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THE SOCIAL SIGNIFICANCE OF SCIENCE.*

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BEGINNINGS OF SCIENCE.

Insatiable curiosity is one of the most important characteristics of the human mind. From his earliest days to the present, man has observed and wondered and been ill at ease until he has found satisfactory explanations of natural phenomena. Every primitive people has these explanations. However fantastic they may seem to us, they are nevertheless just as reasonable as our own when consideration is given to the limited experience and knowledge on which they are based.

These primitive explanations of natural phenomena are no sooner formulated than they begin to be modified by further experience. Here are the beginnings of philosophical and religious speculation and of science. Religious speculation is primarily concerned with the unknown, philosophical speculation with the projection of the known into the unknown, and science with the known. The early progress of science is excessively slow. The power of tradition is great and old beliefs give way but slowly to new ideas. Step by step, however, naturalistic ideas make inroads upon the field of pure imagination. There is never-ceasing conflict between tradition and new knowledge.

The field of the known is ever increasing, but the unknown ever extends limitless beyond. Some minds find satisfaction in the known. Some are chiefly concerned with the unknown but apparently knowable borderland. Some find compelling fascination in the further distances of the unknown where imagination can have free play.

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THE PRICE OF SPECIALIZATION.

These three interests have been characteristic of all ages. The great change that has taken place is the stupendous increase in the scope and complexity of knowledge. This has had two momentous consequences. The first of these is that no thoughtful person can now orient himself toward life and environment without a broad understanding of science. The second is the increasing difficulty of acquiring such an understanding. The time when an alert mind could fairly comprehend the sum of knowledge is not far behind us, but it is gone beyond recall. The problem before us is to find means of maintaining a broad culture in the midst of ever-increasing specialization upon ever-decreasing segments of knowledge. The solution of these problems requires an interest in imparting knowledge among those who know and an interest in receiving knowledge among those who do not know. Most of us are among those who know in some small field and among those who do not know in many other fields. However dangerous a little knowledge may be, one of the real needs of modern society and one destined steadily to increase, is for accurate general information. The urgency of this need in respect to the field of science can be appreciated only after some consideration of the influence of science upon modern society.

THE YOUTH OF MODERN SCIENCE.

Our own civilization and social structure is of recent origin. Its immediate beginnings are to be found in what we call the Renaissance. This was a profound but gradual change resulting from the freer circulation of men and thoughts associated with the Crusades, with the widening of the horizon by travelers like Columbus, with the invention of printing, the re-discovery of Greek culture, the development of universities and learned societies, the establishment of museums and botanical gardens. It was a period of revival of interest in learning, and it was beginning to bear complex fruits in the Sixteenth Century.

Our culture is thus built in part upon the culture of classic Greece, in part upon the learning of our own period. Slowly during the early part of this modern period scientific methods were perfected and fundamental concepts of science established. With these foundations laid, an ever-increasing acceleration of scientific progress has ensued.

OUR SCIENTIFIC AGE.

One of the results of modern science has been the growth of our present civilization upon a foundation of applied science. The life of the people is conditioned largely by the utilization of natural materials and forces made possible by science. The mechanisms of applied science and the industrial processes by which they are produced have a major influence in determining the environment, the occupations, and the habits of thought and behavior of mankind. Science makes the preparations for our reception into the world, prescribes the diet, clothing, and daily routine of the infant, provides the houses in which we live, together with our food, fuel, water, light, furnishings, and multiple labor-saving mechanisms. Science determines the occupations of most of us, and where and under what conditions our working life shall be spent. Science provides the means of transportation and thus controls the range of our movements, a large part of our play, and the breadth and nature of much of our thinking. We depend upon science to keep us well, and we turn to science when we are ill. It is no wonder we boast that we live in an age of science!

EFFECTS OF SCIENCE.

