SCIENCE AND LIBERAL EDUCATION

Science can no longer be dismissed as "purely technical" or "merely vocational." It has an essential role to play in a liberal education—along with human liberalism and practical technology.

by L. A. DuBRIDGE

ABOUT A CENTURY AGO the introduction into the curricula of the American universities of courses in the field of science met with powerful and bitter opposition. It was revealing that the opposition was intensified when laboratory work by the student was inaugurated in these courses. It will be necessary to examine the reasons—as we see them today—for this opposition. For to some extent the opposition still exists.

For the American university to resent the intrusion of science was rather surprising in view of the fact that modern science was created largely in the halls of the universities of Europe. In the universities of Italy and later of France and still later of England the foundations of modern science were laid in the 17th, 18th and 19th centuries.

The early American universities, however, were not established as communities of scholars as had been many of the European predecessors. They were, in fact, often more of the nature of vocational schools, schools for the training of preachers and teachers in the pioneer communities. Later, as these communities developed, the lawyer, the public servant, and finally, the "gentleman and scholar" received their education in Greek, mathematics, philosophy, history and jurisprudence at these same colleges.

The seething intellectual ferment going on in Europe, represented by such names as Newton, Boyle, Pascal, Harvey, Lavoisier, Faraday, Maxwell, Pasteur, Darwin, hardly touched these colleges at all. Indeed, except for a few conspicuous exceptions like Benjamin Franklin and Joseph Henry (who were not in any college or university), this ferment hardly reached the shores of this continent at all.

The results of these new achievements in science, however, did eventually have their effects here. These new discoveries gave rise to new technologies and these new technologies found fertile ground in a nation whose people were developing a virgin continent. The steam engine ushered in a mechanical era and, stimulated by the needs of a frontier area, a host of brilliant American inventors were in the 19th century introducing devices and techniques which revolutionized agriculture and transportation and laid the basis of modern American industry.

But where was American industry to find the technologists (or engineers as we now call them) to carry on the task of building factories and railroads and canals and bridges and mines?

Not in the 19th century American colleges! Why? Here, indeed, is a curious paradox. The American college, though originally a vocational school, had now become the home of the gentleman and scholar and the college rejected science and technology (not distinguishing between the two) because they were too vocational! Noisy, dirty machines and smelly chemicals clearly had no place in a temple of classical learning! It was inevitable then that the first schools of technology had to grow up as separate institutions. Rensselaer Polytechnic, and later M.I.T. and others, came into being in response to this demand which the older colleges refused to meet. After the passage of the Morrill Act the state colleges of agriculture and applied arts were created. And as a direct result of all these new institutions, American technology grew by leaps and bounds and was soon in a position to lead the world.

Now possibly it was proper and desirable that centers

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of technological training should have not found their first homes within the American college or university. At least it was probably a good thing for technology that these institutes were separately established.

However, the sad part of the story was that basic science, on which technology is based, became tarred with the brush of prejudice against technology, and so science, too, found few friends in university halls. And this was tragic for all concerned. While the most exciting intellectual adventures in human history were taking place in the universities of Europe, American intellectual centers were but vaguely aware of what was taking place. A strong stimulus to strengthening the dynamic, intellectual quality of American institutions of higher education was thus rejected.

Furthermore, technology could not long continue its advance without new advances in science. As long as these advances were coming from the universities of Europe only a few people were worried. But if the exclusion of science from the American University had lasted another dozen years or so American scientific centers would have been unprepared to carry on when World War II put European centers so completely out of action.

The dawn of the 20th century then found the American university a pretty pale reflection of the European centers where the revolutionary discoveries in basic science were being made that have transformed both science and technology in the past 50 years. Neither the American universities nor the technological institutes had yet entered this exciting new realm of intellectual endeavor.

