Science in the Universities

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SCIENCE CONCERNS US ALL, and especially those who have just completed their university training. These young men and women are going to live and win their spurs in a world which is increasingly influenced by science. Many are preparing to make their living in scientific research or teaching, or in professions, like medicine, which apply science. Even if their careers are in fields remote from science, their future well-being cannot fail to be profoundly influenced by present and forthcoming developments in scientific research. Above all, the last decade has demonstrated that this country needs a strong science if it is to be the type of postwar country we desire or probably even if it is going to survive.

There is but one science, but for convenience we contrast that type which we term fundamental, basic, or pure, with that type which we term applied or developmental. At the extremes, this division is sharp. It is easy to distinguish the purely basic work of the nuclear physicist, who is interested in understanding the structure of the atom, from the applied work of the scientist and engineer, who are interested in manufacturing the atomic bomb; it is easy to recognize the basic character of the work of the biologist, who is studying the hormonal regulation of physiological processes, and the applied work of the clinician, who is using hormones in curative medicine. Actually, however, there is a gradual spectrum of interest starting with fundamental science, whose votaries try to understand and explain natural phenomena without regard to practical value, and extending to developmental science, whose adherents attempt to apply basic science to the needs of mankind. Frequently, both types of work are done by the same person. I wish to discuss basic science and some of the dangers it is facing.

It is hardly necessary to mention that science is more than exact observation, accurate measurement, and detailed analysis; nor is it necessary to point out the freedoms necessary for the preservation of basic research and teaching in the universities. No discussion of basic science would be complete, however, without mentioning the value of pathfinders, "worthless facts," and luck. Like other people, most scientists follow pathfinders—those men who become leaders because they have the flair for tying scientific observations to some exciting or ingenious hypothesis, which stimulates others to test the hypothesis and thereby accumulate more observations. It is not unexpected, therefore, that many observations, unnoticed, ignored, or forgotten because they do not seem important at the time, bob up to form integral parts of the basis of scientific laws formulated later. Luck always plays an important role, but it generally happens to what has been termed the prepared mind. Thus, it was intelligence that led Morgan and his co-workers to turn to the fruit fly, which Lutz had shown was peculiarly well adapted for genetic studies because of its ease of handling and short life-cycle. It was sheer luck that the fly was later found to show "crossing over" of characters in the female and not in the male—a combination which was exploited to the utmost in the brilliant studies of linkage and in determining the loci of genes in the chromosomes.

We need both pure and applied science in our universities. No one wishes to belittle or stop the great applications of science in medicine, in agriculture, in engineering, in industry, or even in war, when our country is in danger. Not only must men be interested in such work in our universities, but, actually, when they are working shoulder to shoulder with basic scientists, there is mutual stimulation and benefit. We need have no fear, however, about the continuation of high-grade applied science in the universities. Everything, today, is making it easier and easier for universities to develop this type of science. The sales appeal is self-evident for the support of work which promises to yield a better artificial rubber, a method of keeping fats from becoming rancid, or a cure for some dread disease. But there is no appeal except the ardent interest of some scientist for the support of work which deals with the symbiotic relationship of termites and their intestinal protozoa, the reactions of a flat worm to light, the oxidation of pyruvic acid in minced pigeon breast muscle—to mention an infinitesimal few.

It may seem strange, on this day, to talk on the thesis that science in our universities is in danger, especially when unheard-of millions of dollars are being poured into it by the Government, industry, and private philanthropy, when our scientific departments are crowded with students, and when the American public is more science conscious than ever before in our history. It is basic science that is in danger, however, not applied science.

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The fact that basic science is in danger is of consequence to all of us, because universities and nonprofit research organizations, by their very nature, are its chief shepherds and custodians. In fact, in spite of many points in common, basic science and applied science thrive best under different conditions. Developmental or applied science can, to a large extent, be satisfactorily carried out and greatly accelerated by the organization of large teams of scientists and technicians under scientific directors. No clearer example of this is seen than the remarkable work done by the Office of Scientific Research and Development during the war. Just as surely as directed and organized research yields results in developmental work, it fails to yield equal results in basic fundamental research. This stems from the fact that the director and his staff know their ultimate goal in applied work and can make fairly good guesses as to what basic findings already known can be best applied. The basic scientist, to a greater extent, defines his goal in terms of interest and is largely dependent on lucky guesses (inspiration, if you like) and often just plain fumbling. For this reason, the basic scientist is much more of a lone wolf than the applied variety. His work cannot be directed, because he must be allowed to change his goal as he works and because his best ideas are unorthodox and are only too often known to be impractical by his famous colleagues who would be his most likely directors. It is the abstract, atypically brilliant individual, considered peculiar by the practical man, who most often provides the keystone to the arch of accumulated scientific evidence that makes possible the formulation of broad, often sweeping generalizations. An example of this is Einstein's formulation of the relationship of matter and energy in the deceptively simple equation, $E = mc^2$, which played such a great part in the study of the fission of the atom. Another example is the study of the food requirements of bacteria which led to the first rational theory of the action of chemotherapeutic drugs.