These profound changes in human life are the results of applied science. They are of such recent development and of such obvious portent for good and evil that they require the most serious consideration of mankind. In so far as they facilitate the meeting of the primary necessities of life, conserve health, broaden the horizon of our experience, and increase leisure, they ameliorate the harshness of a more primitive manner of life and open possibilities for the enrichment of life. Whether at the same time they soften the fiber of the people and sow the seeds of decay in the civilization of which they are the outstanding characteristic, is uncertain. We know, although we may not always remember, that throughout the long history of life every great expansion has been followed by a decline to extinction or obscurity. Every human civilization has flowered only to decay. In no nation and at no time in history has prosperity been so nearly universal as it is with us today. By all standards of the past we are now arriving at a pinnacle never surpassed. In the very greatness of our achievement we cannot but sense a note of warning. If our material

prosperity leads to habits of luxury and indulgence, to indifference to the fundamental problems of individual life and of society, our prosperity may well become a curse. If, on the other hand, our increasing knowledge and leisure lead to the enrichment of our individual inner lives, to a greater interest in a more intelligent approach to the multitude of unsolved problems of society, we may well hope to continue our progress in the building of a finer social structure and a greater personal happiness than any people has yet attained.

It is not conceivable that the progress of science will soon be retarded. We must rather expect an ever-increasing acceleration and an ever-increasing complexity of life resulting from this acceleration. Our main reliance must be placed upon more science; not merely in the production of more mechanisms, but especially in those fields of science which hold promise as yet but dimly apprehended of a truer knowledge of the reactions of men to their physical environment and to their social contacts with one another. The increase of happiness in the broadest and highest sense of the word, happiness not of a favored few but of all, is a worthy object of human endeavor.

THE SPIRIT OF SCIENCE.

Applied science is undoubtedly highly appreciated by mankind, but the spirit of science is far from being generally appreciated. The great contribution of science to humanity lies in its indefatigable industry in accumulating facts, in its honesty in facing whatever facts are found and whatever principles those facts may indicate, and in its open-minded readiness to modify its opinions in the light of new evidence. We cannot have true science without sincerity in the search for truth and without the realization that most truth is relative. The attitude of science stands in sharp contrast to the attitude of the unscientific, which is controlled by tradition and by emotion. Prejudice and lack of understanding of science, especially biological science, is one of the handicaps in the intellectual adjustments of the people to the progress of knowledge and in social practice and legislation.

The mechanistic products of science are quickly accepted by the people. So largely do these utilitarian results bulk in the popular mind that they are all too commonly regarded as the sole purpose of science. "Of what use is it?" is the first question of such minds regarding knowledge. It is of the greatest

importance that the general public learn to appreciate, first, that useful inventions are invariably developed from apparently useless knowledge—there can be no applied science until we have science to apply—and, second, that the mechanisms of civilization are but the paraphernalia of life, that the most precious human experience, the highest form of happiness, lies in harmonizing the experiences of life and in adjusting ourselves satisfactorily to life and to our environment. This orientation of one's self in life has been from time immemorial the great desire of human beings. Science is rapidly providing a necessary basis for this orientation. Never before in all the long millions of years of the history of life, we may be sure, has any species ever before attained an objective point of view toward itself, projected its mind into the magnificent distances and dimensions of astronomy, into the remote time of geological history, into the minute realms of chromosomes, bacteria, atoms, and electrons.

Even today we are just beginning to apprehend what natural history means, beginning as it does in infinitely remote time and space, sweeping like a great stream through the ages, seeming to pause a moment in the eddy of our personal experiences, and sweeping again in full flood toward an infinitely remote future. Only with some understanding of these major concepts of science can we hope to experience the full richness of modern life, or to make such adjustments in our attitude toward life as are worthy of the minds with which we are endowed, and of the rich race experience that is our heritage.

THE SOCIAL DUTY OF SCIENTISTS.

It takes many men of many kinds to make a world. Scientists tend to withdraw themselves from the turmoil of practical life, to associate with kindred minds, and to seek the seclusion of the laboratory and the study. This is appropriate in so far as it facilitates that concentration which is essential to research, yet it is but the first step in meeting the social need of science. Some fortunate scientists are able to emerge from the cloister either in person or through the written word with a message of great import to humanity. These perform a social service of the highest order. I conceive one of the great needs of society today to be the provision of more effective means for the interpretation of science to the general public.

The progress of science is recorded by custom in technical publications. These are a necessary and admirable means of communication between scientists of the present and of the future. It must not, however, be forgotten that these technical publications are written in a dialect incomprehensible to the people, and that the ultimate end of research is to contribute to society. Society needs accurate and judicious interpretation of science.

