Science at the Universities*

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THE general growth in the teaching of science at secondary schools has naturally been accompanied by a great increase in the number of students of science at universities. There are now about 50,000 students in the universities of Great Britain, half of whom are studying some form of natural science. This growth has been made possible only by the provision of public money; all universities in Great Britain are now dependent on the taxpayer and ratepayer. The State alone provides annually for university education a sum nearly ten times as great as was provided before the War; and local government bodies, in addition to their direct contributions, find large sums for maintenance allowances to students. The student of science has to be provided with laboratories, where he consumes power, heat, light and expensive material. He is in consequence the most costly of university students: I estimate that the public expend, in one way or another, nearly £200 a year on each student of science, with the possible exception of students at Oxford and Cambridge, which are more richly endowed from private sources.

This public expenditure has laid additional responsibilities on the teaching and administrative staffs of universities. Most of us are now in the position of public trustees; we have to examine our expenditure more scrupulously than we should if we were not (indirectly) responsible to the public, and we have continually to ask ourselves whether additional expenditure can be justified.

There was a time when some universities were in the same happy position as the public schools. As self-supporting institutions they could go their own autocratic way, impervious to outside criticism. They took special measures to encourage the influx of students of outstanding ability; and as for the rest, the chief conditions of entry to a college were that they should be capable of paying highly for the privilege, and of passing a very elementary examination—often waived for men of noble birth or athletic renown.

The chief advantage of this complete independence was that it encouraged individuality in teachers and students; the chief disadvantage of the many reforms that have taken place since then, resulting finally in financial dependence, is that they tend to discourage individuality. Is any university school of physics or chemistry, for example, noticeably different from any other? In London we do our best to encourage indi-

viduality by having different final examinations for certain degrees in different colleges; at the Imperial College the B.Sc. degree of London is awarded on the results of college examinations in which outside examiners take part. The advantage of this is that it is not necessary to bring our syllabuses and methods of teaching exactly into line with those of other London colleges. There is, however, a strong, but fortunately not a majority, body of opinion in the University in favour of common examinations, chiefly on the grounds that they are easier and cheaper to organise. I hope it will be long before our measure of independence disappears. I would go so far as to say that individuality, which should be a natural growth in universities, needs to be deliberately encouraged in these days of committee rule. Any step taken to discourage it is a step downwards.

Oxford and Cambridge still have considerable freedom of action, partly because of their old traditions, but mainly, I think, because of the financial independence of the colleges. I do not know how far the ancient universities of Scotland preserve their own complete independence, but, in spite of apparent autonomy, the newer universities of England have not quite the same measure of freedom as Oxford and Cambridge. Their income can normally only just cover their expenditure, for if the margin were great, it would mean that they were receiving too much from the public. The close budgeting that is necessary inevitably restricts freedom of action. For example, if the number of students be reduced, the loss in fee income may convert a slight surplus into a deficit for some years, as it is impossible to reduce expenditure on staff and equipment correspondingly quickly. On the other hand, the immediate effect of increasing the number is to make the balance sheet look healthier: until a strong case can be made for more expenditure on staff and buildings, which eventually results in increased cost to the public.

It is unfortunate that there is quite a strong financial incentive to increase the number of students at universities; it looks so well on paper. Yet I feel that the time has come when we ought seriously to consider whether a further increase can really be justified. The public, I take it, is not interested in the individual; if the taxpayer thinks at all about his contribution to university education—and I do not suppose he does, as it is so trifling compared with other public calls upon his income—he must come to the conclusion that

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the object of his contribution is to help students who will afterwards be of more value to the nation if they spend three or more years of a sheltered existence at a university, than if they were obliged to earn their living on leaving school. Where shall we draw the line?

There are many students who occasion no misgiving. They are those who are capable of teaching themselves, given the opportunity. To them, and ideally to all, the attitude of the university should be this: We give you here the opportunity of learning, if you wish to, from masters of their subjects; we give you access to well-equipped libraries and laboratories; and opportunities for learning from each other. We help you to help yourselves. What use you make of these opportunities depends upon yourselves. If we find you do not, or cannot, make good use of them, you shall go, and make room for others. Broadly speaking, I believe that is the right attitude. In such an atmosphere, learning, individuality, and self-reliance flourish; and public expenditure is worth while. Judged from this point of view, I have little hesitation in saying that universities are too full. As a result, the tendency is towards over-organisation, too little latitude, and too much spoon-feeding. The more distinguished the teacher, the more he is tempted away from teaching and research: his presence is required on committees. In London we elderly gentlemen even organise students' athletics; and official debates take place on such important questions as the site and finance of a university boat club for women. The wider we fling open the doors to a university, the more will such organisation be necessary, and the worse will be the conditions for the best teachers and students.

There is another, more practical, way of looking at this question of numbers. Do graduates find any difficulty in getting suitable employment at the end of their university career? Perhaps it is scarcely fair to attempt to draw a definite conclusion from experience during the last few years; but it does form some guide to policy. The majority of students of the Imperial College enter some branch of industry; and most of them, even in these difficult times, have succeeded in finding posts within six months of leaving the college. Whether they are all suitable posts for university graduates, I doubt; many of them could equally well, and perhaps better, be filled by students from technical schools.

