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IDEALS OF SCIENCE[1]

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WE are gathered to-day to dedicate not merely a building but to perpetuate an idea—the ideals of science. It seems fitting therefore to say a few words in appraisal of science: what science has done and what it may do.

Modern civilization is in large measure the product of science. Recently, however, some have challenged the value of science on account of the baneful effects of certain of its applications. They grant the increase in material comforts which the applications have brought about, but say the cost is greater than the gain. The weapons of modern warfare made possible by science are held responsible for the appalling loss of life, rather than the wayward mind of man. Even if we should take these criticisms at their face value it would be possible to show that science has greatly lengthened rather than shortened the average span of life. Preventable disease has taken greater tolls than war. During the World War, Germany lost one and three quarter millions, killed or died during service. This is less than 3 per cent. or one out of 36 of the total population of about 65 million people in Germany at that time. During the plague of London in the seventeenth century, 15 per cent. of the population, or more than one in seven, died of the Black Death during a two-year period. This is ten times the German mortality rate during the World War. Later when the plague was introduced into Marseilles it killed almost half the population there. During the seventeenth century the plague carried off twenty-five million people in Europe, or a quarter of the population.

The plague has been a periodic scourge to mankind since long before the time of Christ, but thanks to the applications of science we no longer dread its ravages.

[1] Address delivered at the dedication of the John H. Harrison Science Building at DePauw University, Greencastle, Indiana, October 19, 1940.

Other examples could be given to show that the discoveries of science have saved more lives than have been lost through the applications of science.

These arguments against science are based upon a misconception of what science can do. Science is impersonal. It merely provides tools in the form of a body of knowledge, instruments such as the microscope with which to delve deeper into the unknown, methods of studying nature, and points of view. How these tools are used is not the fault of science as such. The use is determined by the aims of human beings, some with good and some with bad motives; some ignorant, some informed. Goodness of motive does not alone determine whether an action is beneficient or baneful. Witness the inquisitions of the church in their well-intentioned campaigns to better mankind, and the Salem witchcraft trials which are connected in the public mind with the Reverend Cotton Mather. In the Civil War, churches on both sides prayed for the success of their own cause and the same was true in the last World War. Even the Church follows the flag. Moral judgments when colored by personal interest are unsafe guides to conduct.

It is true that technological applications of scientific discoveries have brought us material comforts, but they have been too often recounted and their emphasis tends to obscure the real values of science. Technological applications and physical comforts are not the greatest gifts that science has to offer to mankind. Lincoln has been called an emancipator. He liberated people from physical bondage. Science has been a greater emancipator. It has liberated humanity from the shackles of ignorance and superstition. It has freed men's minds. It has disclosed nature and from this knowledge man may walk in accord with nature's ways. The influence of science on human betterment is usually indirect. As an example, the ancients used human sacrifices to ensure bountiful harvests. We use commercial fertilizers, not primarily because we feel human sacrifice is morally wrong, but because we have learned by experience that commercial fertilizers yield better results. With new knowledge superstitions based on untenable premises gradually fade away. Thus before the behavior of chromosomes and genes was understood, it seemed reasonable to believe in "maternal impressions"—that, for example, if a pregnant mother was chased by a turkey gobbler, the child's face was likely to be "marked" with a red birthmark. Such a belief, as also that in so-called "acquired characters," is no longer held by informed people, since it runs counter to the known mechanisms of heredity.

The recent findings of genetics in plants and lower animals are having a profound effect upon man's philosophy of life—or should have. The realization that no two people are exactly alike or ever have been, that human differences are due to factors of heredity which are innate as well as to influence of the environment, can not but change our attitude toward problems of education, rewards and punishments, and all efforts for human betterment. The environment can be readily controlled; the heredity can be controlled only by genetic methods. There seems no good evidence that man to-day is inherently better physically, mentally or morally than at the dawn of history. Through changes in environment, however, man has risen far in social evolution. Many of the gains have been called moral, since they tend to benefit mankind as a whole. This does not prove that the moral nature of man has changed. It may merely show that what we call morality has been found to be profitable in the long run. Despite lapses of individuals and of nations, I believe morality does pay and will prevail as the recognized standard of life. Those who think otherwise I trust in time will come to agree with the man who said, "Honesty is the best policy. I have tried both." Time may come when man will attack the problem of his own biological evolution and man may then become better morally as well as mentally and physically.

