SCIENCE

VOL. 97 — FRIDAY, APRIL 23, 1943 — No. 2521

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

THE SCIENCE PRESS

Lancaster, Pennsylvania

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.

SCIENCE, SCIENTISTS AND SOCIETY[1]

By Professor M. G. MELLON

DEPARTMENT OF CHEMISTRY, PURDUE UNIVERSITY

THE subject selected for this address—"Science, Scientists and Society"—is indeed formidable, at least to any group assembled for an occasion such as this. On the one hand, the range is nearly limitless; and, on the other hand, time and the ability of the speaker are definitely limited. Then, too, triteness is a handicap, for often equivalent subjects must have served many a commencement speaker needing a non-committal title for his remarks.

Nevertheless, the choice was made deliberately, since previous addresses by chemists before this academy have all been very general in nature. Formulas and equations, the chemist's indispensable form of sign-writing, have been almost entirely avoided. In following this precedent it seemed wise to reject as possible subjects various aspects of analytical chemistry, my principal field of research. In a more positive direction, the choice was made because of a feeling that what is most fundamental in science for a chemist is equally fundamental for other scientists. Whatever interest the discussion may have, therefore, should be general.

THE PROBLEM

Many years of teaching and research have aroused a personal desire to know, as far as possible, the essence of the scientific activity to which most of us are devoting our lives. Just what is science? Is it a kind of religion, sufficient in itself as a way of life in modern society? If all were trained in science, would we be able to live together happily thereafter? Possibly what I have in mind may be clearer in the form of another question—What does science mean to me? Obviously, the answer to be proposed is entirely personal. My only justification for presuming to present it is the

[1] Address presented by the retiring president of the Indiana Academy of Science at the fall meeting, October 30, 1942.

hope that each of you, if you have not already done so, will make a similar effort to answer the question yourself. Like John Dewey, most of us must feel some urge to pursue such a quest for certainty. One's answer reflects his attitude as a scientist.

These broad aspects and implications of science seem to have little interest for the average scientist and technologist. Busy with their respective activities, these people transmit tradition, pigeon-hole facts, theorize about them, and apply them in a thousand ways. Although the total effect of these activities during the last two centuries has been profound, both on our daily lives and on our thinking, only occasionally have writers tried to evaluate the really basic contributions of science and scientists to society and to focus their possibilities on the future.

Such evaluations as have been made range from high praise to disparagement. The former is represented by the predictions of A. H. Compton and of J. D. Bernal that science can remake the world, and by the assertion of W. B. Pitkin that scientists are the only ones to-day who have anything worth saying. For the latter we may mention the book, "Science the False Messiah," by C. E. Ayres, and the statement of Vice-President Henry A. Wallace that science, during the last hundred years, has merely increased the speed of life without increasing its quality.

President R. M. Hutchins, of the University of Chicago, a prominent student of educational trends, has questioned the basic contributions of science to society. Excerpts from his addresses are quoted.

> The sciences at best may help us to attain our ends if we knew what those ends were; . . . but we do not know where we are going or why, and we have almost given up the attempt to find out. We are in despair because the keys which were to open the gates of heaven have let us into a larger but more oppressive prison house. We think those keys were science and the free intelligence of men. They have failed us. Many have long since cast off God. To what end can we now appeal? The answer comes in the undiluted animalism of D. H. Lawrence, in the emotionalism of demagogues, in Hitler's scream, ''We think with our blood.'' . . .
>
> The centrifugal forces released through the dissolution of ultimate beliefs have split the universities into a thousand fragments. These institutions, instead of leading us through the modern world, mirror its confusion. . . . We are in the midst of a great moral, intellectual and spiritual crisis. To pass it successfully or to build the world after it is over, we shall have to get clear about those ends and ideals which are the first principles of human life and of organized society. Our people should be able to look to the universities for the moral courage, the intellectual clarity, and the spiritual elevation needed to guide and uphold them in this critical hour. . . . Research is not enough either to hold the university together or to give direction to bewildered humanity. We must now seek not knowledge, but wisdom.

In re-examining science for its essence there is this year, as never before, more than satisfaction of mere curiosity to be considered. Involvement in another world war, threatening our very civilization, makes especially urgent the question of what permanent help we may expect from science. We need occasionally to transcend our specialties to gain a balanced perspective of just what science is, and is not, in contemporary life.