SCIENCE IN EDUCATION.

One of our most characteristic institutions for the interpretation of knowledge is our educational system. Since we are living beings in a world of nature, it would seem that no college course would be complete without a serious presentation of what is known about life and its environment. In actual practice, however, science occupies a much more subordinate position than would seem natural from our present point of view. I attribute this to two general causes. First, failure of the general public to appreciate the magnitude of the concepts science has to offer. Second, the failure of science faculties to appreciate how much more important the major concepts of the sciences are in education than the minutiae.

I well remember how in my college days I was thoroughly imbued with the idea that science is a very serious matter; that I must train my powers of observation by prolonged search for minute facts with the careful recording of my observations in notes and drawings, and that only by long practice in small generalizations might I come in time to understand the spirit and the broader conclusions of science. Looking back I find no fault with this experience as a foundation for science as a profession. I am impressed, however, by the very small proportion of college students who go far enough with such a program to obtain the kind of understanding of science that ought to be a part of the equipment of every college graduate.

Even in the most intellectual circles of a great city I hear little discussion of most of the subject matter of my college courses in science. Principles of erosion, Boyle's law, chemical formulae, Amoeba, the anatomy of the earthworm, alternation of generations, the germ layers, are not subjects of general conversation. I do hear, however, at the round tables in the clubs, at social dinners, in short wherever intelligent men and women gather together, expressions of vivid interest in scientific

events and discoveries. I take as my type of the better element of the general public the successful business man and his family. They are endowed with good minds, they are well educated, they are deeply immersed in the problems of their vocation, they are of an inquiring disposition, they want to know what is happening in the world and what it signifies, they desire culture but find it rather difficult to attain. They are interested in events and the significance of events. Their interest does not begin with general principles and proceed to the illustrations. It begins rather with particular events and is not satisfied until the principles that give them significance are indicated.

My experience suggests that a sharp distinction should be made in the college curriculum between courses of professional training and courses of general culture. However assured we may be that one cannot fully comprehend a scientific problem except by studying all its details, we must admit that one may at least apprehend a principle from consideration of conspicuous illustrations.

The successful college course must meet two fundamental conditions. It must present accurately and in due proportion the important concepts of the subject. It must also make the largest possible contribution to the enrichment of the mind of the student. The student's needs may best be understood if we consider what influence the subject matter of the course may be expected to have upon his later life. The success of the course will be proportionate to the degree to which it illuminates his experiences.

One of the best popular lecturers on astronomy that I know is a lawyer to whom astronomy is a recreation. Popular audiences are fascinated by his astronomical descriptions. Their effect is to broaden the mental horizon of the hearers, and to give significant facts that may serve as the nuclei around which may adhere ideas obtained from other sources.

In practical life most people are not interested in mathematical physics or in chemical formulae, but they are greatly interested in the nature of matter and the inter-relations of its various forms as seen by the physicist and the chemist. In geology they are not interested in the intricasies of crystallography, but they are greatly interested in the history and structure of the world in which they live. In biology they are not interested in the anatomy of animals that are for the most part outside their experience, but they are deeply interested in

the living things about them, or which come into their experience through the work of expeditions. Whenever their attention is drawn to facts, their minds are receptive to an explanation of the significance of the facts.

NATURAL HISTORY.

A hundred years ago natural history was a term in general use to cover the field now apportioned among the sciences of astronomy, geology, paleontology, biology, and anthropology. The increasing complexity of these sciences has obscured the fact that they are but different aspects of one great unit—nature. There is already noticeable in college curricula a tendency to overstep these departmental fences and to offer courses of increasingly broad scope. This is the logical step toward meeting the needs of students who take science for general culture. General science is a rather heavy and uninspiring title. The good old term, natural history, is coming back into use. I commend it to the consideration of the colleges for the richness of its connotation and the directness with which it describes the kind of science for which I find so great a need in society.

THE SOCIAL NEED OF SCIENCE.

At best a college education opens the doors ajar to a series of fascinating vistas of human thought and experience. Among these a student can hardly select more than one for intensive exploration in later years. There is an inevitable tendency for the other doors to swing to and leave the vistas to which they lead as mere memories. There is increasing consciousness of a real social need for means of maintaining the vividness and extending the richness of college experience. There is also an increasing consciousness of the social need of better methods of interpreting knowledge to those who have not had college experience. These needs are evidenced by the space devoted to science in newspapers, magazines, and books; by the popularity of lectures; and by the conversations of social groups.