Last month I had the privilege of taking part in the Bicentennial of the founding of the University of Pennsylvania in 1740 by Benjamin Franklin. It was interesting to review the state of science at that time. In the first place, there were no laboratories then and few who could be called scientists. Franklin probably knew personally or through correspondence all the scientists there were in this country and most of those abroad. In Franklin's time there was hardly a chemistry since the atomic theory had not yet been proposed by Dalton. Two hundred years ago a little was known about static electricity, but the Leyden jar was not yet discovered and nothing was known about galvanic and induced electricity. Here are some of the biological things that were not known two hundred years ago: the binomial system of naming plants and animals, later introduced by Linnaeus; bacteria as causes of disease; experimental work in hybridizing plants, started by Koelreuter; the cell theory; the theory of organic evolution; chromosomes, genes, hormones, vitamins. Knowledge of the mechanisms of heredity has been developed entirely within the last forty years. It is certainly true for biology and perhaps for most other branches of science that more progress has been made in the last one hundred years than in all time before. Equally important examples could be mentioned from other fields. The selected items I have mentioned that Franklin did not know are not technological advances but fundamental discoveries, many of which have, however, formed the basis for technological applications of great value.

Franklin, though perhaps the foremost citizen, philosopher and scientist of his time, knew relatively little of the orderly processes of nature. To him the universe was fashioned in six working days by a mechanistic God. To his time, all men were created equal and environment (with the occasional aid of Divine Grace) was considered the sole arbiter of man's fate.

In Franklin's time science had little or no place in the educational curriculum and there are those to-day who would deny cultural value to study of nature. To us, science is not to be defended primarily because of its utilitarian values except perhaps in such professional schools as those of engineering. It should rank in cultural value with art, literature, and music, since science also nourishes the spirit.

I had chosen as my topic for this morning's talk "The Ideals of Science." I have come to the conclusion, however, that strictly speaking there is only one ideal of science—the search for truth. The searchers for truth, the scientists, have developed ideals for their endeavors, but they are human beings with human emotions and frailties and, like the rest of humanity, their opinions are consciously or unconsciously tinged by personal interest. Personal interest, however, does not give added weight to conclusions of science. We need emotion as a motive force to our labors, but the more heat in our emotions the more likely we are to be blinded in our conclusions. First among the ideals of scientists is freedom of thought and its expression. A censorship on what problems may be studied and on what conclusions may be reached is lethal to science. The scientist covets for all the freedom to investigate any problem, economic, social, governmental or other human activity as well as problems of genes and electrons, and to state conclusions whatever their effect on current beliefs. In his search for truth, the scientist attempts the difficult task of accepting realities though unpleasant. With Thomas Huxley he can say "God give me strength to face a fact though it slay me."

Cooperation is an ideal of scientists. Whether we realize it or not, each is working with a multitude of collaborators, of the past and of the present. Discoveries are not made in a vacuum but are the culminating result of the labors of many on whose shoulders we rise. The present also has an unconscious influence. We often hear the expression "Leaders of Science." As a matter of fact so-called leaders often lead less than they are pushed. The advancement of science is like that of an amoeba—a mass movement with individual projections extending only a slight distance beyond the advancing edge. It is for this reason that so frequently important discoveries have been made independently at about the same time. This was the case with the rediscovery of Mendel's law of heredity. Mendel communicated his discovery to Naegeli, an acknowledged leader in heredity, and his published paper was cited in Focke's "Cyclopedia of Hybridization." Mendel's discovery remained unused for over thirty years, until 1900, when it was independently rediscovered by three other investigators. Biologists in unconscious cooperation had brought their science to a stage in 1900 at which the early discovery of Mendel's law was an inevitable event. If de Vries, Correns and Tschermak had not made the discovery, others would have done so soon.

Another example near our day. Thirty-six years ago, at our Department of Genetics in Cold Spring Harbor, a building was dedicated to the study of experimental evolution. Hugo de Vries, the world's leading student of heredity, was brought from Holland to make the address. He advised the use of the recently discovered radiations of radium and x-rays to penetrate into the interior of cells and induce mutations in what we now call genes. Some of the leading geneticists of the time heard the address and it was published, but again the time was not ripe and the advice fell on stony ground. About twenty-five years later the effective use of x-rays in inducing gene mutations was announced by a worker with *Drosophila,* but others independently had already started radiation experiments for the same purpose. None of these workers had known of the advice of de Vries. The stage was set for the discovery, and it could not have been long delayed. My purpose in giving these examples, which I believe are not exceptional, is to emphasize the part that the scientific environment plays in the advancement of science. The individual so-called leaders of science could probably be eliminated without so much loss as most would imagine. It is the mass movements that really count. They furnish a scientific atmosphere, as it were, to which we all may contribute our bit.