Most scientists would probably agree that science represents primarily an extension of knowledge. Presumably such accumulated information is expected to accrue to the benefit of mankind, for people have long been told that the truth would make them free. Thus, in theory at least, it would seem that science should serve society in some constructive way.

By itself, and through innumerable practical applications, science has been, in fact, of untold benefit to us. We know more about the material universe, and we are better able to control it, than any preceding generation. All this is, or could be for the general good. Such information and activity are potentially constructive in helping us to meet the ceaseless succession of events constituting the cosmological drama. That knowledge is power has become a proverb of the race. The scientist and technologist appeared in the scene only recently; but so significant have been the results that we often hear the present period referred to as the age of science.

Unfortunately, science, especially in its applications, does not necessarily contribute to the general welfare. As a result, many individuals have been, and some still are, critical of our work. Lavoisier, the greatest chemist of the eighteenth century, was beheaded with the curt comment that France had no need for scientists. Recently holidays for research have been advocated, presumably in the hope of reducing technological unemployment thereby. The year 1942 finds us in the midst of the most devastating war in history, one whose unparalleled destruction is possible only because of scientific knowledge.

We are faced, then, with a great paradox of constructive versus destructive possibilities and actualities. I shall attempt to examine the relation of science and scientists to human affairs in the hope that an orientation of our perspective may aid in making dominant the constructive potentialities of science. Also we shall note what science does not, and probably can not, do. In the time available it will be possible to indicate only in broad outline what seem to be the most important aspects of this problem.

SCIENCE AND ITS ACCOMPLISHMENTS

Science may be defined as knowledge which has been systematized with reference to the discovery of general truths or the operation of general laws. The process of assembling, organizing and applying this knowledge has long been under way. For centuries the rate of progress was very slow; but in recent decades it has been so accelerated that to-day the civilized world is relatively aware of the larger subdivisions of science, such as biology, chemistry, geology and physics.

For the present purpose our interest is not in the minutiae of any of these subjects. What seem important are the items that may be considered as a kind of scientific common denominator. Long contemplation of what these are has led to the conclusion that all science, theoretical and applied, can be reduced to two categories—facts and their interpretations. It will now be necessary to examine each of these categories more at length. Subsequently, attention will be directed to the procedure of science, the scientific method, including its motivation and application.

I. *Facts.* Science begins with facts and facts form its body. These units of funded experience and knowledge are its basic truths.

A. S. Eddington refers to facts as being often primarily meter readings. Yet we must have many of them, for they are the basis of understanding and of intelligent action in the physical world. For example, the uninformed might eat cyanide, but only once, of course. Constituting the principal portion of the descriptive material in sciences such as biology, chemistry and geology, facts represent observational records. In addition, they serve as the foundation of all applied science. Through invention they yield new machines, processes, compositions of matter and biological plants.

Incidentally, in spite of their obvious importance, facts may be overemphasized in teaching. We instructors may be largely responsible for the development in certain students of a near-allergy for the sciences. These subjects, instead of being a thrilling intellectual awakening to such students, mean chiefly the memorization of endless bare facts, to be parrotted back to the instructor and then promptly forgotten. As stated by a novelist, the subject is treated as "a corpse which bit by bit we painfully dissect."

Facts should be definite and unquestionable. Also it is highly desirable to have them demonstrable in order to make later verification possible in case of doubt. Indeed, some consider that in science a fact must be mechanically demonstrable to be true.

There are, however, many conflicts over facts, for scientific observation is often subject to illusion and error. Thus most people state that the sun rises in the east and sets in the west, although it does neither. Frequently facts are difficult to obtain, and there may be disagreement as to what they are. One needs only to mention such problems as prohibition of alcoholic liquors, the economic depression of 1932 or one's chances for immortality without baptismal immersion to illustrate the confusion that may prevail. For these troublesome cases Glenn Frank advised that "all the remedies for all the types of conflicts are alike in that they begin by finding the facts rather than by starting a fight."

"The recording of facts," according to the late Justice O. W. Holmes, "is one of the tasks of science, one of the steps toward truth; but it is not the whole of science. There are one-story intellects, two-story intellects and three-story intellects with sky lights. All fact collectors, who have no aim beyond their facts, are one-story men."

