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SCIENCE AND PROSPERITY[1]

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I. SCIENTIFIC METHOD AND NATIONAL POLICIES

ONE of the fundamental laws of physical science is that inanimate nature, if left to herself, moves in the direction of chaos. This is a somewhat crude way of stating the Second Law of Thermodynamics. If the molecules of air in a room, for example, were all given uniform motions, and then left to themselves, their interactions with themselves and the walls would quickly change their velocities into the most random possible arrangement of motions, sometimes called the "Maxwell distribution of velocities."

In the field of human affairs many analogies may be drawn with this second law of thermodynamics. Human affairs, if left to themselves, also tend toward chaos. A business organization, if left without a guiding hand, becomes a disorganized business. A farm, if left to itself, becomes a wilderness. An economic policy of "let nature take her course" leads inevitably to economic chaos. A political policy of inaction can lead nowhere but toward anarchy.

[1] Address before the American Association for the Advancement of Science in Berkeley, June 21, 1934.

It is a significant fact that, in physical science, only one way has ever been suggested by which the tendency toward chaos can be circumvented. In slang phrase, there is only one way to "beat" the second law of thermodynamics. This way is by the exercise of intelligence in carrying out a planned policy. It was Maxwell who showed how this might be done in the case of molecules of a gas through the agency of a hypothetical intelligent being, who has been dubbed "Maxwell's demon" and who operates as follows to separate the fast from the slow molecules of a gas, which in nature remain mixed together.

Imagine a partition dividing the room into two parts and provided with a small opening just large enough to let a molecule pass through. Over this hole is a tiny trap-door operated by Maxwell's demon. Whenever he sees a very fast molecule approaching from one side he opens the trap-door and allows it to pass through. Similarly, whenever he sees a very slow molecule coming from the other side, he lets it pass through. So, after a while, he has separated the fast from the slow molecules, with the partition dividing them. Thus, contrary to the second law of thermodynamics, he has substituted a systematic for a chaotic distribution of molecules and has thereby created a store of energy, because the fast molecules on one side are at a higher temperature than the slower ones on the other.

The analogy here with human affairs is apt. It is only by intelligence, creating and carrying out a plan, that a business, a farm or a government can be made productive, instead of degenerating into disorganization and impotence. In particular, we may draw an analogy with pressing problems of federal administration: without debating the pros and cons of details of any particular program, we can subscribe heartily to efforts of the Federal Government to introduce intelligent planning into national affairs. When a prominent New Dealer defended the "Brain Trusters" by asking what other part of the anatomy the country would prefer to be run by, he had in mind the facts which I am here pointing out by scientific analogy. By this analogy we may call the Federal Government the "Maxwell demon" of America, striving, by intelligent operation of economic and legislative controls, to bring order and power out of the chaos into which the country would necessarily drift in the absence of adequate intelligent control and guidance.

It is not an easy thing to introduce control and guidance. Individuals like to have independence; business organizations resist control; labor groups do not take kindly to the imposition of regulation from without; yet we must realize that society, like a gas, is chaotic and powerless if its human molecules, like gas molecules, have complete independence. Civilization consists in giving up a certain amount of individual freedom and irresponsibility in favor of group responsibilities and relationships which are socially more beneficial. I take it that our nation is now in the throes of becoming a little more civilized. Perhaps since this ascent from chaos is dependent on the use of intelligence, it is not going too far to say that the agonies of the past and present months are the natural accompaniments of a national effort at constructive thinking—said by psychologists to be a rare and difficult process even in individuals.

We have excellent illustrations of attempts to do these things in the past and present federal administrations. President Hoover, like a good engineer, started out to ascertain the facts, through a group of fact-finding commissions such as the one which completed the great report on social trends. He planned, from a study of these facts, to discover those aspects of our social, economic and political life which were most in need of attention and to direct his great energy toward their improvement along the lines of a well-founded program. It was an intelligent scientific approach to his problem, but, unfortunately, political conditions and the sudden breakdown of our unstable economic system (which was the accumulation of preceding years of unintelligent enjoyment of a fools' paradise) prevented progress of this program beyond its initial stages.