Science without technology

On the other hand, during the 19th century in Europe, and particularly in England, a curiously reversed situation had arisen. There science *was* a respectable field of inquiry for the human mind. New discoveries in astronomy, theoretical mechanics, thermodynamics, molecular chemistry, the theory of evolution, and later in atomic physics, were shaking intellectual foundations, were creating a new philosophy, a new kind of civilization. It was all a part of an intellectual adventure of the highest order. But the British university apparently failed to realize that these new discoveries were resulting in practical applications—that they had initiated the industrial revolution. Hence, the British failed to establish schools of applied science and technology. And to this day, Britain suffers from the fact that she still has no really first-rate institutes of technology. One might say that England developed the world's best physicists and the world's worst mechanical engineers.

In other words, in England science was regarded as too pure to be dirtied by practical technological applications. And at the same time in America science was so thoroughly tarred with the brush of vocationalism that it never occurred to anyone that any part of it could be pure and respectable.

It was in Germany that a reasonable balance was finally found. Pure and applied science each had a place in the university system—and the two must be and could be closely tied together. The successes which resulted from developing both were astounding. Germany by 1914 was not only taking the lead in progress in basic science but was also leading the world technologically.

Sadly enough this success went to her head. Soon Germany was apparently asserting the inherent superiority of the German mind. Science and technology provided the answers to *all* human questions. Cold intellectualism was enthroned as a new god, and considerations of simple moral principles were forgotten.

Where then does reason lie? Is there any hope that warm human liberalism and cold intellectualism can come together and live side by side? Is there a way in which understanding the facts of nature and also of human nature can both be thought of as essential and respectable intellectual pursuits, and both be regarded as necessary not only in preparing men for living but also in preparing them to make a living?

The essential elements

The solution which the colleges and universities of America have reached has been achieved by combining three essential elements. The German universities seized upon science as a supremely challenging field of intellectual endeavor and recognized, too, the importance of its practical applications. But they forgot that a nation or a university which neglected human beings would inevitably ride to a fall. In Britain the human being was not forgotten—indeed, he reigned supreme. And when human beings sought to use their intellectual powers to understand their environment and their own physical bodies they were recognized as being embarked on a worth-while human endeavor. But the practical task of putting the new knowledge to use for the benefit of man was neglected. In America before 1900 practical technology was reaching heights undreamed of—in some places. And in other places the humanistic studies reigned supreme. But the gap between remained unfilled. The study of nature was regarded solely as a practical matter of building new devices and new machines—not as a bold human adventure in understanding.

But today the gap is at least partly bridged. For the first time in history an educational platform rests upon three legs instead of two. Human liberalism, scientific inquiry and practical technology have all found their places. Our educational system is shedding its narrow vocationalism on the one hand, its intellectual snobbery on the other. Furthermore, our universities have moved toward the goal of being not only centers for the dissemination of knowledge but also for its achievement. They are communities of scholars, not merely collections of teachers. As a community of scholars they will neither ignore nor suppress the advancement of knowledge in any field. But neither will they refuse to recognize that knowledge may be useful and that it is worth while

to help young men and women learn how to use it.

It is now recognized that professional education, whether it be for law, the ministry, medicine, science or engineering, need not be "mere vocationalism," providing two conditions are met: first, the professional education must be built on a broad basis of a general liberal education; second, it should emphasize the essential intellectual content of the field rather than the routine skills, techniques and practices. I think you will agree that the history of professional education in this country during the past quarter century has been the story of striving toward these two objectives. The leading professional schools have, in fact, consciously or unconsciously, adopted the point of view outlined by Oliver Wendell Holmes when he said, ". . . . if a man is a specialist it is most desirable that he should also be civilized; that he should have laid in the outline of the other sciences, as well as the light and shade of his own; that he should be reasonable, and see things in their proportion. Nay, more, that he should be passionate as well as reasonable, that he should be able not only to explain, but to feel; that the ardors of intellectual pursuit should be relieved by the charm of art, should be succeeded by the joy of life and become an end in itself."