Mere collections of facts do not make science, any more than a pile of stones makes a house. The facts must be systematized, according to suitable criteria, to constitute scientific knowledge. This classification process is really only an extension of the description process of fact collecting.

Chemistry presents two striking examples of classification. The compounds of carbon are arranged in the monumental treatise of Beilstein according to classes. The 4,877 types projected about the year 1900 have been found adequate for the third of a million organic compounds now known. The compounds of the other 91 chemical elements are discussed in inorganic treatises primarily according to families, as found in Mendeleef's famous periodic table. Without such organization, the countless facts covered in either case would be largely useless.

Finally, it should be noted that facts, in and of themselves, do not move us to do anything with them. For instance, how many, even among scientists, act on the basis of the known facts of genetics when they select the parent of their prospective children? Neither more facts, nor wider dissemination of those we already possess, will alone be sufficient to improve society.

II. *Interpretation of Facts.* The poet Noyes visualized the next step in his statement, "Day after day the slow sure records grow, awaiting their interpreters." Such are the multi-story men of Justice Holmes. "Two-story men," said he, "compare, reason, and generalize, using the labors of the fact collectors as well as their own. Three-story men idealize, imagine, and predict. Their best illumination comes from above, through the sky light."

Interpretation of facts consists, then, of finding relationships and formulating generalizations. The facts are the basis for conclusions, reached by induction. One may distinguish between the process followed and the products obtained.

(1) *The Process.* The first step in any interpretation is to study the facts, both individually and collectively. After they are subjected to scrutiny from all feasible viewpoints, possible or probable conclu-

sions are proposed. Finally, we formulate our tentative generalizations or plans of action.

Many would maintain that this operation consists in explaining the facts. We should note, however, that one does not explain phenomena in any final sense. Science merely locates things and their actions in space and time. It does not indicate what finally makes them act or why they are.

According to H. Poincaré, the mathematician, science can not teach us the nature of things—only their relations. Science "explains" a phenomenon, the effect, by showing that it is a necessary, or probable, consequence of another phenomenon, the cause. As R. W. Emerson said, "the effect already blooms in the cause." Over-zealous teachers, in asking for explanations of phenomena, run the risk of developing in their students an unjustified feeling of finality in this respect. At best, with Shakespeare's soothsayer, one can state, "In Nature's infinite book of secrecy a little can I read."

If we have difficulty agreeing upon the facts which bear on a given problem, it is little wonder that different people may interpret a given set of facts differently. The development of science has seen the rise and fall of many an interpretation. One of the most famous examples in chemistry was the phlogiston theory of combustion, advocated for more than a century by all the famous chemists of the time but now recognized as a totally erroneous concept.

(2) *The Products.* The results of generalization, whenever the process is carried far enough, may be recognized in one of three forms. These are so well known that they need little more than mention here.

An hypothesis is the least definite of the interpretations. It is not much more than a tentative assumption regarding possible cause-effect relations, an intelligent guess about the how of things.

A theory may be considered as a more or less matured hypothesis. It has advanced far enough toward certainty to be subject to experimental verification. It must be open to modification as long as experiments do not support the necessary conclusions. A theory is the working plan of projected experiments, such as the enterprise of the Tennessee Valley Authority.

A law is a generalized statement of the order or relation of phenomena. A law of nature explains nothing, of course, for it is only a descriptive formula which states what things do. In it isolated fact-descriptions are given a generalized description form. Even then few laws are more than approximations, for they generally rest upon statistical probability.

III. *The Scientific Method.* Our vast stock of facts, and of interpretations in the form of theories and laws, combined with myriad technological applications based upon them, represent a truly remarkable achievement of the human race. The material contributions of the last two centuries far exceed all similar prior progress. Such extensive accomplishments merit consideration of their cause.

Many factors must have been operative; but probably it would be conceded that objective experimentation and impartial thinking, more than anything else, are responsible. In fact, A. N. Whitehead has stated that "the greatest invention of the nineteenth century was the invention of the method of invention." In the words of E. C. Wickenden, "progress no longer waits on genius or the occasional lucky thought—instead we have learned to put our faith in the organized efforts of ordinary men." Our great industrial research laboratories are striking evidence of this faith.