MUSEUMS AS INTERPRETERS OF SCIENCE.

As agencies of public education, museums are coming to perform an increasingly important social function. In this country the museum movement is older than the nation. It began with the founding of the Charleston Museum in Charles-

ton, South Carolina, in 1773. This founding, curiously enough, was an expression of a part of the Revolutionary spirit. The committee which founded this institution included Charles Cotesworth Pinkney, and its minutes state that it was animated by a desire to show the intellectual independence of the Province of South Carolina from the mother country.

In more than 150 years since the initiation of the museum movement in America, there have naturally been many phases of museum development. Between 1814 and 1826 there was in Charleston an intensity of public interest in museums astonishing to contemplate. "The State Legislature and the City Council, alive to the importance of this object, with a promptness and liberality, which will forever redound to their credit," made the first appropriations of public funds for museum purposes on record in this country, and these appropriations, together with sums subscribed by individuals, were applied to the purchase of an extensive natural history collection brought to Charleston by Dr. Felix L'Herminier. South Carolinians in the diplomatic service procured extensive foreign collections for the enrichment of the museum; among these was the Hon. Joel R. Poinsett, minister to Mexico, from whom the Poinsettia is named. The collections were described as rich in minerals, fossils, and shells, in ornithology, herpetology, ichthyology, and entomology. There were 800 mounted birds, 70 mammals, 200 fishes, and 4,000 minerals. The exhibits were arranged in glass cases, and the museum was advertised as "open every day from nine o'clock, and brilliantly illuminated every evening." An editorial in the *Courier* of November 23, 1824, contains this remarkable statement: "In these enlightened times, a public museum is as necessary an appendage to a city, as a public newspaper or a public library."

This extraordinary activity of a museum as a public institution was not without parallel in other cities, notably Philadelphia and Salem, Mass. Museums of this type were usually founded by societies.

Early in the Nineteenth Century two other classes of museums were conspicuous. One is that of the scientific societies, among which are conspicuous the Academy of Natural Sciences of Philadelphia, founded in 1812, and the Boston Society of Natural History, founded in 1830. These museums were primarily of the research type. The scientific publications based upon them mark milestones in the progress of American

science, but these museums have not been adapted to the performance of the functions of public museums as we now conceive them.

The second class of museums conspicuous in the first half of the Nineteenth Century was the college museum. Most of the colleges of the period were denominational colleges. Nearly all of them maintained chairs of natural theology. The principal thesis of these chairs was the evidence of the nature of deity as shown in the complexities and adaptations of creation. The museum of natural history was the laboratory of the chair of natural theology. It had a profound influence upon the college graduates of the period, and as they traveled to the far corners of the earth they sent back to the college museum new examples of the wonders of creation. Museums in this period were a vital part of our colleges.

The publication of Darwin's Origin of Species in the middle of the century inaugurated a profound change in the attitude toward nature. The main thesis of the chairs of natural theology was undermined. Interest in the museums declined. A new interest arose in laboratory studies of morphology and embryology. Selected forms in quantity for dissection, and small synoptic series for demonstration replaced the museums. Departments of biology were everywhere established, usually by robbing the museums of their curators.

Approximately 38 percent of the 600 museums nominally existing in the United States belong to schools, colleges, or universities. Most of these museums have no vital college function, and a great majority are practically without funds. inactive and deteriorating.

The greatest and most active museums of America today, with few exceptions, are of a new type which may be designated, for want of a better term, as public museums. Some of the greatest of these were founded in the last quarter of the nineteenth century, including the American Museum of Natural History, 1869, the New York State Museum, 1870, the Milwaukee Public Museum, 1882, the Brooklyn Institute of Arts and Sciences, 1889, the Carnegie Institute Museums, 1896. Public museums have two outstanding purposes. Research for the increase of knowledge, and the interpretation of science to the people for the enrichment of life. These museums are usually supported by a combination of private and public funds. Their importance to society increases with the urban

concentration of population. They stimulate and guide interest in local natural history and they bring the natural history of the far corners of the earth into the city for educational purposes. More and more these public museums are becoming the centers of the science interests of their communities.

