## DISCUSSION ON UNIVERSITY–INDUSTRIAL RELATIONS

**G. A. Olah** (*Case Western Reserve University, Cleveland*)—I wish there were more large companies like Shell with the attitude and liberal approach towards research as explained by Dr Mackor. I wonder, however, whether this is limited to Shell in the Netherlands, because in my experience Shell in the U.S.A. or U.K. is quite different in practice.

Some universities question why is Shell doing fundamental research and why could they not undertake fundamental research for Shell. In my view fundamental research is research for *understanding*; exploratory research as practised by Shell is research for *discovery*. Understanding should not necessarily be limited to one user. University research should advance the general understanding of chemistry without necessarily considering applications.

**J. F. Bunnett** (*University of California, Santa Cruz*)—Academic and industrial research involve challenges of basically different character. In academic research the objective is to establish some principle or discover some reaction or find some relationship which is of lasting fundamental significance. It does not matter *what* principle or reaction is discovered and it is not necessary that an initial goal be attained. If a certain line of research runs into difficulty it can simply be abandoned. On the other hand, in industrial research the objective is to solve a practical problem. It does not matter whether the solution attained is scientifically mundane or sophisticated, but it is essential that the problem be solved. If a difficulty is encountered, the project cannot be abandoned unless failure is to be acknowledged. The challenge of solving a difficult practical problem is intellectually of a high order, equal to that of discovering new knowledge of lasting value, but there is need for a better recognition of the difference in these challenges.

**J. C. Bailar Jr** (*University of Illinois, Urbana*)—In America, as in the U.K., there are many Ph.D. candidates who hope to get academic posts but who will fail to do so. They take industrial positions as a second choice. They do not consider this a 'traumatic' experience and I do not understand why Dr Stern feels that Englishmen who go through a similar experience are so upset. They may be disappointed, but once in the industrial laboratory they find the work interesting and are quite content with it.

**H. Zollinger** (*ETH, Zürich*)—Dr Stern emphasized that chemists in Industry should have some training in economic methods. This is definitely true for a percentage of industrial chemists but higher degree holders in chemistry (particularly Ph.D.s) are, however, concerned with training in *chemical* research. Ph.D.s should be used in Industry for work where research-trained chemists are really needed; for other posts Ph.D.s should not be used.

**N. N. Greenwood** (*University of Newcastle upon Tyne*)—Dr Stern has suggested three possible sources of attitudes which might dissuade British students from going into Industry: (a) the schools, (b) the universities, (c) the

Government. There is a fourth source, which he has overlooked, namely, Industry itself. If Industry does not seem attractive to graduates it must surely bear some of the blame for this. For instance, many students who take up vacation jobs in Industry become disenchanted with what they see. They are often equally uninspired by interviews with Recruiting Officers whom they meet from various companies. The Universities cannot be entirely to blame since British graduates find little difficulty in gaining satisfying posts in Industry overseas and are often highly regarded by their employers.

It was also valuable to hear five specific suggestions for topics to be incorporated into the already overcrowded curriculum of the undergraduate. If each of the five sections of 'Chemistry in Action' were to involve ten contact hours, this would be equivalent to about fifty lectures. What would Dr Stern suggest should be eliminated from the present courses to make room for this?

**G. S. Hammond** (*California Institute of Technology*)—I have recently looked into the matter of adaptation of Ph.D. graduates to industrial work. Probably more than half of these are either intensely unhappy or totally bored. The general company evaluation also seems to rate the majority of their Ph.D. employees as unsatisfactory. The critical factor seems to be the fact that for some students Ph.D. thesis research develops attitudes and intellectual skills for problem solving; and problem solvers are valuable everywhere. Other students doing similar thesis research only acquire styles and techniques, which are frequently not transferable to new kinds of problems.

**M. Cais** (*Technion, Israel*)—If I try to summarize the substance of Dr Stern's lecture, I arrive at what amounts to an indictment of universities by chemical industry. While some of the points made by Dr Stern may be well taken, I wish to turn this around and formulate an indictment of chemical industry by the universities.

Chemical Industry wants us to do their job for them and transform university chemical education into a workshop training people for the Industry. My question is: What has Industry done to make known the attractions of chemistry as a profession? Whilst chemistry teachers, both in high school and in universities, are trying to impart to their students some of their enthusiasm for chemistry in order to attract youngsters to this field, they can do so largely on the basis of the intellectual aspects and challenges of the profession. If Industry wants to attract young people, they should undertake their share in promoting enthusiasm for chemistry, stressing not only that chemistry is a generator of industrial wealth, but pointing out also that this branch of science can provide a rewarding intellectual experience.