Thus the goals of professional education have now encompassed those of a liberal education and the conflict between them is being made to vanish.

But it is my thesis today that science (not technology) has a place in a liberal education, whether or not this is in preparation for a later or concurrent vocational education. After all, what is a "liberal education"—what is the liberal tradition in education? Everyone has his own definition, but the word liberal can hardly be disassociated from the concept of liberation—the act of freeing. Liberal education then should be education which frees men's minds; frees them from the chains of ignorance, superstition and fear; frees them from the atrophy which comes from lack of being used; frees them to be of use. A man with a free mind is simply a man prepared to act intelligently.

What then must one do to prepare a man to act intelligently in the world in which he finds himself? Aside from certain elementary skills which should be acquired in early years, a college graduate should have acquired a certain degree of knowledge and understanding of things—a type of knowledge and understanding which can be acquired only if at the same time he has learned to *think*.

Knowledge and understanding about *what* things? Very briefly, I suggest that the intelligent man should know about three things: (1) about himself, (2) about the physical world in which he lives, and (3) about his relations to the other human beings who inhabit that world. These, of course, are short titles for big subjects. In fact, I can't think of any recognized intellectual discipline that is not concerned with at least one piece of one or more of these three subjects.

If we accept these three subjects as essential goals of the educational process, the place of science is already clear. For the story of science is nothing but the story of man's attempts to understand himself as a physical being and to understand the physical world around him. The humanities and social sciences have to do with man as an intellectual and spiritual being and his relations to other men. To leave out the subject matter of science, therefore, is to leave out a substantial part of the picture.

But aside from the fact that the subject matter of science is a vast and important part of all knowledge, there is still a deeper reason for it to command our attention. That has to do with the method and spirit of science.

Science and common sense

It was a matter of great good fortune that during the period when I was preparing these remarks there appeared from the press the book, *Science and Common Sense*, by James B. Conant. For those interested in a straightforward discussion of the methods of science I can suggest no more profitable or enjoyable experience than reading this volume. And in what follows I shall borrow heavily from Dr. Conant's analysis.

To the nonscientific layman the field of science often appears as a cold and complex collection of slide rules and microscopes, elaborate glassware, machinery and mathematical equations, tables of data, cold uninteresting facts. Unfortunately, many scientists have themselves contributed to the spreading of this view of their field by emphasizing exclusively just these things—portraying the scientist as a cold fish, oblivious to all but his instruments and his notebooks.

Dr. Conant, however, presents a different view of the world of science. He introduces us to the very real and intensely human men and women whose efforts have built and are building the structure of science. He presents the human mind at work—complete with its flashes of genius as well as its stupidities and prejudices. He presents the story of science as the story of the struggle of the human mind to build a conceptual framework which helps to "make sense" of the many things which we observe in the physical world. The essential feature of any area of science is not the collection of observations, the tables of data, no matter how elaborate or elaborately systemized or classified the observations may be. The essential thing which converts a collection of observations into a science is a conceptual framework, a system of theories if you wish, which ties these observations all together, which interprets them and—most important of all—predicts the results of new observations.

The fact that such conceptual frameworks can be built at all is one of the great achievements of the human intellect. And it is one of the great hopes of the human race that such frameworks can encompass not only the field of the physical and a portion of the biological sciences, but also, eventually, all of natural science and what we now call social science. Clearly an understand-

ing and appreciation of this intellectual process must be an essential feature of the equipment of every educated man. Surely a liberal education—an education that frees the mind—should impart some understanding of how the human mind has already freed itself in many areas from ignorance and superstition and fear.