President Roosevelt also shows something of the spirit of the scientist in that he is attempting by theory and by experiment to develop a better economic and social program for the nation. We see this attempt in such agencies as the National Recovery Administration, the Agricultural Adjustment Administration, the National Planning Board, the Business Advisory and Planning Council, the Tennessee Valley Authority, the Science Advisory Board, the Federal Aviation Commission and a score of other bodies.

We see the experimental scientific method in the President's realization that much of what is done is of the nature of social experiment in which some features will be found to be unsuccessful and will be dropped and the problem will be tackled in another way, whereas other features will have proved to be successful and will be continued and developed further. Every scientist knows that this is the way of progress if wisely carried out. He also knows that some experiments inevitably will fail, for if the successful outcome could be predicted with certainty from the beginning, they would not be experiments at all and would add nothing to our present knowledge or development.

"Letting nature take her course" was listed above as one of the paths to chaos. Yet there is a very fundamental truth in the minds of some people who express their economic philosophy in this phrase, namely, that experimenting or maneuvering, to be successful, must be directed to take advantage of natural laws and not to run counter to them. The achievements of science come by the intelligent, skilful utilization of established laws of science. Similarly, experiments in human affairs will be successful if they are planned in accordance with, and not contrary to, basic social laws. If, as is unfortunately so often the case, we do not yet know what these laws are, then the "trial and error" method is the only recourse. The success of this method depends on a combination of knowledge, judgment, skill and luck. The present experiments in social adjustment lie somewhere within the boundaries of this paragraph.

Favorable to the success of these new social experiments is the fact that the people have had such a rude shock as to have awakened them from their complacent acceptance of the old order, which was suited to the simpler life and undeveloped natural resources of our expanding pioneer days, but which broke down under the growing complication and competition which necessarily followed modern technical progress and the final complete occupancy of the country.

The people generally realize that something was wrong, and are in a mood to support well-directed effort toward fundamental improvements. Opposed to the experiments may be those who personally suffer in the readjustments, or who do not trust the intelligence or motives of the present experimenters, or who are chiefly impressed with the unsuccessful rather than the successful experiments, or who would await more recovery before making bold experiments, or who are just naturally so conservative as to deplore departure from the "good old times." To these latter ones, however, I would point out that the old régime was not good, as proven by its disastrous debacle, and that a return to it would be as silly as for a scientist to repeat an experiment which proved unsuccessful.

II. SCIENCE AND THE STANDARD OF LIVING

Let us pass, for the moment, from consideration of the scientific method as applied to national problems to the more specific application of science itself to public welfare. I will introduce this by describing one particular example, taken from electrical science.

It is just over a hundred years ago that Michael Faraday in England and Joseph Henry in America discovered the principles of electromagnetism which underlie most of our present electrical science and industry. Before them the few electrical and magnetic phenomena which were known were only scientific curiosities.

Joseph Henry started out as a young man in Albany, New York, to be an actor. He organized a theatrical troupe, wrote plays and was well started on his career when he was taken sick. While recuperating, a friend loaned him a book on natural philosophy, which raised and discussed such questions as: "Why do stones, when thrown in the air, fall back to the earth?"; "Why does the flame of a candle point upward?"; "If the candle were pointed downward, would the flame point downward and, if not, why not?" These questions so aroused Henry's interest that he forsook the stage, entered the Albany Academy to study science, became its science teacher, then professor of physics in Princeton University and finally director of the Smithsonian Institution in Washington. Many interesting stories can be told of his building of the first powerful electromagnet; perhaps the first telegraphic signal set; certainly the first wireless set—used by his wife to call him to meals from his laboratory; of his use of students to measure induced high voltages by seeing how many of them in a row he could shock. But his great discovery was the phenomenon of electromagnetic self-induction.

Simultaneously, in England, Michael Faraday was carrying on experiments in the Royal Institution through which he discovered electromagnetic mutual-induction between separate electrical circuits. It is said that the King once asked him, "What is the use of these experiments?", to which Faraday replied, "Your Majesty, of what use is a baby?" Again, when the Prime Minister visited his laboratory and asked the same question, Faraday is said to have replied, "My Lord, some day you can tax these things." How true this turned out to be can be amply testified to by any officer of a present-day public utility electric company.

