THE HISTORY OF SCIENCE IN MODERN EDUCATION*

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FORTY years ago, or more, students of the natural sciences formed a comparatively small part of the student population of universities of Britain; to-day a very different picture is presented. Men and women studying science, medicine, engineering, technology and agriculture are in the majority; students of the arts faculties form only about 43 per cent of the total number of undergraduates. This means that a very large number of people with the best potential intellectual capacity devote themselves each year to scientific or technological studies. Many of them should become leaders in thought and culture; they should play a leading part in society and in politics, and they will have to help in guiding Britain in the difficult times ahead.

A few years ago the University Grants Committee said in one of its reports, "A University would, in our view, fail of its essential purpose if it did not, by some means or other, contrive to combine its vocational functions with the provision of a broad humanistic culture and a suitably tough intellectual discipline". It seems to me to be a matter of considerable national importance that science students should be given that humanistic culture so that they may become effective and enlightened citizens in the days to come.

Many of those who are in close touch with students are becoming increasingly uneasy about the results of modern specialization, especially in science. Does the study of natural science in our universities include any real education which will help pupils to understand their fellow men? Does it train them to form sound judgments about the things of everyday life? Does it help them to live more happily in society?

Present-day science students have been specialists since the age of sixteen or earlier: they have a very limited knowledge of the world and of the behaviour of man, derived mainly from newspapers and the cinema screen: they know little real history, and are scarcely sensible of their debt to the past. Too often the student has a poor understanding of the meaning of words and of the implications which words can convey; hence he is unable to appreciate poetry and good prose. He is quite at home with formulæ and equations—the shorthand of science—but is seldom able to write fluent unabbreviated prose and to express his thoughts in a way that is easily intelligible to others. Even his ability to think logically and to understand the philosophical foundations of his own studies is often weak.

But we must not blame our students for these cultural deficiencies. They all must work extremely hard in endeavouring to learn and remember the vast body of information which is now presented to them, and which they are expected to understand and remember. Every branch of science has progressed enormously during the past fifty years, and the schoolboy of to-day is taught about subjects which, in my time as an undergraduate, were recent discoveries on the confines of knowledge. Moreover, while the field of study has been steadily increasing, very little of the older material has been omitted. Our universities seem to take little heed of the fact that the load placed on the science students is becoming, or has become, unbearable, and that this in its turn means a demand for more intensive study at school.

The training now given to students of the natural sciences is generally planned, consciously or unconsciously, with a view to the production of professional scientists who will spend their lives at research or teaching. But in fact a considerable number of people do not reach the necessary standard and have to look for other posts. Many men and women in this class have undoubted ability; they might become good administrators, works managers, journalists or business men, if their training were broader and less specialized. While the training of students is so detached from human affairs, they are seldom able or willing to embark on a career outside the limits of their own special subjects. For the same reason they are often unsuited to become really effective teachers in schools. The provision of some broad humanistic culture for the majority of university students is thus of importance both to the individual and to the community as a whole.

We must consider what can be done to remedy the situation which I have outlined. What modifications can be introduced into the teaching in the universities and schools to give the science students a broader intellectual training? One suggested remedy is the postponement of specialization until the pupils' minds are more mature, and the continuation of a study of a wide range of subjects up to or after entry into a university. I do not think this is a satisfactory solution of the problem. Some specialized study at school is valuable, even for those who will not go to a university; it can bring a wonderful zest into the intellectual life of many students. It is also necessary for those who look forward to a career in science, or in other subjects, to have the opportunity of showing that they have the capacity to begin advanced education with good prospects of ultimate success. But when a boy or girl has decided to embark on a particular course of study, all intellectual work which does not seem to be directly connected with the chosen field is regarded as a waste of time. The same consideration applies to students at the university, where the first-year undergraduate finds much new work to interest him and occupy his attention. The best method is not to impose a compulsory study of subsidiary cultural subjects but to widen our science teaching, so that it not only imparts information about the phenomena of Nature but also deals with the humanistic aspect of natural knowledge. If we can lead students to appreciate the way in which man's concepts of Nature have been built up, telling them of past failures as well as of successes, and revealing the personal characters of some of those who have worked in the search for knowledge, we should make them better scientists and at the same time illustrate the social and human aspects of their studies. All this can be done by the institution of well-planned courses in the history of science.

In speaking of the history of science I do not mean a mere knowledge of the names and dates associated with discoveries that have stood the test of time. In the first place, I should draw no hard and fast line

* From the presidential address to the British Society for the History of Science, delivered on May 3.

between the history and the philosophy of science. Science is still in essentials 'natural philosophy', though the old name is now seldom used. The present-day search for the principles of things can scarcely be understood without reference to its history. Most young scientists need some philosophical training, and we have evidence at Cambridge that many of them find their introduction to philosophy most fascinating. This is an age when few specialists have had a philosophical training, and when non-specialists are unable to understand the language or details of many scientific subjects.

