Ewing Galloway

SCIENCE EDUCATION IN THE UNITED STATES

by F. A. Philbrick

A traveler to our shores (who remained here after his second visit) reported on science education in the United States to the land of his birth. Physics Today reprints his article, first published in the English quarterly Endeavour, as a communication which was, perhaps, meant to be overheard here.

Many writers have noted that pragmatism is the chief trait of the American character, whether this is to be attributed to the cast of mind common in emigrants to the New World, or to the conditions of life that they found and developed there. And just as pragmatism has been the dominating philosophy taught in the universities, so in pedagogy has everything been subordinated to immediate and practical ends. In America, the battle for the inclusion of science in the curriculum was easily won. Money for laboratories has been generously provided—it has always been more readily available for buildings than for the men who teach in them—and the visible successes of modern science have given it enormous prestige as an academic subject. So greatly envied is the position of the scientist in the universities that his colleagues in other departments are tempted to describe their own subjects as sciences and themselves as scientists. Thus a historian who emigrates to America may find that he has become a *social scientist,* and in a recent book a psychologist goes so far as to say, "Scientists study and write about people and the world in which they live"—a definition which seems to include all possible topics.

There are two ways of teaching physical science. One of them begins from the data, either those that were thought significant by early workers (the historical method) or those that are relevant today, and by induction derives the laws of nature. The other begins with the laws, and explains the data as deductions from them or as examples of their application. Whereas the inductive method aims at developing the mind of the student by helping him to organize the data, the deductive method presents him with the data already organized. This second method is universally followed in the United States, whose schools were scarcely touched by the heuristic movement that began in England half a century ago. Thus in an American chemistry course the laws of chemical combination may be presented as deductions from the atomic theory, and such a difficult point as the diatomicity of hydrogen molecules appears as an unaccountable act of intuition.

It is true that there are doubters. Jacques Barzun, in his brilliant and iconoclastic Teacher in America (Little, Brown, and Company, Boston, 1945), has a chapter on The Ivory Lab in which he says that science is the worst taught of all subjects. In advocating the historical method of teaching, he claims that the education of students as men and citizens is sacrificed in the colleges to vocational training, and that current methods have produced among the teachers themselves "many highly trained and absolutely uneducated practitioners." In his Terry Lectures (published by the Yale University Press in 1947 as On Understanding Science), President Conant of Harvard, possibly the most influential scientist in America, likewise appeals to teachers of science for a new attitude to their subject deriving from some understanding of its history.

These, however, are exceptional views, and the character of American scientific achievement is a consequence of the pragmatic conception of scientific education. The unrivalled successes in technology, and the relatively unimportant contributions to fundamental knowledge, are consequences of the nature of American teaching. Geoffrey Gorer, whose book The American People (W. W. Norton and Company, New York, 1948) is the most penetrating study since de Tocqueville, is excellent on American science. He points out that basic inventions, whether radar, penicillin, or jet propulsion, are usually foreign, but that improvement, industrial adaptation, and above all diffusion are carried out in America with unique success. "Make a better mousetrap, and the world will beat a path to your door." It is improvement that is recommended, not novelty. "Their attitude towards things," writes Gorer of the Americans, "is untroubled by ambiguity, serene and confident, audacious and creative to an extent that no other society in the world has seen or imagined. . . . This ingenuity in the exploitation of things has, fairly recently, been given a special term —'know-how'; it is rightly considered peculiarly American." The admiration accorded to science has in some degree protected science teaching from the encroachments of the athletic coach, the great enemy

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of education in America—before whom even college presidents are dumb. To the alumni the new laboratory block may be scarcely less an object of pride and interest than the stadium.

Two important pedagogical devices are used in America in presenting to untrained minds the complicated systems of the sciences. The first is a thorough correlation of the discussion with the experience of the student. Any European glancing through an American textbook of elementary science is impressed with the variety of illustrations designed to hold the interest of the reader, and by the pains taken in the text to connect the unfamiliar with the known. If the author is unskilful the device may lead to mere descriptive chitchat, but it is unusual to find an American text in which pedantry or a too rigorously mathematical treatment has kept the exposition above the levels of attention or understanding that can be expected of the reader. The present American eminence in thermodynamics, though perhaps partly derived from the great example of Willard Gibbs, may probably be attributed to the excellence of American textbooks on the subject, which never let the reader forget that this branch of science deals with the real world.

The second pedagogical device is the division of the subject into parts of manageable size. This plan is likewise much in the minds of authors of textbooks, and one may find a discussion of, say, respiration headed in bold type UNIT 17. To gain a rapid mastery of a topic it is undoubtedly wise to study one part of it at a time, and to finish that before going on to the rest, though by this method there may be some loss in total grasp. The efficiency of the method was demonstrated during the war by the success of the service courses which trained men to operate and maintain complicated scientific apparatus. It was perhaps inspired by another typically American technological improvement, mass production, in which a manufacturing process is divided into separate operations that can be performed on an assembly line.

The fragmentation of the subject matter of science in American teaching is encouraged by the institutions of the *course* and the *credit*, and by the objective examinations now in vogue. A student takes a number of courses, for instance Botany 1 or Qualitative Analysis, each lasting a year. When he has successfully completed the course he gets a credit for it, and when he has enough credits he graduates and receives his diploma. Once a particular course has been passed, a student need expect no further examination in its subject matter, for comprehensive examinations in the whole of some branch of science are, if not unknown in the United States, at least uncommon. It is not surprising, therefore, that the essay type examination, which tests the candidate's ability to correlate his knowledge of the different parts of a subject, has now been almost displaced by the objective test, consisting of a large number of separate questions often little related to each other.