The story of the electrical inventions of Thomas Edison, but recently dead; of Elihu Thomson, still living; of the more recent discoveries and inventions of Fleming, Coolidge, Kettering and a host of others is too well known to need telling. The point is that within one lifetime the entire electrical industry has grown up; most of it has come relatively recently; and there is in sight practically no limit to the possibilities of its future development.

Most of the basic discoveries have been made by professors in educational institutions, spurred on to their investigations by insatiable scientific curiosity. Most of the rest has been done in industrial laboratories, especially recently, and governmental laboratories have played an important rôle, especially in fixing standards of measurement. The industrial laboratories have taken the lead in developing useful applications of the discoveries. Here and there have sprung up inventive geniuses. All this work has brought enormous returns to the public. I will enumerate a few of them:

(1) Electricity has been found to be basic to the understanding of the structure of matter and of natural phenomena.

(2) Electricity has transformed modern life through its use in wire and wireless communication, lighting, transmission and application of power, household appliances, radio broadcasting, cinema, control of machinery, medical applications such as x-ray, railways, essential parts in automobiles, location of mineral and oil deposits, metallurgical and chemical processes, navigation, etc. These things have contributed mightily to man's safety, comfort, power and interest in life.

(3) Electricity gives employment to some millions of our people. For example, in electric manufacturing, distribution and operation of electric machinery, light and power, 1,035,000; in radio manufacture, distribution and servicing, 94,000; in motion pictures, 290,000; in the telephone industry, 357,000. If we take activities not wholly electrical but dependent upon electricity we have many more, such as 1,573,000 in the automobile industry (manufacture, distribution and servicing). It is probably no exaggeration to say that 10,000,000 people in this country are continuously dependent for their support on the results

of progress in electrical science. (Figures mostly from 1930 census.)

(4) As Faraday predicted a hundred years ago, electricity pays taxes.

We must admit that the public has been well repaid for whatever part it may have taken in providing the opportunities whereby the creative scientists, engineers and inventors were enabled to produce the present stage of electrical development.

Now this recital would not be so significant if it were an isolated instance; its significance lies in the fact that it is but one of hundreds of instances, some of major and some of minor magnitude, but all of which lead to the same conclusion. An equally impressive story could be told of the development of chemistry and its importance in our modern life. The same thing could be done in medicine or agriculture. We sometimes think of steel as the product of an old and rather primitive art, digging, smelting and hammering; yet a bulletin was prepared a few years ago which listed some twenty laboratory discoveries, without any one of which the modern steel industry would have been impossible.

The same conclusion can be reached by considering the engineering arts. Civil engineering, dating from the earliest times when men made paths and homes, has for its object the making of the earth a convenient place on which to live and move about. Mechanical engineering has to do with increasing man's power and the convenience of its application. When the Egyptian developed a mechanical water wheel to lift water from the Nile to irrigate his fields, he did not complain about technological unemployment because the water wheel had relieved him of the necessity of lifting the water by hand; he used his new device to increase his crops and his spare time and profits to build a better home and to devote himself to more cultural pursuits than carrying water. So it is all through the field of engineering, whether it be civil or mechanical, or the newer types of electrical, chemical, automotive, aeronautical, refrigeration, agricultural or mining engineering. All these have given man comfort, power and opportunity. Just as old civilizations were limited by their tools of stone or bronze and therefore described as the stone age or the bronze age, so our civilization is epitomized by our progress in the engineering arts. These are prepared to advance as never before if given opportunity. It is inconceivable that their advance should not be encouraged unless, fainthearted or shortsighted, we wish our civilization to stagnate or go backward.

In thus emphasizing the importance of science and engineering to civilization I am not unmindful of the fact that civilization should not be measured by its material features and I realize that the chief end of man is not material productive power. But I am mindful of the fact that these material things create a possibility for doing and enjoying the finer things of life. With all due respect to the genius of Aristotle as one of the great creators of civilization, it is not without significance that he had the services of more than 10,000 research assistants, provided him by King Alexander, who brought him information from all parts of the known world. Nor is it without significance that the great advances in civilization were made by peoples whose drudgery was done for them by slaves or serfs—the Greeks, Romans, Egyptians and the sixteenth century English. To-day we have done away with slavery. In its place we are served by the products of science—by mechanical power equal to the work of fifty slaves for every man, woman or child in the United States. It is this which has created our so-called high standard of living, which has given us our time for education, our insurance or pensions for old age, our vacations, our limited hours of labor. If developed and managed properly, it is this which can give every person in the country such opportunities for the finer things of life as were never before enjoyed even by the favored few.