Different branches of industry seem to hold different views about the value of a university education in science. Compare, for example, the present position of the university chemist with that of the engineer. The chemical industry calls out for university graduates; every year you will

find leading representatives of the prominent firms in the universities, looking for recruits. It is not demanded of the recruit that he should possess a large stock of practical knowledge; it is expected of him that he should have high scientific qualifications, and that he should have shown aptitude for independent work. The attitude of the engineering industry seems different. In some branches of the engineering industry the university graduate is as welcome as he is in most branches of the chemical industry; but in many he seems to be regarded as a misfit. One prominent manufacturer, the creator of a great industry, who has lived most of his life near a university, has been known to boast that he employs no university graduates. Many employers seem to expect of an engineering graduate a degree of acquaintance with practice that they have no right to expect; for we do not pretend to teach at universities what can be better learned at the works. Finally, my experience is that too many engineering graduates find themselves in blind alleys from which they have little opportunity to escape.

Where does the fault lie? With the employers or with the universities? I think there are faults on both sides: let me leave the faults of the employers for others to discuss, and for time to correct, and deal with some of the problems of university schools of engineering.

Engineering is a branch of technology. The object of a university school of technology is to seek to advance and apply scientific knowledge for practical purposes. Many people at universities still think there is something derogatory about this; they would prefer that instruction and research had no relation to the practical needs of mankind, forgetting perhaps that most, if not all, university education started with a practical aim in view, or we should have had no schools of law or medicine.

Let me quote from the report of the University Grants Committee for 1921:

"There is nothing in the nature of technology which makes it necessarily unsuited to the methods and spirit of university work. . . . The very fact that this alliance [between science and industry] is intimate, and the border line between pure and applied science difficult to define, involves serious difficulties for the universities. We cannot ignore a certain tendency to lay an exaggerated emphasis on utilitarian applications in some technological departments. . . . It would be in the worst interests of industry itself if the study of scientific problems were to be approached by the universities from the point of view of immediate material advantage. . . . We believe it to be urgently necessary, therefore, to define more closely the aim of university courses in engineering and technology, and to differentiate such courses from work properly assignable to technical colleges."

With these views and criticisms, I heartily agree: what is more to the point, perhaps, is that they have, I feel sure, the approval of many university professors of engineering, who would say that their aim is to teach principles, not practice; to train the mind without neglecting the training of the hand; and to send out ultimately from the university resourceful men whose education and outlook enable them to attack with confidence the new problems that are perpetually arising in the engineering world. A university school of engineering should be primarily a school of what is now called classical physics, the principles of which are illustrated in lecture room and laboratory by examples and problems which have a special bearing on engineering. To a less extent it should be a school of mathematics and chemistry. I think we are inclined, at universities, to value mathematical ability in an engineer too highly. Many students have obtained first-class engineering degrees mainly through their mathematical ability; but such students do not necessarily become first-class engineers, and some of the most original and distinguished engineers are poor mathematicians: one of whom I believe had to be content with a pass degree at his university.

I am inclined to think that there are too many students of engineering at universities. There are many young men who have a practical flair, but who cannot respond to the kind of teaching that I believe to be appropriate to the university. Their presence at the university, where everyone wishes to do their best for them, inevitably encourages the introduction of practical instruction of a kind more suited to technical schools. The university school is then trying to fulfil two functions, and runs the risk of failing to fulfil either well.

The same is true, I suggest, of other branches of technology. The chief aim of a university department of technology should be to produce the leaders of the profession. The best education for potential leaders is not the same as the best education for the rank and file. It cannot be expected that all university graduates will become leaders; but at least we ought to look for, and develop, the qualities of leadership. This we cannot do if we fall into the temptation of mass production.

Highly specialised schools of science at universities present somewhat different problems. How many students, for example, should one encourage to study subjects such as mining geology, biochemistry, plant biology, entomology, when the demand for such specialists may be small and fluctuating? Take the biological subjects as typical. Two years ago there was published the

report of a strong committee appointed by the Government to advise on the education and supply of biologists. Their first two conclusions were:

(1) There is a substantial and growing demand from Government departments for biologists for service in Great Britain and in the colonies, and there is a small but probably growing demand for biologists from concerns engaged in agricultural production overseas and in industry in Great Britain.

(2) It is not possible to state this demand in precise arithmetical terms, but the supply of candidates for biological posts is not equal to the present demand, and even in those branches where the supply is sufficient in quantity it is deficient in quality.

Whatever evidence in support of these conclusions existed when the Committee started its inquiry in 1930, I think it safe to say that even before the report was published these conclusions were falsified by events. The fact is that some ten to fifteen years ago there was a sudden demand for biologists to meet the needs of new and of rapidly expanding research organisations at home and in other parts of the Empire. Highly trained biologists of all kinds were sought for, and naturally could not be found in sufficient numbers, for universities cannot suddenly increase the rate of production of first-class specialists. Some of the new organisations made the mistake, therefore, of accepting less able and less highly trained men, which is bad for the individuals concerned and for the organisations; for, if a first-class man is really needed, it is better to wait until one is available than to make shift with a second-class man, who runs the serious risk of having his livelihood taken away from him later on.