Several things are conspiring to jeopardize basic science in our universities. We lost ground because of the necessity of diverting the interest of our basic scientists to developmental work during the war. We lost a large part of one generation of young scientists through a not-too-enlightened policy of training during the war. Now we are rapidly losing many of our best basic scientists, especially the younger ones, because they are being enticed into industrial and government laboratories by high salaries and by equipment which is beyond the means of the universities. Although some will continue to do basic work in their new positions, all will be influenced to some degree by immediate or practical objectives, and most will become more and more interested in developmental aspects of science and will be completely removed from teaching.

Even the interests of our basic scientists who remain at the universities are being endangered by the large sums which are being poured into science. Lest I be misunderstood, let me say at once that I should be the last to question such generosity, especially during these times of increasing prices and decreasing income. Let us, however, face the dangers frankly. Most grants from commercial companies and frequently those from the Government are for applied fields. Some of these are absolutely necessary for applied fields which are legitimate for universities. These and others support a certain fraction of basic work. The question is: How far can the basic scientist accept such grants without losing his fundamental attitude? Will he recognize the insidious danger in time? Will he change his problem or interest to fit the terms of a proposed grant for applied work?

It is generally agreed today that, with the rapid disappearance of large fortunes and the continuing diminishing income from endowments, all of our universities and, in particular, our privately endowed universities must turn to the Government for support of their scientific research. In not a few cases, government officials have given grants for basic work with a minimum of direction and interference. Such grants are admirable, and the responsible officials are to be congratulated to the fullest. Inevitably, however, officials will be under continuous and, I expect, increasing pressure to pick fields and approve projects which are directly concerned with, or which they believe will help, applied subjects of special importance to their agencies. The officials will also be faced with the danger of orthodoxy. They will have to rely on boards of experts frequently composed of famous university scientists for the selection of projects. Such boards are generally conventional in their collective views and, hence, tend to frown on seemingly impractical ideas. This tendency will limit the number of really new types of research which are inestimably the most valuable.

The value of unorthodoxy and the disregard or ignorance of current scientific dogma is well illustrated by the remark of a former colleague that he liked to have young men in his department because they had such fool ideas. Most of these fool ideas, he went on to explain, were no good, but when one of them panned out, it was something that no well-trained man would ever have thought of.

We must find a way to support men and not projects. We must support the promising young men and the able mature scientists without regard to what they are doing. Some such method is necessary not only to let the scientist follow new leads as they appear, but also to keep the universities from financial ruin. The common practice at present, to pay only the direct costs of a project, is an increasing drain on our university finances because of the many hidden costs of research.

This problem has been recognized by some of the proponents of the National Science Foundation. Among other types of support, large unrestricted grants to the universities have been proposed for scientific work. None, however, has so far been made. If made, such grants would represent a wise evolution of government policy in supporting science.

While some departments of the Government and a few industries are alarmed at the situation, as indicated by the government grants just mentioned and a few similar ones from industry, all agencies should try harder to do something about it, if for no other reason than selfish interest. All must learn that they should support unrestricted, undirected basic science. It is probably too much to hope for, but if they were truly wise, they would support universities without regard to subject, because no science—and least of all basic science—can exist in a vacuum. In the first place, if the present trend continues, the Government and industry will not be able to obtain a supply of properly trained men, even for applied work. In the second place, really new technological developments stem largely from findings regarding the fundamental workings of nature which are not suspected to have practical value at the time of their discovery. No man can guess what knowledge will be practically applied next. How many men, for example, would have suspected that the discovery by Alexander Fleming of the fact that the mold, *Penicillium,* is antagonistic to certain bacteria would lead to the practical drug which we now know as penicillin? Who could have predicted that Clerk Maxwell's work in 1865 and 1873 on the propagation of electric action through space and the experimental and mathematical work of Heinrich Hertz in 1888 and 1889 on the electromagnetic effects of rapid electric oscillations would eventually lead to modern radio? If we are going to have a backlog of fundamental findings sufficient to support various medical, agricultural, and technological developments, we must find a way to support countless investigations on the workings of nature that at the time seem to have no possibility of practical value. To put it another way, if we support only work which the wisest men believe promises practical application, we shall miss, almost by definition, new and revolutionary discoveries. From the very nature of things, most of this basic work will have to be done in universities and other nonprofit organizations.

One can say with a great deal of truth that the situation I have described results from the fact that our universities and nonprofit research organizations are plagued by decreasing incomes and increasing costs. In part, however, they are plagued by a lack of understanding of the nature of basic science and by confusing it with applied science. Ask the average government or business executive, not to say many university administrators, what country has led in basic science, and he will generally answer: "The United States." Nothing could be farther from the truth. Having been a pioneer country until only recently, the United States has emphasized the practical and applied aspects of science and, with certain very notable exceptions, has relied upon Europe for discoveries in basic science. In thus not differentiating between the two varieties of science, applied work is naturally lauded because it promises greater immediate returns. The shortsightedness of this attitude lies in the fact, as mentioned before, that basic science is the spring—the source—of applied science. Fortunately, throughout its history, the United States has produced a few outstanding basic scientists, and, in recent years, this few has grown to amazing proportions. We have thus proved that we can lead. If we are going to continue to lead, we must divert resources to fundamental science to a much greater extent than we have in the past or are doing now.