III. Pressing Problems Challenge Science

We pass now to a brief consideration of a few of the national problems which urgently require attention, in order to see if science can make a contribution toward their solution.

(1) Unemployment still grips some 10,000,000 of our population. A paternal government may care for them at the expense, by taxation, of those who have an income, or it may give them work by forcing a division of available work among all people capable of performing it. These are socially necessary relief measures if no more permanent cure can be found. Necessary in an emergency, they become socially dangerous if carried too far or too long. The permanent cure is to provide more employment. It is here that science can help, as amply proven by the past experiences cited above, by creating new industries to provide new things that people want or by creating improved equipment or processes which will render obsolescent old equipment and thereby maintain a demand for new.

A difficulty with this cure is that it requires time, and therefore foresight. It may be years after a scientific discovery is made before the inventive idea or the combination of need and knowledge or the perfection of a method for applying it usefully brings it to the point of providing employment. Scientific developments can not, like the tricks of political demagogues, be pulled out of a hat. It would require a very rare type of far-sighted statesmanship on the part of political leaders to urge financial support of creative science in the present for the sake of the national welfare at some future date. Yet the record of past events shows that no other known investment is likely to pay such large future dividends. Kettering saw this when he wrote, "The present troubles are not so much due to over-production of goods as to under-production of new ideas." Hoover saw it when, as Secretary of Commerce, he stated that this country was in danger of industrial stagnation because of its failure adequately to advance the sciences on which future industrial developments must be based. The National Academy of Sciences saw it when it attempted to raise from industrial organizations a large fund for research in pure science on the grounds that such support by these organizations was both the payment of a debt to science and an investment for the future—an attempt which was wrecked by the depression after coming within sight of the goal. The British saw it when, in spite of post-war financial troubles, they made a large government grant to aid the scientific work in their leading institutions. Germany, until perhaps recently, has seen and acted on it. Russia, though inexperienced, is bending every effort toward it. Japan has made it a national policy for years, and is now drawing dividends on it. What our government is doing about it I will mention later.

(2) Natural resources in land, minerals, timber and water power are at the root of our national life. Their wise use and conservation are basic to any far-sighted planning. In some aspects, they present problems which can not be passed by with thought of letting the future take care of itself, but are pressing for solution right now.

Take, for example, land use. Just how serious is soil erosion? In how many years, if unchecked, will it bring about a desperate condition of land sterility? How can it be controlled and how expensive and effective will this control be? Again, scientific study has recently shown that, if the number of trees per acre is reduced below a certain minimum in the yellow pine belt just east of the Cascade Mountains, then the ground water level drops and the country becomes a desert. Just what are the facts, and what should be the government's policy in view of them? Again, the great Mississippi River Valley used to include much lake and swamp land which has been drained to provide fertile farm land. Now a large part of the rainfall is run off in these drains to the streams and flows away, with the result that the ground water level is steadily falling and the climate is generally drier and warmer. What should be done about this? The California water problem is too well known to require discussion. In many parts of the country climatic conditions and soil are such as to cause repeated crop failures, with recurring burdens thrown on the country for relief. Should such sub-marginal lands be repossessed by the government and, if so, on what criteria should the selection of such lands be based?

Similarly, in minerals, we find no clear-cut national policy. Tariffs may operate one way, NRA codes another, state and federal taxes still another as regards such basically important considerations as conservation or an economically planned production program.

Some of these matters are now receiving governmental consideration. It is highly important that policies should not be determined principally on grounds of political expediency, but on a sound economic policy based on an accurate knowledge of the facts—which it is the business of science to provide. Thus in this field the national welfare calls for scientific study and for national backing of such study.