This process, which has proved so fruitful, is known as the scientific method. Briefly, it involves collecting the facts, sorting or classifying them, formulating conclusions therefrom, and, if possible, subjecting these to experimental verification. Publication of the results usually follows with academic scientists. Perhaps the most succinct statement of the process ever made is that of Glenn Frank, a non-scientist. In his words, "our concern with the facts is to (1) find them, (2) filter them, (3) focus them and (4) face them."

In discussing progress in his book, "The Mind in the Making," J. H. Robinson outlined four principal types of thinking. (1) We day-dream—an activity to be observed among one's students, or possibly one's colleagues. (2) We make routine decisions—often a necessary activity; for example, one has to select items at a cafeteria counter. (3) We defend our prejudices —an activity in which we really begin to show some zest, especially if the subject in question is economic, political, religious, or social, and if we have been suitably conditioned in early life. How much time and energy have been wasted here. (4) We think creatively—an activity Professor Robinson ranked low in quantity. Its quality, however, is about the only hope the race has for material progress. The great performers in this category are Holmes's three-story men—the Newtons, the Darwins and the Einsteins.

With scientists this creative thinking involves the scientific method. Its effectiveness depends upon obtaining the facts without resort to authority and upon reasoning with an unprejudiced mind. The most important result of science teaching, according to scientists, would be achievement of this self-elimination in forming judgments. The significance of this attitude of mind can not be over-emphasized. Probably the basic test of a scientist is his sincerity toward the scientific method.

The extent of our factual knowledge, and of its technical applications, would seem to be ample evidence of the worth of this method. Nearly every science teacher extols its merits, and he would vigorously affirm that his first teaching objective is to inculcate his students with this process of thinking, to be used not only in the specific subject studied but also in everyday problems. To illustrate its industrial effectiveness he may point to the fact that chemical research laboratories of the United States have produced more than 200,000 products since 1914.

Limitations of Science and Scientists

With this record of achievement, represented by an immeasurable extension and application of knowledge, using a process of proven worth, who could be dissatisfied? Yet thoughtful individuals have expressed disappointment in the total results. Thus, according to Vice-President Wallace, himself a scientist, the last century of science has not improved the quality of society, although science yields annually an ever greater stream of truth.

The present state of society and the attitude of men toward each other, after two centuries of contact with modern science, make one wonder. Is there any basis for adverse criticism? If weakness exists, can anything be done about it? Or have we simply been misled to expect too much?

Since the scientific method has been so effective in obtaining truth about the physical world, many have assumed that knowledge of this effectiveness insures application of the process, at least by scientists and those trained in science, to focus this truth on our daily problems. If one is shown the way, it is only reasonable to assume that he will follow it. Such complacency, however, is destined for disillusionment. Once again, the process consists in finding, filtering, focusing and facing the facts. Obviously, this is merely a logical sequence of actions. What is lacking is motivation for action. There is nothing inherent in the method either to make one want to get the truth or to act upon it if and when obtained. How many chemists, for example, to say nothing of the thousands who have studied chemistry incidentally, try to live according to the best knowledge of physiological chemistry? We know well enough the way to normal weight and to sobriety; but the fat and the alcoholic continue wih us. We need, as Glenn Frank stated, a fifth step—following the facts. Even this would not provide the initial urge to get them.

H. G. Deming, a chemist, must have sensed this limitation when he wrote:

> science is but a feeble means for motivating life. It enlightens men, but fails to arouse them to deeds of self-sacrifice and devotion. . . . It dispels ignorance, but it never launched a crusade. It gives aid in the struggle with the hard surroundings of life, but it does not inform us to what end we struggle, or whether the struggle is worth while. . . . Intelligence can do little more than direct.

This lack of motivation in the scientific method, combined with the mental inertia of the ordinary habit-laden individual and the emotional inertness of facts, undoubtedly accounts largely for what we find on surveying the adoption of the process by scientists for general use and by the educated public.

Most reputable scientists are likely to conform to the method reasonably well in their specialties, particularly if the work is to be published. It is well known, however, that even eminent men may show little more than the prejudices established by early conditioning when they presume to discuss topics outside their own specialties. In fact, it is not common to find scientists who can be generally trusted for scientific soundness of judgment on non-scientific subjects. Winning a famous scientific prize or holding an important position give no assurance that the individual's opinions on economic, political, religious or social questions have any considered factual basis. This abandonment of the scientific method by many scientists, when they close the door of their laboratory, reminds one of the pseudo-religionist who goes to church on Sunday and then grabs all he can on Monday. A man's veneer of scientific attitude must be thick to prevent his thus easily reverting to the prejudices of youth.