Our government officials and especially our business executives can learn a great deal from our great medical leaders. Medicine is, and should be, first of all a profession dedicated to the application of science to the prevention and alleviation of human disease. A large proportion of its rank and file understandably looks down on any basic science that cannot be justified by practical application to medicine and public health. Its top leaders, however, recognize that the profession cannot really advance without a firm foundation in basic science. They not only insist on basic science as a preparation for medicine, but approve its forming a large part of the professional curriculum leading to the M.D. degree. They support basic science only tenuously connected with medicine. They recognize the fact that the really new clinical applications are just as likely to come from basic science entirely unrelated to medicine as from medicine itself. This is illustrated by the development of such new antibiotics as streptomycin from what would originally have been termed agricultural bacteriology. Finally, some of our great basic biologists are recruited from routinely trained medical men.

Here at the University of Chicago basic biology and the Medical School have been combined into the Division of Biological Sciences. I have always believed, and we are fast demonstrating, that this combination gives the greatest opportunity to build mutual respect between the basic biologist and clinician, to infiltrate medicine with basic science, and to reap the benefits of the mutual stimulation of basic and applied science.

The dangers I have referred to are real and concern all those interested in universities. The damage probably will not go as far as feared by one of my colleagues, who remarked that, if the present trend keeps up, our scientific faculties will eventually consist of the overaged, the incompetent, and a few fanatics who prefer the academic atmosphere, no matter what the cost. Yet it is true that basic science has always had to depend a great deal on fanatics or "queer ducks," and I am sure it will continue to do so. To those who belong to this peculiar group and who are willing to continue in university work, there are compensations for the flesh pots of his life payable in the joy of teaching, in the advantage of close contact with scholars in other disciplines, and in real freedom and independence in intellectual pursuits. These benefits of academic life mitigate the lack of great material rewards. They are sufficiently satisfying, provided the disparity in the material reward of the basic and applied scientist is not too great. It is up to the various interested parties to see that the present unjust difference is lessened in order that one of the important reasons for the present grave situation may be corrected. The difference should, however, not be entirely eliminated, because too great an emphasis on material rewards would result in recruiting to the universities men who are lacking the missionary spirit and the burning interest in understanding nature that are so necessary for basic research.

Royal Society Scientific Information Conference

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WHILE THE WAR WAS STILL IN ITS DARK PHASE, in 1941, Dr. Alexander King, then of the Ministry of Supply and now of the Central Scientific Secretariat, and Mr. Neville Wright, then of the New Zealand Office in London, approached the secretaries of the Royal Society to propose an Empire Scientific Conference. After three years of study it was decided that an Empire Scientific Conference should be convened as soon as possible after the war. The Conference was finally set for 1946 and was planned in two parts: a Royal Society Empire Scientific Conference, followed by a British Commonwealth Official Scientific Conference.

During the course of these conferences it became evident that scientific information services are a matter of first importance to the development of science, and it was therefore recommended by the Empire Scientific Conference that the Royal Society convene a conference of libraries, societies, and institutions responsible for publishing, abstracting, and information services in order to examine the possibility of improvement in existing methods of collection, indexing, and distribution of scientific literature. The British Commonwealth Official Scientific Conference endorsed this proposal and adopted the following resolution:

> The Conference endorses the general recommendation of the Royal Society's Conference but desires to record its opinion that such a discussion should be regarded as preliminary to a wider Conference, invitations to which should be extended to the U.S.A. as well as to the operating agencies of the United Nations which are concerned with the subject.

The Royal Society, in accepting responsibility for arrangement of the Scientific Information Conference, provided that it ". . . will be limited by considering the subject only from the point of view of use and service to the scientific community. . . ." This Conference was held in London from June 21 to July 2, 1948.

Planning the Conference

Preparatory work divided subjects before the Conference into four sections: (1) publication and distribution of papers reporting original work, (2) abstracting services, (3) indexing and other library services, and (4) reviews and annual reports.

Planning of the meeting, extending over more than 6 months, resulted in the preparation of 46 papers dealing with various aspects of the work of the Conference and in the statement of more than 100 problems relating to scientific communication, for consideration by the Conference.

While substantially all of the subjects considered have been discussed over the years by scholars and by librarians, the distinguishing features of this Conference were: (1) that, as noted above, subjects were to be considered only from the point of view of use and service to science; (2) that the scientific

[1] Representative of the U. S. Government at the Conference on behalf of the Department of State and its London Scientific Mission.