(3) Hereditary weaknesses, both mental and physical, constitute a terrific annual drain on the happiness and on the finances of the country. They present a tremendous challenge to science, a challenge which I believe will ultimately be met. We need to know in what respects these weaknesses are hereditary and in what respects they are individual accidents. We need to know if and how they may be cured. If incurable, and hereditary, the welfare of the race requires their elimination, perhaps by some such means as have been found successful in repressing undesirable or developing desirable physical and mental traits in domesticated animals. Much scientific work has been done in these lines, but only a beginning has been made. For example, I am informed that it is only within the last year that there has been found a definite physiological disturbance associated with the most baffling kind of insanity.

Such controls as are here suggested will be found unpleasant to contemplate by many people. But think, on the other hand, of the terrible unhappiness of defectives and their families; remember that their number runs into the hundreds of thousands; remember that they constitute one of the greatest drains on our economic resources. If science can find effective means to cure such cases or, if incurable, to prevent their occurrence, this alone would justify all the scientific work that has ever been done. To be sure, education and probably legislative action will also be required to complete such a program, which would fail without supporting public opinion. But science must do its part first. Legislative action not based on thoroughly established scientific findings would probably do more harm than good.

(4) Sickness, despite the wonderful advances of medical science, still remains as a challenge, continually reminding us that the job of science in this field is incomplete. The annual toll paid to physi-

cians is enormous and is a double economic loss (except to the physician); first, because the patient pays for something which is no gain over what should be his normal healthy state; second because, while sick, he is a social parasite.

The great challenges here are to develop preventive medicine and to find curative treatments for the few outstanding ailments which still baffle medical science. The goal is the continual maintenance of every man's highest level of physical and mental fitness.

(5) Crime presents abundant features to engage the attention of scientists. The physical scientist can develop better means of crime detection; the medical scientist and psychologist can find better means of treating the criminal to subdue his vicious tendencies; the social scientist can study those aspects of social environment which are conducive to right or wrong living and point out desirable reforms; the educator has his job of implanting sound habits of character. It is too much to hope that the devil will be banished from the face of the earth, but science can certainly help to reduce the number of his followers.

To this list might be added many more items. I would suggest, as a stimulating and interesting exercise for any scientist, that he form the habit of analyzing important social, economic or political problems, as they come to his attention in reading or otherwise, for the purpose of inquiring at which points science can usefully be brought to bear on these problems. If all our scientists were to do this, the most important step toward their scientific solution would have been taken.

IV. How Can Usefulness of Science be Increased?

Scientific work in this country is supported chiefly by four agencies—the government, the universities, industry and private philanthropy.

The Federal Government devotes about one half of one per cent. of its regular budget to its scientific bureaus. Most of this amount is spent for routine operations, such as testing and accumulation of data. Much of the rest goes into research work, some of which is excellent, but which is definitely restricted to certain particular fields. This scientific work is highly important to our national functioning. It is not, in my opinion, done under conditions most advantageous for the discovery of new phenomena or laws, or for the development of new industries, nor have these been its objectives. The Federal Government also makes small grants to land-grant colleges primarily to assist in their educational work, and in some instances to support experimental work, particularly in agriculture.

The state governments support the great system of state universities, where some of the finest scientific work in the world is being done, but often where such work is only tolerated by the authorities or is supported solely for its value in the educational program of the institution and without consideration of its inherent value to the public.

The universities, from the earliest times, have been the great productive centers of scientific research, and doubtless will so continue, since they offer uniquely favorable advantages of a wide variety of facilities and of cooperating experts, they have continuity, and their activities are not restricted into narrow utilitarian channels. No other organizations have such a continual supply of new blood and new ideas, brought in by the ambitious, exuberant youth in staff and student body. They have a great tradition of intellectual activity and freedom, from which springs originality.

Industrial laboratories, within the last generation, have come to take a very prominent and productive part in scientific research. They have certain advantages, such as large financial support for research which promises to yield financial profits. On the other hand, they are necessarily much restricted to such work as shows promise of relatively quick returns and, hence, big, new and unexpected things are not so likely to be discovered there. It is one of the paradoxes of past scientific history that most discoveries which have proved to be practically valuable were not made in the course of a search with such an objective. The unique field for industrial laboratories is in the application and adaptation of scientific phenomena, wherever discovered, to the objectives of the particular industrial organizations which maintain these laboratories. It is, in a sense, paradoxical that these industries, which stand to be the first gainers from scientific progress, can not from self-interest support pure research on a large scale under present conditions. The reasons are obvious:

The results of any program of pure research are uncertain as to their nature, time and importance. In the Research Laboratory of the Bell Telephone Company, for example, the net practical result of a year's work by a hundred scientists may be nil; or it may not be of commercial value until a dozen years later, and then perhaps only in combination with some other results from the General Electric or Westinghouse Laboratories; or it may turn out to be valuable to the steel corporations or the chemical companies rather than to the telephone company; or it may be seized upon and exploited by pirating companies who have had no burden of research expense. Theoretically, our patent laws should take care of these latter difficulties; practically the situation is too complicated and the laws are too antiquated, inadequate and costly to enforce. For example, the issuance of a patent by our Patent Office carries practically no presumption that the patent is valid, and the establishment of validity is left for future litigation in the courts. This situation arises from a combination of factors, such as the enormous number of patents, the antiquated procedure in securing patents and the inadequacy of pay and tenure for highly qualified men on the staff of the Patent Office. The patent law was designed to create a temporary monopoly in order to encourage development and production, but it did not anticipate modern trends of invention into the complicated fields which require the control of many patents in order to produce a product. The court before which a patent case is tried is not provided with disinterested technical advice, with a result that the trials are long and expensive and their outcome does not always reflect the merits of the case. This whole situation is vastly in need of clarification, but meanwhile the industrial laboratories are doing an efficient job of industrial development and relatively little research on a wider base than that of their immediate practical interests.

Private philanthropy has played a uniquely large rôle in the scientific work of this country, in the endowment of universities, the building of special research institutes and the establishment of the great foundations. One hundred twenty-nine such foundations are said to exist in America. Seven of these foundations have already distributed more than $280,000,000, of which a considerable portion has been for support of science. A very rough estimate is that perhaps one fifth of the total amount has gone into research, excluding the very important fields of medicine and public health. These foundations are so well understood as to require no comment. I can not refrain, however, from noting that the contributions to human welfare, made by these foundations, have involved altogether but the expense of one battle fleet, or less than one tenth of last year's appropriations for emergency public works, and I would raise the question as to whether such examples do not suggest a lack of balance in the distribution of government expenditures which should be remedied.

Granting that the national welfare demands increasingly effective scientific work, the practical question is, "How can this work be supported?" The increasing control of business by government plus the tendency toward a more uniform distribution of wealth will probably reduce the magnitude of those large private bequests and altruistic foundations which have been so peculiarly the backbone of American enterprise in science and other fields. The general burden of taxation and the limited interests and responsibilities of individual states make it unlikely that the state governments will shoulder the primary responsibility of supporting scientific work. The problem is essentially national in scope; the public is the ultimate beneficiary, gaining or losing according to the degree of success of the work. Should not the public, therefore, contribute at least a large part of the necessary financial backing? Such public support of course means support through the Federal Government, ultimately through taxation. I further believe that, if this were done and wisely executed, it would prove to be in the front rank among governmental undertakings in the ultimate beneficial returns to the public per dollar expended.

Of equal importance to the securing of funds is the problem of their efficient administration. Money can be wasted faster in so-called research by placing it at the disposal of uninspired groups or hack-work programs than in any other way that has the guise of respectability. No formula, organization chart or administrative dictum can produce scientific progress. Perhaps the worst way to carry on research is to distribute funds according to some formula such as that followed in the support of land-grant colleges, $50,000 to each state in the Union or so much to every research laboratory. Almost as bad would be the pouring of funds into a centralized research bureau and saying, "Let there be research." Scientific progress can be gained only through securing the happy combination of scientists who have ideas with facilities for carrying them out. The job of administering funds for research is essentially to bring about such combinations.

I believe that the best method for administering funds for research is that which has been developed over a long period of experimentation and training through the great foundations, such as the Rockefeller Foundation and the Carnegie Corporation. They have been experimenting to find the most productive ways of administering funds for research. As a result they have trained large numbers of scientists through service on boards and committees, who have studied the needs and opportunities throughout the country with a minimum of overhead expense and a maximum of results. If large funds should become available for research this experience could be effectively used. These considerations would point to the National Academy of Sciences and the National Research Council as the natural advisory bodies in any large program of public expenditure for science. These bodies have status in the government through their charters and by executive orders, and they include representation from all important scientific and engineering societies. They have had more experience than any other similar groups in the country in the administration of funds for research.

