RELATIONS BETWEEN UNIVERSITY AND INDUSTRY

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The scope of the subject covered by the title of this paper is extremely wide. Universities differ from country to country, in range and level of the subjects taught, in entrance requirements, in size and in traditions. The term 'Industry' may refer to the whole of a country's or even a continent's productive effort or to one or more of the individual enterprises, some small, some large and internationally ramified, that contribute to this effort. I shall therefore have to limit myself to those aspects of the subject with which I am most familiar. As most of my contacts have been and are with universities in the Netherlands, most of what I have to say will specifically apply to the situation in that country. This implies among other things that, as far as chemistry is concerned, the difference in educational system between Technical and other universities, although significant, is not very great. The term University in my paper refers to both categories, except where the differentiation is explicitly mentioned.

As to the 'Industry' part, I shall mainly view matters from my position in a research laboratory of a large international group of companies. This is rather a good vantage point, because Research is frequently the entrance for graduates or Ph.D.s into an industrial enterprise, not only into the scientific and technological sphere, but sometimes into the heart of the business and the higher echelons of management.

The subject of our meeting is Chemical Education. Most of my remarks, however, apply equally to other scientists of various descriptions.

Although I shall not be able to produce references for many of the opinions I am going to express, I certainly do not claim to have originated all of them. Much has been written and said recently about relations between University and Industry[1], and some of it inevitably has found its way into my paper.

SCIENTISTS IN INDUSTRIAL RESEARCH

Industrial research cannot avoid being extremely interested in developments at the universities: these are the source upon which Industry as a whole must draw for most of the talent—scientific, technological and managerial—that has to keep the process of continual technical evolution going. The young scientists coming from the universities are going to determine the shape of Industry and indeed of society tomorrow.

A large industrial enterprise is not run purely by directives issuing miraculously, as it were, from top management and passed down the line.

Such directives are to be considered as the managers' reaction upon the flow of argued information, suggestions and criticism being passed up the line, to which the whole staff, the most junior member included, contributes. Seen in this light, the essential function of research is to provide the inquisitive atmosphere in which literally nothing is taken for granted.

I have already said that Research is an important entrance for graduates into Industry. Let us therefore try to formulate the qualities Research is looking for in the prospective employee. Mere knowledge of facts and theories is obviously not enough. The graduate starting his career in industrial research should primarily be able to think critically and should be prepared to envisage the consequences of his actions; he must have the courage and the ability to switch from one type of problem to another and must be prepared—and even eager—to delve into the scientific background and go to the roots of the problems as far as necessary. The insight thus gained must be translated into action; for this purpose he will be required to record and transmit the results of his work. Further, he (or she) must be able to work in a team with colleagues of different backgrounds and disciplines, while retaining his individual outlook and approach.

Having formulated these desirable qualities in the prospective industrial research worker, we must now consider whether such a paragon may be expected to issue from our universities, and whether there will be enough of his kind that are inclined to make their career in Industry. If not, we have to analyse whether this must be an incentive for the University to adapt its methods or whether Industry must adapt itself to the type of graduate that the University does produce.

Quite apart from quality, the number of chemists (and other scientists) expected to graduate in the next few years remains a cause for concern. In the Netherlands at the moment, Shell alone expects to need every year a number of chemists and chemical engineers corresponding to about 20 per cent of those who will take their degree in these disciplines at Dutch universities and are qualified for and interested in a career in Industry. Of the positions meant here, a number will be taken by graduates from outside the Netherlands. This is in itself desirable in an international organization and in research in particular, because of the diversity of outlook it will provide. Most of the places, however, will have to be filled by graduates from the Dutch universities and as other employers, some of them also needing large numbers of chemists, are fishing in the same stream, the supply can clearly be called restricted.

The limitation of the supply is aggravated by the decreasing proportion of science students among the younger generation. But the main point, forcibly expressed by Stern[2] is that 'It is essential to get more of the best brains into Industry'. His point was taken up in a recent article by Butters[3], who notes that many highly qualified scientists would rather devote their careers to academic research (or seek posts abroad).

This refers to the situation in Great Britain, but the problem also exists in other countries, albeit not always to the same extent. Butters goes on to say that 'the main onus for creating the right climate, in which real co-operation can prosper, rests largely upon the colleges and universities'.

However this may be, Industry must do everything in its power to show

that it can offer intellectually satisfying careers. I shall revert to this point, which is perhaps the main theme of my paper, in a moment.

To return to the qualitative aspect, some of the desirable qualities of the research scientist enumerated above are traditionally part and parcel of University education. In most universities the facts and theories are taught as a matter of course. Critical thinking is a habit not usually taught explicitly, but gradually instilled in the course of every University education that deserves the name. It is generally accepted today that this part of the education should receive the main emphasis: that learning to understand and to analyse facts is more important than the factual knowledge itself, which anyhow tends to get obsolete very quickly nowadays*.

The creative scientist—and this is the sort Industry needs most—must go one step further, however. It is not enough for him to understand and to 'analyse', but he must then put to work the things he understands, he must 'synthesize' and usually must forge his own tools, and he must communicate the results of his efforts.