THE SCOPE OF MUSEUMS.

In contrast to the university, the museum deals potentially with the whole public almost literally from the cradle to the grave, while the university deals with but a limited fraction of the public enrolled from four to eight years. Where the university's instruction is intensive, that of the museum is extensive. The university represents a concentrated molding and directing influence upon the early years of adult life; the museum combines instruction with recreation, and stimulates rather than compels attention. Public museums work in close partnership with the public schools, where they have an important and unique social service to render.

MUSEUMS IN ADULT EDUCATION.

In adult education these museums have an equally important service to perform. They offer one of the most promising means of continuing and developing through adult life the interest in science that is created in college, and to the non-college public they afford a substitute for college training in science. Up to this time adult education in museums has been chiefly through the arrangement and labeling of exhibits, and through lectures given in the museum or before other organizations.

The great reserves of material necessary for the technical work of museums have not hitherto been effectively utilized for any form of adult education. There appears to be here a fertile field for development. Experiments on a small scale indicate that it is quite possible to bring small classes of adults into reserve collections, and that the offer of this service will be eagerly accepted by the public. These groups should be given organized instruction quite different from that of regular or extension university courses. Appointments of an hour and a half each, once a week for four weeks, offer sufficient opportunity for a cultural experience of distinct social value. Such brief courses can be taken without too great disorganization of the complex activities of adults. The most accessible

clientele for such cultural courses will probably be found among intelligent women who can take these courses during the day. In order to reach men it will be necessary for the museums to provide evening instruction.

Among public museums we can already find some of the most fundamental thinking and skilful methods for bringing about a sympathetic understanding between technical scientists and the general public. These museums offer fascinating possibilities as the intermediate wheel to gear together the power wheel of research and the work wheel of practical life. The educational work of museums is not a duplication of school or college work, but a parallel service, and there should be close understanding, sympathy, and co-operation among these institutions. The educational departments of museums will furnish the technique of interpretation; their scientific departments will furnish the facts and principles. College scientists can make important contributions to this service and in doing so can receive valuable suggestions and stimulation.

If there is such a need as I have described for the interpretation of science to the people, and if there is need for co-operation among colleges, museums, and scientific institutions generally in this social service, the Ohio Academy of Science should have a function of significance to the whole State.

OPPORTUNITIES OF THE OHIO ACADEMY OF SCIENCE.

The Academy is the common meeting ground of the scientific activities of the State. One of its important functions is to provide a forum for personal contact and exchange of ideas that cement together in friendly association the scientific men of the State. This function is so obvious and so generally appreciated that it does not need to be stressed.

The second function of the Academy requires more thought. This is the interchange of institutional and personal programs in order that each of us may be better informed about the scientific work in progress in the State, and in order that we may co-operate more effectively in a common cause. I recommend that consideration be given to the desirability of conferences for the specific purpose of articulating more closely the varied activities in Ohio.

The third function which seems to me to devolve upon the Academy is that of presenting to the people of the State by means of special papers at the Academy meetings, and with the

organized aid of the newspapers of the State, broad summaries of the progress of science in the State. There are two important reasons for doing this. The first is the obvious duty of scientists to contribute as largely as possible to the enrichment of the life of the people. The second is that the progress of science depends upon the financial support and social encouragement which it receives, and these can come only from a general appreciation on the part of the people of the importance of science and very clear understanding of the needs of scientific workers.

The Ohio Academy of Science has a long and honorable history. It is so constituted as to possess inherently a large potential influence. Its very nature imposes upon it a serious obligation to serve society to the best of its ability. The more intimately we integrate ourselves with the general public, the greater will be the mutual advantages to be experienced.

Science is one of the dominant factors of our age. Its complexities are bewildering. Its spirit and its meaning are but dimly apprehended by society. My plea is for the enhancement of the social value of science in the enrichment of the life of the people, in the adjustment of personal experience to the world of phenomena, and in the diffusion of the scientific spirit of indefatigable industry in accumulating facts, of honesty in facing whatever facts are found and whatever principles those facts may indicate, and of open-minded readiness to modify opinions in the light of new evidence.