The undoubted American talent for teamwork and organization relieves a teacher of science of much work that in Britain he would expect to do for himself. In America the duties of a junior instructor may be confined to explaining the textbook, supervising the laboratory work described in the manual, and correcting the objective examinations sent to him in bundles once or twice a month by the head of the department. The class work follows the order laid down in the textbook, which is begun by the teacher and the class on the first page and faithfully followed to the last, each division of the book being completed by all the classes on the same day. In large institutions the textbook, written by the teachers, often circulates for years in an edition produced by photography from the typescript and frequently revised until it is ready for printing and public sale. The system allows little initiative to the teacher and departmental control is often strict. Instruction under these conditions, though usually efficient, is not stimulating either to teacher or to students, and the more enterprising teachers, if they cannot rise to positions where they have control over their courses, either take administrative work or go into research.

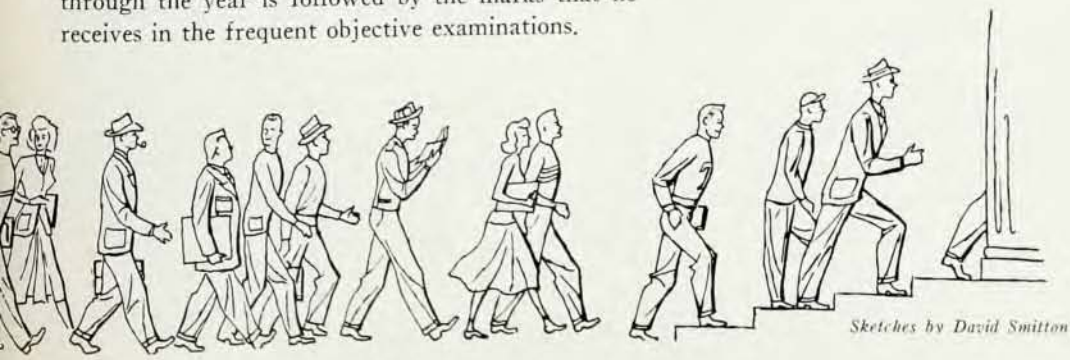
The institutions in which these ideas are put into

practice range from the grade schools, through high schools and colleges, to the graduate and professional schools of the universities. The entire population attends at the lowest level, but only a small fraction of it at the highest. Great efforts are made to ensure that the selection for higher training is intellectual as well as financial. In science, for instance, the Westinghouse Corporation conducts an annual search of the high schools to make sure that the boys and girls of greatest promise are sent to college. The early specialization usual in England is deplored by American teachers, and in high school it is most uncommon for any branch of science to be studied for more than two years, one-year courses in physics, chemistry, or biology being almost universal, and astonishingly uniform throughout the country in content and treatment.

The peculiarly American problem of higher education is, however, the presence in the colleges of great numbers of students little suited by taste or training for the academic life. Inspired by a generous desire to make higher education as nearly universal as it can be, the colleges long ago opened their gates to almost everyone who could pay the fees, and the prosperity of the country has multiplied the number of students. Most American private schools send nearly a hundred percent of their alumni to college. The state universities, almost entirely maintained by state funds, and hence exposed to political pressures, are in positions of special weakness against the invasion of the incompetent. The hard discipline of the sciences, however, has little to attract triflers, so that the departments of science suffer less than most from standards depressed by excessive numbers of mediocre students. But the methods of instruction have had to be adapted to them. The lecture demonstrations, often given by the professor in charge of the course, may be attended by as many as two hundred, and the rest of the teaching is done in the laboratory and in small discussion groups conducted by junior teachers. Attendance at all these is obligatory for every student taking the course, and his progress through the year is followed by the marks that he receives in the frequent objective examinations.

In some colleges specially devoted to science the quality of the work is considerably higher than elsewhere. Chief among these are the Massachusetts Institute of Technology and the California Institute of Technology, with its remarkable list of Nobel prizewinners from the faculty. These two colleges have high standards of admission, and every June the great industrial corporations are in eager competition for the services of their fortunate graduates. Only a few of the less specialized universities, Harvard among them, are able to offer scientific courses of this quality to undergraduates. If, however, the scientific education of undergraduates in most American colleges is admirable chiefly for the efficiency with which large numbers of indifferent students are given elementary instruction, many of the graduate schools are as good as can be found anywhere. The difficulties that at present beset the academic life in other countries have brought to America brilliant teachers and students from overseas, and a young graduate wishing to do research in the United States is unlucky if he cannot find at least one American university where he can work in perfect conditions and under a scientist of world reputation.

In this brief article only the outline has been traced of scientific education in America. It is impossible to give a fair description either of the great medical schools, or of such unique foundations as the Institute for Advanced Study at Princeton, directed by Robert Oppenheimer and with Albert Einstein on the faculty, or of the extraordinary Museum of Science and Industry at Chicago. After investigating such spectacular exhibits as a full-size working coal mine, a visitor to this museum can witness a demonstration of sensitive apparatus such as the Michelson interferometer. This museum should be seen by all scientific visitors to the United States, who will find here and elsewhere that the traditions of American hospitality are fully shared by her scientists, and that libraries and laboratories are gladly thrown open to scientists from abroad.



Sketches by David Smitton