**J. W. Linnett** (*University of Cambridge*)—I agree very much with Professor Cais that Chemical Industry has failed to stress and put over the intellectual interest of the work that it does—at any rate this is true in the U.K. They have been so anxious to make sure that we know that they are the source of wealth that they have failed to publicize the interest of the jobs they have to

offer, and after all this is what matters to the individual chemist in Industry. He is very much concerned that his job should be interesting.

Chemical Industry in the U.K. expresses great dissatisfaction with the Ph.D.s we produce in universities in the U.K. but the U.S.A. does not seem to be so dissatisfied with British Ph.D.s. They have taken them on in considerable numbers, so much so that the Brain Drain became a problem and many people felt that we were losing too many first-class young men in whom much training had been invested. We are accused of making our Ph.D.s too narrow—too narrow-minded and too narrowly trained, but it has always seemed to me that in the U.S.A. Ph.D. training is just as narrow and often even more academically inclined. Again, the Ph.D. in West Germany receives a long and thorough training on very fundamental topics. Where then do our Ph.D.s differ from those of other countries?

**W. A. de Jong** (*Technological University, Delft*)—In the Netherlands 65 out of every 100 graduates, M.Sc. and Ph.D., in chemistry and chemical engineering begin their career in research. There is a widespread tendency among industries, particularly the major companies, to have graduates enter industry by way of research. Some of them remain in research during most of their professional lives, but the majority move on to other positions after a relatively short time, say after two to six years.

Now this may indicate that Industry tends to regard research training as an excellent preparation for future, more general professional activities of chemists and technologists. Universities, at least those in the Netherlands, thereby tend to be strengthened in their conviction that research training is an indispensable part of chemistry curricula. I share that conviction.

Yet all is not well. Having heard Dr Stern formulate some sort of indictment against present day university education beyond the B.Sc. level, i.e. where research plays a major part, and knowing that similar but possibly less severe criticisms are voiced elsewhere, we should search for alternative answers to the question why Industry sometimes appears to be unhappy about our work. One of the answers could be that the courses and the research training we give our students are not the type needed for a successful career in Industry.

One of the reasons is that different skills are needed for industrial and academic research. In Industry, the main task of the university graduate is to combine a large volume of related but not yet systematically arranged facts to create an operable system. Furthermore, he has to foresee his own activities and tasks over a period of several years and to predict those of others. I think university training leaves the graduate ill-prepared for such functions because the student is often given a well-balanced combination of courses without adequately telling him what type of creative effort went into establishing the ordered system presented to him. A better way would be to provide him with some of the facts and let him draw his own conclusions. Of course, guidance is needed to help him arrive at the right answers. A necessary condition for such courses would be that more factual knowledge is transferred to the student, but this is not fashionable: principles and theoretical foundations are thought to be superior to factual knowledge.

I do not wish to imply that there is no room for improving curricula to

make them more comprehensive, but merely that we should not compress such basic science courses into as short a time as possible. We should not be too preoccupied with establishing curricula that are meaningful to experienced chemists but much less so to inexperienced students. Our primary aim must be to encourage them to arrange facts for themselves and to develop their skills in their own way. As I see it, we can teach the same science in a different manner which prepares the student more efficiently for an industrial career. The teaching of nothing but basic knowledge either turns the practical minded student away from applied chemistry or converts him to basic science without motivating him to apply his science.

**E. S. Stern** (*ICI Ltd, Petrochemical and Polymer Laboratory*)—The main business of Industry is to make and sell goods; for this to be viable some Research and Development are necessary. The amount of Research and Development effort varies—in the Chemical Industry it is somewhere between three and five per cent of all the effort. Pharmaceutical firms expend 10 to 15 per cent of their effort on Research and Development and extractive industry less than three per cent. Thus the top management of a firm spends 95 to 97 per cent of the effort on things other than Research and Development and three to five per cent on Research and Development; the research chemist, however, sees all his own effort in Research and Development and unless he is enlightened he cannot understand why top management does not expend all *their* time in helping him with his problem. This divergence of objectives leads to a communications block that is difficult to overcome. As regards the chemistry departments within universities, they tend to fall into the same trap, regarding Research and Development as comprising all of Industry that is worth consideration, merely because Research and Development is the point of closest contact. This is distinctly misguided and university teaching might like to consider collaborating with Industry on a broader front; after all less than 15 per cent of all chemists in Industry are in Research and Development departments.

**J. C. Bailar Jr** (*University of Illinois, Urbana*)—The college and university system in the U.S.A. is evidently much more diverse than in most other countries. For example, we have large universities with an extensive graduate programme and small colleges with no graduate programme at all.