Some tentative suggestions may be made as to the kind of teaching which might lead to a broader humanistic outlook. First, we might hope that a general survey of the history of scientific effort would give the student some idea of his own position in the world by reference to the past. The story of the empirical quest for knowledge, extending far back before our era, should not be passed over lightly. The discovery of the methods of extracting metals, of curing hides, of making pottery and raising crops and stock, represent substantial scientific achievements by primitive peoples. Still more remarkable were the abilities shown by the ancient Egyptians in fashioning and using stone on a scale that has never since been equalled, as well as in the construction of buildings, i mechanical problems, in dyeing, weaving, wood and metal working.

A concise account of Greek thought and culture and of the civilization of the Hellenistic age seems essential. The world owes so much to the Greeks that one who is ignorant of the main facts about Greek civilization and thought can scarcely claim to be educated. Some teaching about the philosophers, scientists and medical men of classical times would provide a means of introducing students to the life and thought of the ancients, and of showing how mathematics, mechanics, astronomy, medicine and systematic scientific thought found their early expression.

The organization of society in Greece and Rome, which is so closely linked with early scientific progress, is a topic through which an outline of the political history of Europe can be approached. I do not suggest the study of more political history than is necessary as a background for the consideration of the progress of civilization and the movements of thought. Of course, at many points after the sixteenth century the history of science becomes much linked with political events, and can scarcely be understood without reference to them. But battles and treaties, the struggle of men for the domination of governments, and much of the detail usually taught in ordinary courses on history need little attention. The history of science is essentially the study of the growth of ideas. The successive views on the nature of things, both living and non-living, should be followed. The factors which led to the formulation of these views should be examined, and especially the relation between experiments or observations and the opinions current at the time when these were made.

Some historians of science pay little attention to the erroneous hypotheses widely held at certain periods. But for the more mature students the study of theories like that of phlogiston or of the imponderable fluids may, I think, be very instructive. I often wonder what I should have thought about phlogiston had I been living at the end of the eighteenth century.

Of the general educational value of history there can be no doubt. The modern biological study of organisms in Nature shows clearly how present-day populations owe their existence to events and changes in the past. Scientific thinking should make us more and more conscious of the fact that we cannot understand man, his societies and his social systems without reference to history. Most boys and girls are taught some English history at school; but it seldom includes enough social history or references to changes in thought and technical skill. Some knowledge of the past and of the ways in which men have acted under different situations is also, I think, of the greatest value to all of us to-day when we have to face the complex problems that arise in both public and private affairs.

This reflexion leads to a consideration of what is probably the greatest deficiency in the education of the young scientist. How much does he know of human beings, their motives and desires, their hopes and fears, their affections and hates? Students of the classics, of literature, history and law become well aware of the complex nature of human personality and of its wide variety; but the scientist often seems to think that all men in the world have minds that work like his own. He does not realize the power of the more primitive human instincts, of racial and social background, and of early training. He is thus surprised or disappointed when other people do not act in the way in which he thinks they should behave. Some people appear to regard men as they would substances or organisms in an experiment, where an alteration of environmental conditions is expected to produce a predictable response. Human beings, however, seldom react in that way.

We may not be able to give our students very much insight into human personality; but through the history of science we may, at least, make him aware of the different ways in which some people have thought and acted in the past. The story of the lives of well-known scientists provides a considerable fund of material from which the development of character and the influence of personality can be illustrated. I think that writers and teachers might well pay more attention to the selection of biographical details to bring out the character, good or bad, strong or weak, of the people they describe. We can find among our records plenty of interesting human stories, showing love and affection, jealousy and hate, perseverance in the face of adversity, triumph and tragedy.

An entirely different aspect of our problem concerns the training of the young scientist in the use of his native language. So much of his written work is done in the form of tables and diagrams, graphs and formulæ, and so little in the form of connected prose, that one hears constant complaints about the inability of the young graduate to express his thoughts in a way that is readily intelligible to others. It may be that similar criticism may be made of the abilities of some arts students; but to-day, more than ever, the scientist should be able to express himself in language that can be generally understood.

While I do not think that a gulf exists between the scientists and the non-scientific public in Britain to-day, as is said to exist in the United States of America, there is considerable risk that one may develop in the future. Although we have some first-rate scientific journalists and broadcasters, there is also a tendency, not without foundation, to regard the scientist as the 'back-room boy' who knows little of the world around him. This may become more pronounced if our young scientists are unable to tell about their work and ideas in a way that the ordinary man can understand. To remedy this, I can only suggest that our pupils should be encouraged to read more books in good connected prose, like those on history and philosophy, together with some selected works by scientists well known for their prose style, and that they should be encouraged to try to imitate that style.