Then came the world depression, and far from there being an increased demand for 'industrial' biologists in recent years, there has been a contraction. This is a serious state of affairs for universities. It would be a fatal policy to encourage young men of good ability to spend long years in specialised study, only to find at the end that there was no demand for their services, or that what little demand there was offered inadequate prospects for the future. It is a far better policy deliberately to keep the supply somewhat short of the demand; the world will not appreciably suffer if any particular application of science to industry and agriculture develops rather more slowly than the enthusiast could wish, and there are few spectacles more distressing than that of the highly educated specialist who is unemployed through no fault of his own, and whose training and interests do not fit him for other work. The lessons of the last few years teach us that public statements about the shortage

of specialists in any branch of science and technology are apt to have an unfortunate effect in schools and universities; for they may be out of date before a normal period of advanced training is finished.

It is of interest to examine a little further the Committee's belief that the supply of biologists at universities is lacking in quality as well as in quantity, which they attribute to the neglect of biology as a subject of study in schools. While sympathising with their views, which are shared by many people, I think it cannot be denied that whereas a biologist must have an adequate knowledge of physics and chemistry, it is not necessary for a physicist or chemist to have a knowledge of biology; and if one considers the position from a cultural rather than from a practical point of view, it would be fair to say that the boys who need least to study biology as a cultural subject at schools are those who are going to study it at a university. The only point that remains, then, is that if biology were taught more widely in schools, it is possible that here and there a boy "may experience from biology a pull which he had hitherto failed to secure from his special subject"

For my part, I feel confident that directly there is an assurance of reasonable careers in biology, suitable candidates will be forthcoming, and education at schools and in the universities will

develop on sound lines. Lack of teaching of biology at schools has not led to a shortage of doctors. How, then, can it be mainly responsible for a shortage of other biologists? It needs no inspired prophet to foresee a great development some day of the biological sciences: the work of pioneers to-day makes that sufficiently obvious. The next generation may live to see a development comparable with that of the physical sciences, and their applications, in the last thirty years; but the time is not yet ripe. Until it is, our duty at universities is to keep our biological departments moderate in size, but high in quality.

These practical considerations are not exhaustive and do not lead to any definite conclusion on the problem of the size of university departments of science and technology. In the end, the optimum size is a matter of judgment; my judgment, for what it is worth, is that on the whole there is no strong case for increasing the numbers of students of science and technology at universities. In thirty years' time, this statement may look ridiculous, but one cannot foresee events so far ahead. Rather than any marked expansion in numbers should take place during the next five years, I should prefer to concentrate on giving the better man a better chance than he has now; to improve the quality rather than to increase the quantity.

Obituary

PROF. W. M. HICKS, F.R.S.

BY the death of William Mitchinson Hicks on August 17, the world of science has lost an outstanding figure, whose achievements were perhaps more appreciated by the last than by the present generation. Born at Launceston on September 23, 1850, he went up to Cambridge in 1870 as a scholar of St. John's College, and reached the position of seventh wrangler in the Mathematical Tripos of 1873. This was the year in which the Cavendish Laboratory was founded with Clerk Maxwell as first professor, and Hicks formed one of the small band of distinguished students of experimental physics who gathered round him, and came directly under his inspiration. In 1876 he was elected a fellow of St. John's, and lived there until 1883, engaged in the earlier stages of his mathematical researches on the theory of vortex rings. In that year he was appointed principal and professor of physics and mathematics in the Firth College at Sheffield, and from this time onward his energy was devoted to the furtherance of university education in that town.

This tiny College—the staff numbered only half a dozen all told—had developed, as in other towns, out of the zeal for higher education marking the earlier days of the century, which was shown in this instance

by a bequest of Mr. Mark Firth. It carried on a struggling and precarious existence, but its subsequent history forms a monument to the vision and untiring work of Dr. Hicks.

The first stage of Dr. Hicks's ideal was the union of the Firth College, the Technical School, and the Sheffield School of Medicine into one university college, which he succeeded in accomplishing in 1897. The opportunity for further development, apart from the foundation of new departments, came in 1903, when the Victoria University formed by the Liverpool, Manchester, and Leeds Colleges was dissolved. It was clear that the system of constituting a university by the federation of several distant university colleges was too cumbersome to work, and each town set about providing its own. The opportunity was seized in Sheffield also—it was now or never, and a large sum would have to be raised. Dr. Hicks's quiet but persistent pressing forward of his ideals, his scientific eminence and his obvious single-mindedness and sincerity, convinced the important persons of the city, and ultimately gave rise to a wave of popular enthusiasm which brought the necessary endowment in its train. He was a man content with doing his good work for the founding of the University, and courted no popular recognition,