I need not stress the obvious advantages of voluntary cooperation, especially between those with different techniques and different points of view. Science knows no bounds of nationality or creed. There is not a Japanese wave-length of light nor a German atom of carbon. Consciously or unconsciously all nations have cooperated in building our present structure of science. International congresses testify to the value of international cooperation in science.

Another ideal of scientists is tolerance. The experienced investigator knows too well how hard it is to close every rat hole where an error might have crept into his calculations. His chief demand of others, as of himself, is honesty and a reverence for the truth and withal a willingness to change his opinion when facts show his views are wrong.

Science may be advanced in many ways. We think of research, education and support by public and private

agencies. Each plays its special part. Few can compose music; most of us can enjoy music and some can help in the financial support of music. Patrons of the arts have made possible our present museums with their priceless treasuries of the best thoughts of the past. It would be as unwise to attempt to force all into careers of research as into careers of musical composition. All, however, should have the privilege of knowing and enjoying at least some phase of science. The problem regarding the supply of new leaders of science is to catch them early and give them increased opportunities for the development of their exceptional powers. The problem for those who are enjoyers of science without professional intent is the accurate but interesting presentation and dissemination of scientific knowledge. Beside the formal educational institutions, such agencies as Science Press and the members of the National Association of Science Writers are contributing to the solution of this problem. The problem for the potential patrons of science is the realization that their benefactions are investments in science which should be scrutinized as carefully as a purely financial venture in order to ensure adequate dividends in scientific returns. We congratulate this university that its patron not only provided the funds with which to erect this beautiful temple of science but also had the foresight to provide a permanent endowment in the university which could be used towards its continuing support.

These are dark days throughout the world when in many countries science has been as effectively bombed by governmental fiat as have stately edifices been bombed by missiles from the air. What of the future of civilization, we are asked, and what part has science to play? Turning the pages of history gives us scant comfort. Civilizations widely separated in time and space have flourished and disappeared. Is ours also to obey the laws of growth, decay and death? In the warm summer it is hard to think of winter's cold, and we instinctively feel that our civilization will endure; we have gone so much farther on the upward road, we say, that the curve must continue to rise. It is dangerous to extrapolate the future from the present. Think of the temperature curve of H_2O. Starting with water at room temperatures there is a gradual decrease in volume until at 5 degrees the volume begins to change in the opposite direction and a sudden expansion takes place as the liquid changes to a solid, ice. From the slight range of room temperatures it would not be possible to predict the sudden reversals of the curve, as water freezes. It is equally impossible to be sure that the curve of our civilization will continue its upward trend. There is one fact, however, that may be a ray of hope to our calculations. Science has reached a stage of development in our time that no other civilization has known. The experimental method, for example, has only recently become of use. Scientific methods are now available as never before for study of all phenomena of nature, even that of a sick civilization. It is my trust therefore (though this may be wishful thinking) that science will find a remedy for our present international ills as it has for many a pestilence that walketh in darkness. If and when the time comes for restoration of peace and good will, I believe science may lead the way. I attended the International Congress of Genetics in Edinburgh last fall which was broken up by the advent of war. Some of the members belonged to countries where now liberty is but an empty name. Science had brought us together individually as friends and we separated as friends when the congress was prematurely disbanded. We trust that the internationality of science will some day bring us together again as friends.

We are all the privileged legatees of the past, rich from the toil and sacrifice of those of other days. America is favored as nowhere else. Our science is still free. American science therefore has an especial duty to keep aflame the torch of free research for truth, which is dimmed or gone out in so many lands. We believe that when the goddess of truth is seen snatched from her temple and publicly trampled under foot, our duty is not merely to mildly protest but to summon up our emotions as men and to fight with all the moral energy at hand, fight not merely for the preservation of our own land and the spiritual values we have gained but for freedom throughout the world. In science all nations are one people and the world can not endure part free and part slave. We are not without hope in the ultimate salvation of mankind. We believe that the free search for truth by the methods of science has power to rebuild the world and we have faith that it will prevail.

THE STATE SCIENTIFIC SURVEYS OF ILLINOIS[1]

By Professor W. A. NOYES

UNIVERSITY OF ILLINOIS

THE Board of Natural Resources and Conservation is a non-political organization, the members of which are appointed by the governor of the state but are selected because of their expert scientific training in lines closely related to the work of the State Surveys. The original board was appointed in 1917 by Governor

[1] An address given at the dedication of the Natural Resources Building at Urbana, Illinois, November 15.