The large universities have a great deal of contact with Industry; the small colleges have almost none. Many of the staff members in the larger universities have consulting contacts and are Invited to lecture before the research groups of industrial companies. The large universities have research grants and other support for research; the small colleges do not. The industries send representatives to the larger schools to interview students for industrial positions, but do not send such representatives to the small schools. Thus, it seems to follow that there is a great deal of truth in the adage 'The rich get richer and the poor get poorer'.

There is one other difference between the chemistry departments in a large university and those in the small colleges. The former, for the most part, demand that their students devote a much larger proportion of their time to the study of chemistry than do the smaller schools. (This, perhaps,

comes from the fact that the larger schools have more equipment for advanced work.)

Perhaps as a consequence of this, the students in the smaller schools spend more time in the study of economics, sociology and business, which, I judge from what Dr Eaborn has said, is not at all a disadvantage.

**R. L. Silber** (*American Chemical Society, Washington, D.C.*)—Usually any meeting relating to the Academic/Industrial interface, where representatives of each side are present, degenerates into accusational barbs directed at one side or the other. The blame for problems is placed in the laps of each side represented.

Solutions to the inherent problems involved will never be forthcoming unless the two groups seek more basic understanding. For example, such questions as the following should be asked:

(a) What are the basic aims of both university and industry?
(b) With the above aims in mind, how can we develop understanding of each position?
(c) What are the problems between the two areas and what are the real sources of these problems?
(d) How can we realistically solve these problems?

These basic questions force both sides to evaluate *honestly* the two positions and to seek answers for differences. Concessions must be made on each side.

Possible subjects to explore as a beginning might be:

(a) Is industry satisfied with the product it receives?
(b) What is the impact of chemistry on the economy of the country? The university should be made aware of this impact.
(c) In what ways can industry make an effective contribution to the university programme?
(d) What are the needs of both industry and university and how can they mutually solve them?

The American Chemical Society (ACS) is concerned about this Academic/Industrial interface and through several meetings and committee discussions have developed several programmes or approaches to the problem:

(a) A major study ($100 000) is under way to determine the overall impact of chemistry on U.S. society.
(b) A project, 'Operation Interface', has been launched for one week during the summer, for the last five summers, where chemistry professors are brought into contact with industrial chemists through tours, discussions etc. of industries in particular areas.
(c) A large 'continuing education' programme is operated by the (ACS) taking the form of short courses, films, tapes and packaged short courses to a great extent for industrial chemists (see separate note below).
(d) The launching of a major curriculum study supported by the National Science Foundation, for the training of chemical technicians at the post high school level. Most of these technicians will go into industry after training.

Perhaps an excellent way for industry and university to begin to understand each other and work more closely together would be to attack jointly

a problem for the betterment of society. For example, a joint endeavour to solve such problems as pollution, exploding population, urban planning, low-cost housing etc. would bring the two groups closer together.

*The ACS Continuing Education Programme*

The ACS Continuing Education Programme began with short courses. These courses are one to three days in length and at the present time offer about 45 different topics. Approximately 60 courses are offered each year across the U.S.A. These are attended by B.S., M.S. and Ph.D. chemists from industry, academic institutions and government.

In addition, other forms of continuing education are being developed. For example, a 16 mm film on 'Infra-red spectroscopy' by Norman Colthup is available for hire and purchase. This consists of four one-hour lectures on film. Two more films on other subjects are now being prepared.

Audio-tapes in the form of lectures and seminars on various specific topics are also available and others are in preparation.

**A. S. Dreiding** (*University of Zürich*)—The problem of adjustment of the university man to industry may be partially due to the fact that university research has remained essentially the same over centuries, whereas industrial research has changed. A dissertation research should be an original contribution, preferably on a subject chosen freely by the student or, if the problem was given by the professor, at least on a sideline pursued on his own initiative. The training should stress the individual initiative and contribution.

Industrial research has become team work. The scientist must accept motivations which do not originate within himself. One of the possible answers to the problem may be for industry to take more students who have not completed a dissertation.

**C. H. de Puy** (*University of Colorado*)—In entering upon University–Industry joint projects each side must do so because it believes the objectives worthwhile, not because it expects some immediate tangible recognition or appreciation by the others involved. For instance, in the offering of a course by a university for industrial chemists in the area, the chemistry department may expect approbation for this service and instead receive criticism for a poor set of lectures or for presenting them at an inconvenient time. If the department has only undertaken the programme because it was considered the thing to do and not because they believed in it, Industry–University relations are liable to be worsened, not strengthened.