There is also much to be said for the study of some complete book or paper of outstanding importance, with special reference to the way in which the subject is presented, the evidence is brought forward, and the conclusion reached.

Many school and university teachers will have a short reply to what I have been saying. They will point out that young scientists have already more than enough to learn, and that they have no time to spare for the kind of instruction I have suggested. This, without doubt, is perfectly true at the present time; but the day must soon come when every British university is forced by the accumulation of knowledge to revise its science-teaching and to make radical changes. Those responsible must face the problem of whether teaching or education is to be the first consideration. When this revision comes I hope that it will enable science students to devote some time throughout their education to the history and philosophy of science, so that they may obtain a good measure of humanistic culture, and will not tend to become cut off from the intellectual interests of their fellow students.

This brings me to another aspect of my subject, the value of the history of science to those who are not science specialists. In the past, a knowledge of the phenomena of Nature was considered quite unnecessary in the education of those who would not become medical men or science specialists. For a long time the part played by the scientific revolution of the seventeenth century in altering the currents of man's thought and in improving his material environment was clear to those who cared to think about it. But it received little attention, and the practical results which followed and which led to great improvements in our health, food, housing, transport and communications were taken as matters of course. To-day, most educated people have suddenly awakened to the fact that the discoveries of science have brought about the most profound change in human affairs that the world has yet seen, at least since the discovery of metals. No longer can young people be brought up in complete ignorance of modern science. But this does not mean that they can or should be taught chemistry and physics to enable them to understand the process of atomic disintegration, or learn physiology and genetics for the explanation of blood transfusion. What I think is needed is a general picture of how man's knowledge of Nature has come about, and what have been the results of this knowledge. In several schools a successful attempt is being made to inform pupils, by teaching the history of science, of the ways in which discoveries have affected men's lives. The historical approach enables the more important contributions to knowledge to be linked into a connected story. At the same time, it enables many inventions and principles to be understood by reference to the way in which they have developed from simple beginnings. Thus the early experiments of Faraday on electromagnetic induction are not difficult to understand, and when these are known the principle of the modern dynamo can be explained. By this mode of study much can be done to show the way in which biological and medical knowledge has altered the lives of the people of the world, and, may I add, to direct attention to the unacknowledged debt of the inhabitants of Asia and Africa to the labours of European and American scientists. This study will also stress the importance in our lives of vaccination and inoculation, the dangers of bacterial and virus infection, and the value of hygiene. In these days when so many people are terrified by reports of atomic weapons, there is in some minds a feeling that the progress of discovery in the world of Nature is to be regretted; scientists are only regarded as the authors of horrible contrivances. How important it is to show the manifold ways in which everyone has benefited from the labours of the investigators of Nature.

INTERNATIONAL PEAT SYMPOSIUM 1954

THE first International Peat Symposium was held in Dublin during July 12–17 under the auspices of Bord na Mona—the statutory corporation set up in Ireland to develop the peat resources of that country. It was attended by more than two hundred delegates from nineteen countries, and sixty-nine papers by delegates from thirteen countries were discussed. Nations as far apart as the United States and Malaya were represented; but one large peat producer—the U.S.S.R.—was absent. However, its near neighbour, Finland, was well represented, as were the Scandinavian countries and Austria.

The reason for this widespread interest in peat varies. In Ireland it is its immediate use as a fuel, followed by the reclamation of the bog for agriculture and afforestation. Elsewhere it may be the conservation of native fuel for use in an emergency, or even the employment of evacuees. Whatever the reason, there is no doubt that interest in peat is more intense now than formerly. In the past it was stimulated by war-time conditions, when other fuels were difficult to obtain, and tended to flag in peacetime. At the present time, economic conditions are such that in some regions peat can compete with other fuels on a calorific basis, particularly when modern methods of production and utilization are used. This has led to more research and development, which in their turn have resulted in further improvements in methods and still greater incentives to use peat.

The scope of the conference covered a wide field, including the initial survey and classification of resources, the winning and preparation of the raw material, its utilization in all types and sizes of equipment and, finally, land reclamation.

It was noteworthy that at every stage the discussion was dominated by the same characteristic properties of the material, particularly the large weight and volume of raw material required to produce a given quantity of dry peat substance, its variable composition, and, above all, its high moisture content. Their importance was made strikingly apparent during a visit by the delegates to typical peat bogs and power plants to observe various methods of winning and utilizing peat.

This left the general impression of a long-drawn-out struggle against natural conditions requiring a