Why is it that there has been too little acceptance of this attitude of regarding science as an expression of the free mind rather than as a mere "technical subject"? I fear that much of the blame must fall on the scientists and science teachers themselves. Too often have we emphasized the facts of science to the exclusion of its methods and its spirit. Too often have we treated science as the routine collection of data rather than as an imaginative adventure of the human spirit. The professional scientist, of course, takes this adventure for granted but too often fails to impart it to his students, or even tries to hide it behind a cloak of cold objectivity. But cold objectivity is not enough. It is not enough to advance science. Still more it is not enough to insure the preservation of the conditions which make science possible.

I do not say that cold objectivity has no place in science. Unbiased examination of facts has an important place in all fields of thought. But objectivity is a method, not a motive. What motivates a scientist? What causes him to spend days and nights in the laboratory, seeking new facts, puzzling over their meaning? Some scientists, of course, are motivated by the hope of practical applications of their work, some by ambitions for personal glory. But basically the motive of the great scientist has been aesthetic rather than practical. A successful theory or concept has a beauty and an elegance that appeals to the scientist in the same way that a great painting or poem appeals to those who love art or literature.

The beauty of science

The beauty of science is a subtle one and is fully revealed only to the men and women who have toiled long and lovingly in the pursuit of science. And rare is he who can convey a sense of this beauty to his students in elementary physics. But some teachers do, and more should try. For the student who has come to understand the method and spirit of science and who has come to recognize little of its beauty has had a rich experience—he will, indeed, have had a liberal education.

A liberal education—the education of free minds—is a subject which has unusual poignance for us in America in the year 1951. Clearly a free mind can exist only in a free human being. There would be little use in providing a liberal education to men who are not to be free to think and to act for themselves. Conversely, men will not long retain such freedom unless they learn to use it and to value it.

The world today is split into two hostile armed camps. What is the issue on which these two camps are divided? Essentially it is the moral issue of whether individual human beings are endowed with an inherent, that is a divine right, to life, to liberty and to the pursuit of happiness. The rulers of one portion of the world deny these rights—except in so far as they, the rulers, see fit to confer them. The peoples of the western world assert that these rights are God-given and hence inviolate. Essentially the contest we face today is the one our own nation faced in 1861; a contest to determine (to paraphrase Abraham Lincoln) whether the world can exist half slave and half free.

Some of the particular issues which divide the Communist world from the western world have been subjected to blurring by Communist propaganda and by frequent and sudden shifts of Communist policy. But on the issue of intellectual freedom there has never been any doubt. A Communist must believe what the Party tells him to believe. By almost daily edict and action this point is made abundantly clear. Deviationism is among the most heinous of crimes.

There were many who believed for some time that this requirement of intellectual conformity would actually be imposed by Communists only in the area of politics and economics. But within recent years it has become clear that it is to extend to every field—including the field of science. In the field of genetics the purge of those who held to the "reactionary" theories of Mendel and Thomas Hunt Morgan was apparently completed a year or two ago. During the past year the attack on "reactionary" physics has been mounting and one of the greatest of Russian physicists has recently ignominiously admitted his past errors, has recanted and promised in the future to espouse only the Physics consistent with Communism—whatever that is.

Now I am not one who would assert that anything the Communists don't like is something we should embrace—even though it seems to be a rule with but few exceptions. I do not base a justification of the study of science on the ground that it is something which the Communists think is dangerous. Nevertheless, the Communist attitude does illustrate a fact of deep importance—namely, that the spirit of science and the spirit of freedom are one and the same. Science has developed only in those areas and in those periods when and where men's minds were free. The development of science has at once been the highest expression of that freedom and a strong bulwark to support and extend it.

My thesis is thus a simple one: science has an essential role to play in a liberal education—or can have if science teachers will understand this role. Science can no longer be dismissed as being "purely technical" merely because some of its laws are reasonably exact, and hence can be stated in mathematical form. It cannot be dismissed as "merely vocational" simply because parts of it are useful. Science is the study of some of mankind's greatest intellectual achievements. The method of science is one important method by which the human mind may grapple with the problems that face it. Finally, the spirit of science, like the spirit of true liberalism, is the spirit of freedom.