The so-called educated public gives us even less reason for optimism. President N. M. Butler, of Columbia University, has stated the case in an annual report, from which quotation is made:

> For two generations, a very considerable part, perhaps a major part, of the effort of educational systems and institutions has been expended upon the development of teaching and research in the natural and experimental sciences. . . . The essential fact in all scientific study is the use and the comprehension of the scientific method. Every conclusion as it is reached is held subject to verification, modification or overthrow by later inquiry or by the discovery of new methods and processes of research. . . .
>
> One would suppose that after half a century of this experience and this discipline the popular mind would bear some traces of the influence of the scientific method, and that it would be guided by that method, at least in part, in reaching results and in formulating policies in social and political life. If there be any evidence of such effort, it is certainly not easy to find. Passion, prejudice, unreason still sway men precisely as if scientific method had never been heard of. How is it possible, with all the enormous advances of science and with all its literally stupendous achievements, that it has produced such negligible results on the mass temperament and the mass mind?

This is a question that may well give us pause, for something must be lacking if intelligent men and women, long brought into contact with scientific method and scientific processes, pay no attention whatever to these and show no effect of their influence, when making private or public judgments.

If we teachers are producing only partially scientific scientists, and almost entirely non-scientific laymen, what is the reason? Probably foremost is our own incomplete exemplification of the scientific attitude. We can hope to justify the method to others only as we believe in and practice it generally ourselves, irrespective of the possible personal rewards or costs. To the extent that expediency makes us disloyal to this ideal, we foster the cynical, widespread suspicion that every man has his price. It is hardly necessary, of course, to note that attempting to be scientific in everyday life and to follow one's conclusions may take courage and be costly, as more than one scientist can testify. Stuart Chase has analyzed this problem most effectively in an article entitled "The Luxury of Integrity."

Although more truly scientific teachers and leaders would help, another fundamental obstacle is our current conception of success. We are motivated, with too few exceptions, by dollars and things rather than by ideals of understanding and of humanitarian service. For measuring accomplishment the popular standard is income in industry and number of publications in college teaching. Thus despoilers of the nation's natural resources are likely to be honored as great business men, if they become rich, while the discoverer of a fundamental law of nature may go hungry. "If there is a fatal weakness in American society," writes A. H. Compton, "it is the lack of (enduring) objective." But, undaunted by this idolatry of the material, Lewis Mumford, new head of Leland Stanford's School of Humanities, still thinks the ultimate problem of a university is one of values rather than publications and patents.

Consideration of this diverse motivation, ranging from the idealistic to the materialistic, may help us to understand something of the social actions of scientists and of the technologists who use science.

Those directing their efforts toward idealistic goals are attempting first of all to understand the facts, as far as possible. Individuals with curiosity long to learn about man and his world. How does the firefly produce his light? What causes the succession of the seasons? Why do some people have red hair or in later life have left on their head little of any hue? These and a thousand like questions crowd the mind of any one alert to his physical environment. The thinking man has the capacity and likes to understand things.

To achieve the highest good, this individual attempts not only to understand the facts, but also, in the light of them, to make that adjustment to his physical environment, including his fellow men, which will promote the general welfare. To him knowledge of nature results both in admiration for its laws and in an effort to conform to them. A famous chemist, Justus Liebig, recognizing the ideality possible in this direction, stated that science to such individuals is a goddess to worship.

Although few people would object to a better understanding of facts, evidently what is most often sought of science is facts to use, whether they are understood or not. Control of their environment, by means of applied science, seems to be the goal of the majority of scientists and users of science. Thus the chemist makes synthetics, the metallurgist alloys, the physicist radioactive atoms and the geneticist new plants.

To what purpose is all the latter activity directed? Why are our research and development laboratories, numbering more than two thousand in the United States alone, spending many millions of dollars annually to get new facts and make new products? Primarily the urge is to survive or to gain personal or group advantage. The individual strives to make some discovery, usually in order to reap financial or other personal reward, rather than to improve the lot of humanity. The great corporation aims to keep in advance of competitors; real competition spurs ingenuity, discovery and invention. Something of the extent of such activity is revealed by the announcement each Tuesday of approximately a thousand new United States patents.