It is a fact that many chemists find intellectual satisfaction in working towards a concrete industrial goal, without forsaking the scientific approach in the process. They absorb science, make use of existing science and often 'produce' new science on the way. But the particular charm of this type of work appears to be largely unknown to the young graduate who has to decide whether he wishes to embark on an industrial career. The attitude in some universities still seems to be that the scientist's task is to understand nature—not to put it to work.

This leads to the question whether the University should not pay more attention to the 'synthetic' aspect of science and thus prepare the student for a position where the ultimate aim of his scientific work is that it should result in something that can be applied. What is needed is surely not a complete about-face, but rather some shifting of the accent; one needs an amount of 'making' to reach understanding, and certainly understanding is required for making.

Institutes of Technology, although in many respects very similar to Universities (at least in the Netherlands) are different in that they definitely prepare their students for a job in Industry. They must avoid the pitfall of paying disproportionate attention to technical details that will probably be obsolete tomorrow.

Aptitude for teamwork with people from other disciplines is another quality for which our universities do not always provide a preparation. The compartmented structure of the Dutch—and I believe of most other European universities—is not conducive to interdisciplinary contacts. But progress is being made and it is of great value for education as well as for science when such contacts are fostered and if the curricula and research programmes of the various sciences, and even some other disciplines, such as economics, are to some extent harmonized. The student then learns to see the inter-relations and interdependence of the various disciplines and University research may advance on a broader front (and sometimes possibly in a more meaningful direction).

* This was one of the main conclusions reached by a State Committee which was set up to study the teaching of science in Netherlands universities.

In industrial research we know that such harmonization is not easily achieved and can never be complete. We are constantly faced with the analogous problem of dovetailing the programmes and relative efforts of fundamental and applied research, and those in a host of disciplines from mathematics to biology and from quantum mechanics to fracture mechanics.

Evidently, Industry and in particular industrial research has every reason to be interested in an extensive exchange of ideas with the Universities. What it certainly should not do is to try to interfere with the university's responsibility for its curriculum and research programme.

What it can do—and the industry where I work makes every effort to do so—is to provide ample opportunity for both academic staff and undergraduates to become acquainted with its activities. We can show, among other things, what types of work we do and what type of man is in our opinion best suited to it. It is then up to the student who is attracted to this type of work to orient his studies accordingly. The University in its turn should provide the corresponding courses if there is a sufficient demand for them, from the side of the students or from society as a whole.

INDUSTRY'S CONTRIBUTION TO UNIVERSITY EDUCATION

Industry can and does help the universities in broadening the scope of the courses it can offer.

We have found that visits by a university professor with a group of his students to an industrial research laboratory can be of mutual benefit. Usually during such a visit one particular project or process is discussed by the people actually involved in the relevant research and is illustrated by demonstrations. Our laboratory in Amsterdam has received seventeen such visits involving some 350 students in the past twelve months.

Guest lectures at universities by industrial research staff are less frequent but could also contribute to better understanding.

By a liberal policy of publishing results of industrial research in scientific journals or as contributions to conferences and symposia, Industry can promote exchange of scientific ideas and contribute to the advance of science in general. It has the added advantage of making the academic world aware of the standard of the scientific work being done in Industry.

In the Netherlands in particular, Industry makes another, unintentional contribution to university education, in the form of a sort of inverse recruiting: scientists who leave Industry to occupy a chair on the faculty of one of the universities. Of the 120 or so professors of various branches of chemistry in the Dutch universities at least 60 have started their professional career in Industry, usually in research.

Radical youngsters tend to see this as a gradual encroaching of Industry upon the traditional 'freedom' of the University. They forget that the universities take the initiative and call upon scientists to accept a chair because of their high scientific standard, and not primarily because of their industrial background.

I realize that this switching from Industry to the University is less frequent in countries other than the Netherlands.

If I have not yet spoken of Industry's direct financial contribution to higher education this is because here again there are wide variations from country to country. In the Netherlands, endowment of a chair by a single enterprise is practically unknown.

Industry does spend considerable sums for educational purposes. The university grants budget of any one of a number of industrial concerns could probably be cited in proof of this, but as I am most familiar with Shell's contribution, I shall take this as an example. Worldwide, this group of companies spends about £1·5 million per annum in grants, awards and subsidies. Obviously the aim can never be to carry a substantial part of the cost of higher education. The money spent must primarily act as a catalyst, to speed up or initiate promising developments that otherwise would have remained dormant. Timeliness is often as important as the magnitude of the sum.

It is in this spirit that Shell—I am talking again about the industry with which I am most familiar—recently made available over half a million pounds (over and above the amount mentioned above) to subsidize a three-year programme of studies connected with innovation of education in Europe, to be carried out by existing international organizations.

FUNDAMENTAL RESEARCH IN INDUSTRY

In any discussion of the relations between University and Industry one cannot avoid touching upon the question of the most suitable place for fundamental research. Leaving aside the exact definition of fundamental research, we can say that traditionally the University is the place where this is carried out, the aims being twofold: to widen the frontiers of human knowledge and to serve as an exercise in science for the prospective scientist.