In conclusion, I must confess to considerable doubt as to the wisdom of advocating federal support of scientific research, not because of any doubt as to its value or logic, but because of insidious dangers which are perhaps too obvious to require elaboration. If government financial support should carry with it government control of research programs or research workers, or if it should lead to political influence or lobbying for the distribution of funds, or if any consideration should dictate the administration of funds other than the inherent worth of a project or the capabilities of a scientist, or if the funds should fluctuate considerably in amount with the political fortunes of an administration or the varying ideas of Congress, then government support would probably do more harm than good, for large support by government would tend to discourage the support by private philanthropy which has been the backbone of our scientific progress in the past and which will doubtless continue unless discouraged.

On the other hand, if government support of science were undertaken on an adequate scale and administered with the skill and experience that have already been developed in the handling of minor funds for science, such a program of federal support would certainly be a sound national investment, would be an uplifting intellectual and social influence and might well mean the difference between prosperity and economic catastrophe at no very distant date.

In this address I have raised certain questions which have many aspects and whose proper answer I do not know. They are questions, however, which challenge constructive thought and it may be that their wise solution can be attained.

SCIENTIFIC EVENTS

BRITISH MUSEUM'S EXPEDITION TO EAST AFRICA

THE trustees of the British Museum, according to the London *Times,* have arranged an expedition to British East Africa to study the ecological relations of animal and plant life in different areas of high altitude. It is well known that the combination of a nearly vertical sun, high altitude and copious rain has resulted in extraordinary development of vegetation, plants known in temperate regions of the size of shrubs reaching the size of trees, but no intensive and systematic study has yet been made of these areas. It is intended to ascertain what insects assist in fertilizing the flowers of the giant lobelias and groundsels.

The leaders, Dr. F. W. Edwards, entomologist, and Dr. George Taylor, botanist, from the British Museum (Natural History) sailed from England recently and will be away six months, having about four months for their work. The East African Governments are taking great interest in the expedition. The exploratory work will be almost entirely in Uganda, and the government is helping in many ways by financial aid and the loan of transport, and by allowing certain of their officers interested in either insects or plants to join the expedition for some period of its work. The expedition will also be joined by Mr. P. M. Synge, of the University of Cambridge, as assistant botanist and photographer, and Mr. John Ford, animal ecologist, of the University of Oxford, as assistant animal ecologist; both of them are already in East Africa. Allen Turner, of the Coryndon Memorial Museum, will act as guide and assist in collecting insects in the Aberdare Mountains. Of the Uganda officials, Mr. E. G. Gibbons, of the Medical Service, will be assistant entomologist and act as camp steward for the whole period of the expedition; G. L. R. Hancock, of the Agricultural Service, will assist in the camp organization and in collecting insects and birds on the Ruwenzori Range; A. S. Thomas, of the Agricultural Service, will be assistant botanist during the expedition's work on Mount Ruwenzori, and W. G. Eggeling, of the Forestry Service, will spend about a fortnight with the expedition as assistant botanist. Mr. J. F. Shillito, of the Nyakasura Mission School, Fort Portal, will accompany the expedition as guide and assistant collector on the northern side of the Ruwenzori Range.

The leaders were expected to arrive at Mombasa on October 19, and after completing their arrangements they and the remainder of the party, who were to join the expedition at Nairobi, would spend the last week in October in the Aberdare Mountains in Kenya Colony. Their next objective is the Mufumbiro Range in the Birunga Mountains, where they will stay two or three weeks. In December they will return northwards and stay on the southern side of Mount Ruwenzori until the end of the month. At the beginning of January they will proceed to Fort Portal and stay on the northern side of the Ruwenzori Range until nearly the end of the month. On the way back to the coast they will spend three or four weeks collecting on Mount Elgon, and some of the party will proceed to the isolated peak of Moroto if conditions are favorable. The leaders expect to return from Mombasa to England on March 9.

RADIO ECHOES

THE *Technical News Bulletin* of the National Bureau of Standards reports that special signals are being transmitted from two European radio stations for the study of long-delay echoes. The signals and