Liebig must have felt this materiality when he completed his statement about science by noting that to many individuals it is merely a cow to milk. Among the milkers one finds the whole collection of self-seekers, the most offensive of whom use science chiefly as a means for accomplishing their selfish objectives. Here, unfortunately, are the acquisitive, the egotistic, the expedient, the insincere, the dictatorial, the ruthless and the dishonest—in short, the little Hitlers of science. To this group may be traced most of the distrust and discord so often found among academic and industrial scientists. What a change in personal relationships, and consequently in science, would result if these people were to practice the Golden Rule.

Viewed from the standpoint of the possibility of improving society, these limitations may be summarized as (1) emotional inertness of science, (2) lack of motivation in the scientific method and (3) low social consciousness of the majority of those trained in science. As for the first two, we must resign ourselves to the inevitable—they are facts. Any hope of improvement, therefore, must center in the human element. A. A. Berle, Assistant Secretary of State, used these words: "The techniques of modern life—our engineering, chemistry, and medicine . . . are only tools. In and of themselves they do nothing; what they achieve arises from the desires of men's minds."

THE FUTURE OF SCIENCE

What of the future? In such troubled times as these prophecy is extraordinarily uncertain, for no one can foretell the results of the social and political forces now loose. Science might become restricted to implementing the repressive tyranny of those in power. In suggesting other possibilities, we are assuming that no such fate awaits it.

With the return of reasonable sanity and stability in social and political life, it seems safe to predict that science will continue in the general direction taken during the last few decades. More facts will be discovered, technological applications, perhaps undreamed of to-day, will be found for many of them, and new theories and laws will be formulated. The scientific method will work in the future, as it has in the past, in the physical and biological sciences.

But need this be all? Some scientists, at least, do not think so. Since science has revealed so much about things, from coal tar to the stars, and since it has shown how to operate, these men think that economic, political and social problems are susceptible to such treatment. Indicative of this trend is the formation of the Committee on Science and Society of the American Association for the Advancement of Science. Recently its chairman, L. K. Frank, wrote, "if we are to have a social order directed by intelligence and guided by scientific knowledge, . . . scientists must take a more active role in focusing scientific study and in helping to direct the application of their findings." In similar vein, G. H. Boyd has stated, "the task of implanting the aim, the spirit, and the method of science in the minds and the activities of the public is one of the important tasks which science and industry must face."

Much as the social order seems to need such attention, it is not clear that the men quoted realize the limitations of science. It provides means and a method; but there is little probability, judging by the past, that science alone can ever make men more socially minded. Such motivation must originate in ways beyond the scope of this address. According to C. E. Ayres, "science is completely impotent to determine what had better happen. . . . The only attitude toward human struggles appropriate to modern science is serene indifference, the indifference of the dynamo or the mechanical calculator."

In considering what lies ahead, therefore, account must be taken of human possibilities and aspirations. The scientific method undoubtedly can be applied in areas now little touched, even though the process may be more difficult than in the physical sciences. Also there is certainly no reason why it can not be followed more consistently by all scientists outside their specialties, and by those whose education has included an introduction to science. The question is whether they want to do it, and whether they are able as individuals to surmount the type of educational conditioning which causes a scientist to react in ways illustrated by his voting a straight political ticket because his grandfather did.

In an ever-changing world man constantly confronts problems. Current examples are the physically and mentally unfit, distribution of wealth, conservation of natural resources and war. Although we could well use many specific contributions, such as a disease-resistant chestnut tree or a cure for cancer, the larger problems are more pressing. There is needed a long-time program based on collective, planned action rather than rugged individualism. The latter alternative is admirable in theory, to the extent that one practicing it may develop much latent ability; but general adherence to this principle would bring results such as unrestricted reproduction of the mentally defective, waste and destruction of natural resources and general practice of might makes right. Application of science and the scientific method, actuated by adequate social motivation, seems a much more promising approach.

Assuming that scientists of the future become motivated to do something, and that they have the opportunity, how would they attack a problem? The following steps seem obvious: (1) get the facts bearing upon it; (2) study it in the light of these facts; (3) choose the tentative solution which seems likely to work best; and (4) make tests to determine if this prospective solution does work. If it does not, modify the method or select another and try again; that is, resort to the pragmatic test of workability by following the Biblical admonition to "Prove all things and hold fast to that which is good."