Applied research, i.e. research directed towards a specific industrial application, is primarily the domain of Industry.

The research done in the Technical Universities would take up an intermediate position between the two.

Applied research leans heavily upon the 'science' produced by fundamental research. However, the branches and sub-branches of science that are at the basis of a particular field of application are not necessarily those covered by University research, in which there are 'fashions' just like in many other human activities. If Industry is to make progress in applied research, it must see to it that the relevant fundamental research is carried out somewhere. One solution is for Industry itself to do this. This has several added attractions. It creates a bridge between fundamental and applied work in the form of research staff conversant with the methods and language of fundamental science, who are at the same time in regular contact with colleagues doing applied work. Further, it helps to attract first-class scientists into Industry, who will later be among the mainstays of research management. The long-term view which they naturally acquire in fundamental research often makes these people very suitable for directing research teams even in applied research.

Moreover the presence of a sizeable fundamental research group in an industrial research laboratory contributes to broadening the spectrum of

backgrounds, skills and aptitudes, which research needs to be able to act as the scientific and technical conscience for all branches of a highly complex industry.

I suspect that the relatively small part fundamental research is said to play in the whole of the British industrial research effort is a contributing cause of the phenomenon deplored by Butters, viz. the reluctance of highly qualified scientists to join Industry.

Fundamental research in Industry is necessarily long-term work requiring highly trained specialists and expensive apparatus. Therefore only the larger firms or government agencies with sizeable research facilities can afford to go into fundamental research themselves. The alternative of having privately sponsored research carried out in the universities is not accepted practice in the Netherlands.

It should not be inferred from this that fundamental research is insufficiently developed in the Netherlands. Of the total government expenditure for research and development a relatively large part goes into fundamental research and if there is a gap, it is rather in applied research and development. The burden of this part is almost completely carried by a few large industrial firms, while the government-financed Institutes for Applied Scientific Research (TNO) for the various branches of industry have difficulty in realizing their full potential in applied research because of insufficient research-mindedness of the smaller industries. (In the Netherlands only 36·5 per cent of total research and development expenditure goes into development, while in the U.S.A. the proportion[4] is 65·5 per cent and in the U.K. 61·4.)

OBSOLESCENCE OF KNOWLEDGE

I have mentioned fundamental research as an inducement for scientists to make their career in industrial research. In fact, starting in fundamental work is one of the few ways for a Ph.D. fresh from the university to step right into a job in the industrial laboratory without any additional instruction. Normally the University is not expected to provide tailor-made education for any position in Industry, not even in industrial research. Where the formal University education should stop and where further training on the job should take over is a matter for debate. What the University is always expected to provide, is a sound background in basic science and scientific methods and enough experience in problem-solving and handling of factual data to enable the graduate to choose his further career in relation to his real inclinations and abilities. These elements in his education will enable him to acquire the specialist knowledge needed for his particular job in a rather short time and to keep abreast of new developments in his own chosen field. Moreover, proficiency in reporting and communication techniques is essential for optimum functioning in any position. Only in this way can the research scientist perform his important task of introducing the latest scientific developments into his industry's operations.

However, in view of the rate at which science and technology in all fields are developing and expanding, the scientist cannot be expected to keep up also with fields outside his own, on which he will nevertheless have to draw now and then in the course of his work.

I have no ready-made solution to propose for this problem. Concentrated courses, say in quantum chemistry or spectroscopy for organic chemists, are certainly very valuable and a large industrial research organization can well organize such a course for its own staff. I think, however, that a much wider audience could be reached if the universities would consider this as part of their task, the cost being presumably borne by the organizations of the participants. In such a scheme it would probably be sufficient if some of the research staff should thus go back to the sources. It could then in its turn bring the rest of its own industry up-to-date.

In some places work of this kind has already been started. Several British Universities and Institutes of Technology offer summer courses or refresher courses in particular subjects. In my own country the Royal Netherlands Chemical Society is making a commendable effort in this field. More highly specialized are the well-known summer courses in quantum chemistry in Oxford, that of Uppsala University in Sweden, and those of the NATO Advanced Study Institutes Programme. Still, more could and should be done to help the man in practice to remain up-to-date.

CONCLUSION

I have been able in the time available to touch upon only a few aspects of the many points of contact between Industry and University. My main point is that both parties can benefit from an intensification of their contacts. If through these contacts they get better informed about each other, this might remove some of the barriers that hamper the flow of scientific talent to Industry—by which now I explicitly mean the sum of productive activities that provide the material basis for human existence. Neither of the two, however, should ever forget its own identity in these contacts. They can and must stimulate each other, but they should not attempt to meddle in each other's business.

An independent University is of great value to Industry: technological and social progress need independent minds, not trained robots.

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Like almost everything that issues from an industrial research laboratory, this paper represents the result of cooperation of a team. I am grateful for the spirited discussions with my colleagues, which underlined the fact that the ideas of which I am the spokesman on this occasion are very much alive in the research community where I have the privilege to work.

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