullest aid wherever and whenever assistance is possible. The breadth of the foundation from which science and its application must build is indicated in the necessity for international cooperation in study of climate and weather.

It is well known that in no application of science is the need greater for aid of government to the people and for contribution of science to meet needs of government than in questions touching development of agriculture. The fact that cultivation of plants in a multitude of ways will always be possible as individual projects on a small scale, means that much-needed application of constructive effort through science will in considerable measure be conducted by the whole people or the government. But the vast difficulties of research in the fundamentals of such subjects as genetics, photosynthesis, the chemistry and physics of plant biology and the influence of environment upon variation are so great that the contribution of all available research must be given to aid governmental agencies if the largest measure of success is to be attained.

SCIENCE AND THE PROBLEM OF PLANNING

The train of events reaching from the world war into the recent depression having given exceptional stimulus to study of national and world problems, one product of this discussion has been the exceptional development of planning. On one hand are proposals which would hold society to rigorously defined programs laid out by government. In other directions are modes of organization intended to increase liberty of the individual. Whatever the ultimate result, we are now considering the responsibilities of each generation for taking stock of assets and opportunities, and for such a forward look as is of advantage now and for later years. While it is not to be expected that a completely adequate program will be developed immediately, it is of great significance that we begin to recognize clearly that there is a future and that we have relation to it.

It is possible that some of the most important relations of science to government will touch this field of planning. The great study on "Recent Social Trends," carried out by a committee under the chairmanship of Herbert Hoover, contributed in an exceptional way to fundamental materials required in consideration of planning programs. It is important that information in the field of science be examined with reference to its possible value in study of major national or governmental projects.

A wide view over the materials of science and history indicates, I believe, that until we know the past, its processes and experience, we shall not be equipped completely for satisfactory planning. The scientific study of history, with its stages of archeology, extending into early records of the earth and of life, is essential in such a program. Only a people acquainted with the basic meaning of history in the sense of the longer reaches of time, as well as with broad international relations, can make adequate judgments on overshadowing world problems such as face us at the moment. Ingrowing nationalism, which tends to neglect the world, both geographically and historically, is accentuated by lack of perspective.

If available methods of education in history do not give us the needed illumination, I shall hope to see more works like H. G. Wells' book of several decades ago on "The Discovery of the Future," based upon results from scientific and historical study of the past. Perhaps one should say that to-day the prophet is not without honor save when he stays so much in his own country, or thinks so much of his own region and day in history, that he does not know the world either in space or in time. So the relation of science to government may be critically important in that group of functions which concern the forward look as based upon the experience of history.

As bearing upon future relations of science to government in the study of planning activities, one may not avoid calling attention to the probability that the materials of science will continue to increase at a rate not greatly different from that of recent decades. Especially in planning programs is it important that new material be taken into consideration. It is therefore necessary to have increasingly close touch between scientific research groups and agencies of the government concerned with activities of the forward-looking or planning type.

CONCLUSIONS

There is no responsibility of science relating to the future of the country greater than that which concerns development of such an interest in scientific truth and realities on the part of the people as is needed to guarantee that the highest values in life ultimately prevail. In this relation the specific responsibility of scientific agencies is very large. This will be met:

First, by increasing emphasis upon the most fundamental types of investigation for the advancement of knowledge in every department.

Second, by bettered means for interpretation of science and for education of the people as a whole regarding the status of scientific knowledge. In part this work must be done by scientists themselves.

Third, by improved means for securing application of results from science, and at the same time better control of materials secured but not at once applied.

One of the ultimate cautions to be expressed in considering the rôle of science concerns recognition of the fact that, although essentially science represents certain aspects of truth and reality, there are other phases of human interest, as in art and our fundamental philosophical and religious beliefs, which may be looked upon as having meaning at least comparable in importance to science. While it is necessary for us to define the realities and the truths represented by science, the elements sometimes called human values are realized largely through appreciation of what is involved by use of other coordinate or correlated modes of thought, such as those that have been mentioned. In considering their relations to government it may become a responsibility of scientists to join those concerned with study of these other aspects of thought if the ultimate human meaning of scientific truth is to be made clear.

The significance of science as an essential feature in the life of the nation will be kept in balance by the people according as experience and education establish standards of value in which science and its truths take their place along with other critical human necessities. The scientist will not lose sight of the idea that his subject is only one of several requisite groups of things. And while it is necessary to remember that he will be held responsible if he fails to set forth the worth of his discoveries, it is also important to realize that science will be held responsible if over-emphasis is given to isolated groups of facts without reference to their real human signfiicance. It is the responsibility of science to state the truth cautiously, and with care that harm be not done. The manner in which a thing is presented sometimes goes far to nullify the value of what may have great intrinsic importance.

Science should help to develop a clear appreciation of the needs of government, and so to organize and interpret its findings as to aid in solution of all possible problems. This means effort to learn what the application needs are, in order to be aware of the places to which new materials should go for the highest types of use.

The scientist should not necessarily expect to administer the results of his own work, and yet the relation to administration is extremely important. He can not avoid considering the broader implications of his contribution, any more than the student of human questions can avoid knowing something of the meaning of scientific problems if the results of science are to be fitted into the economic or governmental plan.

With these known factors concerning the value and opportunity of science appreciated by an intelligent, educated people, thinking continuously, constructively and unselfishly upon needs of the government, a great contribution would be made in guiding the nation along a safe course.

THE DUAL PRINCIPLES OF EVOLUTION[1]

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I APPRECIATE the opportunity, afforded by Director Redfield's invitation, of summarizing fifty-five years of reflection and observation in the battlefield of evolution, as well as of personal experiences with Hux-

[1] Paper presented to the Seminar of the Biological Laboratories, Harvard University, November 2, 1934. This is the twelfth contribution by the author on the Origin of Species and the principles of biomechanical adaptation as demonstrated in paleontology. The eleventh contribution on this subject was the Eleventh Sedgwick Memorial Lecture: "Aristogenesis, the Creative Principle in the Origin of Species," *Amer. Naturalist,* lxviii: 716, 193–235.