Some famous scientists, advocating such practice, have expressed the belief that the presence of more of their number in, or close to, economic and political life would greatly facilitate the alleviation of our economic and social problems. In accordance with the Platonian vision of a society led by reliably informed rulers, the suggestion is to have a non-political, permanent, group of investigators to provide information for administrators on possible and desirable courses of action. Such boards, if sincere and socially motivated, could provide information and programs; but for success of the plan the administrators would still have to want, and dare, to apply the knowledge in order to achieve what E. Stanley Jones has called a welfare economy.

The London *Times,* in reporting a conference on science and world order, stated recently, "But though science shows the way, it would be presumptuous to believe that science alone can lead us to the goal. The men of science themselves have moved far since the era of uncritical optimism, when progress was regarded as automatic and science as its predestined instrument. We need no evidence to-day that science can serve evil ends as well as good. . . . This is no reproach to the instrument, but a reminder that the ultimate test of its value lies in the moral purpose directing it. The most important service rendered by the conference has been to bring to public knowledge the almost unlimited potentialities of human development and human well-being which science has to offer. Science provides the opportunity. There must be the will to use it."

CONCLUSION

What, then, does science mean to me? The answer includes elements of admiration, disillusionment and faith.

In essence, science represents an unbelievably large collection of facts and interpretations of these facts, relating to every known area of the natural world. Acquisition of this information and application of it in the arts and industry are the glory of the scientific method.

Science and the scientific method are primarily human tools. They provide information and means for action; but they do not suffice in themselves to make any one act or, in case of action, to direct it to human good. The latter ends, if we want them, necessitate transformation and direction of our motivation by other means.

The scientific approach is the most effective procedure thus far discovered for enabling us to understand, and to adjust ourselves to, the physical world. In doing this we may well turn to Glenn Frank for our motto. "Let's stop being radicals or conservatives," he said, "and be scientists. That is, let's *act* in the light of the facts in the case, rather than in the (twi)light of our prejudices or the faded labels of our class, our clique, or our clan."

OBITUARY

EDGAR ALLEN

PROFESSOR EDGAR ALLEN, chairman of the Department of Anatomy of Yale University School of Medicine, one of the best-known anatomists and an outstanding authority on the physiology of sex and reproduction, died on February 3. His contagious enthusiasm and energy and his stimulating personality will be missed not only by his associates at Yale but by many throughout the country. His capacity to appreciate the new and significant, his impatience with inactivity and his friendly yet constructive criticism were familiar to all who knew him.

Less than fifty-one years ago Professor Allen was born at Canyon City, Colo., on May 2, 1892. Shortly after his birth the Allen family moved to Providence, R. I., and it was there that, during his youth, he acquired a love of sailing and knowledge of the winds and currents of the Narragansett Bay and Long Island Sound that persisted throughout his life.

Immediately after completing his undergraduate study at Brown University in 1915 he began his graduate studies in biology. During his college and graduate years he contributed largely to his own support by working as student assistant, as a waiter or at other tasks. These experiences undoubtedly contributed, in later years, to the sympathetic understanding and actual assistance he afforded so many students when they were confronted by financial difficulties.

His graduate study was interrupted in May, 1917, when he volunteered for service in World War I as a member of the Brown Ambulance Unit. Later he transferred to a mobile unit of the Sanitary Corps, in which he served in France. By the time he returned to civilian life in February, 1919, he had been commissioned a second lieutenant.

During the summer of 1919 he was an investigator for the U. S. Bureau of Fisheries in laboratories at Woods Hole, Mass. That fall, however, although he had not completed his graduate studies, he became instructor and associate in anatomy at Washington University School of Medicine in St. Louis. During the following two years he completed the requirements for the degree of Doctor of Philosophy from Brown University. In 1923 he became professor of anatomy and chairman of the department of anatomy of the University of Missouri, and later he became, in addition, assistant dean, acting dean and, in 1930, dean of the School of Medicine. In 1933 he again returned to New England as professor of anatomy and chairman of the department of anatomy of Yale University School of Medicine.

Professor Allen's first interest in research pertained to the problem of ovigenesis. At a time when it was generally assumed that the female mammal was born with a full quota of ova he demonstrated that ova could and did arise after birth and even during sexual maturity. While undertaking these, now classical