Chemistry and the Modern State*

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IN relation to those essential activities of any society which is intellectually alive—the pursuit of new learning and the cultivation of the spirit of inquiry—chemistry is in the forefront. For the promotion of natural knowledge and the increase of our understanding of the universe, the chemist has laboured with extraordinary success, both in his own fields and in those borderlands where chemistry marches with other sciences. It is perhaps worth while glancing at one or two of the chief avenues in the region of chemical knowledge opened up by such fundamental research.

While our knowledge of atomic structure is to be credited mainly to the work of physicists, the chemist's technique has revealed the molecular architecture of the most complex natural products, and on the basis of this knowledge the same materials can be synthesized in the laboratory. One has only to think of the sugars, the alkaloids, the anthocyanins, to realize the astounding results which have been achieved in this field of investigation, while such elusive substances as the vitamins and the sex hormones are rapidly yielding their secrets to the strategy of the organic chemist.

Take, again, that region in the scale of size which lies between the molecule and the visible particle—the colloid region—the "world of neglected dimensions" as it was once described. In this region, as the physical chemist has shown, the relatively great extent of surface is marked by quite special behaviour, and the labile systems encountered exhibit peculiar characteristics—characteristics which are highly significant for the understanding of physico-chemical changes in the living organism. Our knowledge of this field of surface chemistry is still extending rapidly.

Once more, think of the tracking down of the factors which affect the rate of chemical change, and the elucidation of the mechanism of their operation: a little moisture, a speck of dust, a trace of acid, a roughened surface, a ray of light, a rise of temperature—any of these may have a notable influence on the rate of a reaction. The physical chemist has been remarkably successful in unravelling the role of these various factors and in interpreting their significance. It is in such a field as this—the field of kinetics and catalysis—that the progress of chemical science from the qualitative and descriptive way of treating phenomena to the rational and quantitative has been particularly marked.

These are only one or two of the directions in which the pioneering work of the chemist has opened the way to a fuller knowledge of Nature, especially in the more delicate aspects of her balance and her transformations. In the pursuit of natural knowledge for its own sake, the chemist has indeed travelled far, and his exploration has yielded an abundant harvest of discovery. For the pioneer himself it is an adventure, and original research may provide thrilling experiences. All this, however, is far from the common ways of men, and the investigator in the field of pure chemistry moves in a region mostly inaccessible to ordinary folk, and he speaks an unintelligible language, as indeed is true of specialists in other sciences. The so-called 'jargon' of science, inevitable as it is to some extent, presents a real difficulty in the transmission of knowledge and ideas from the specialist to the average educated man, but it should not be forgotten that other specialists besides scientific workers have a jargon of their own: to wit, lawyers, financiers, and even sportsmen.

It has been maintained that the pursuit of learning for its own sake is a selfish occupation; that knowledge should be a means to life, not an end in itself; that knowledge is of value only in so far as it leads to action, directly or indirectly. With this view I have much sympathy; but it has become abundantly clear, so far at least as knowledge and discovery in the realm of pure chemistry are concerned, that we must take a very long view indeed in assessing their practical value. Again and again in the history of the science observations and discoveries have been made, which at the time were of purely scientific interest but later received important practical applications. The laboratory curiosities of a former generation, such as aluminium and tungsten, have become the industrial commonplaces of the present.

The application of exact methods of measuring density revealed the presence of a new gas in the atmosphere—a discovery of purely scientific interest in the first place—which has led to a whole train of remarkable consequences, from a drastic revision of our ideas about the elements to the widespread development of illuminated signs. Just one hundred years ago, at the Bristol meeting of the British Association in 1836, Edmund Davy

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announced the discovery of a "new gaseous bicarburet of hydrogen", now familiar as acetylene. Decades passed, however, before the novel gas acquired any practical significance, and indeed it was not until 1892, when a large-scale method for producing calcium carbide was discovered, that acetylene became of industrial importance. Since then its applications have gone ahead rapidly, and its uses in illumination, in welding, in metal-cutting, and in the synthetic production of organic chemicals are widely known. In view of these lessons from the history of chemical science, one hesitates to apply the epithet 'useless' to any specific observation or discovery, however 'academic'. Reflection indeed suggests that the really big changes in the material conditions of human life have generally had their origin in a search for knowledge on its own account.

There is, however, much more to be said on this matter of fundamental or academic research. A solution of the most practical of chemical problems on rational and scientific lines is possible only because of our accumulated knowledge of natural phenomena and natural laws. It is only against the background provided by the pure research of yesterday that the technical problems of to-day can be viewed in their proper setting and tackled with a reasonable prospect of success. I would submit, therefore, that work in pure science, remote as it generally is from the practical issues of the moment, is building up a real reserve of knowledge and technique on which future generations of practical workers will be able to draw.

Apart from the chemists who are engaged, mostly in our universities and colleges, but to some extent also in the larger research institutes, in the general task of extending the boundaries of knowledge, there are many more who are carrying on what may be called 'directed' research. Their work aims at the solution of some specific problem, concerned, it may be, with the improvement of an industrial process, the elimination of waste, the safeguarding of health, the utilization of by-products, the synthesis of antidotes. More definitely, and by way of example, the object may be to discover a fast blue dye, to purify a water supply, to find a rustless steel, to produce petrol from coal, to isolate a vitamin, to make a non-inflammable film or a creaseless cotton fabric. The general public, however dubious about pure research, would probably admit that the satisfactory solution of any one of these problems would be of service to the community; but it must be emphasized once more that the chemist can do these things only by virtue of his inheritance of knowledge and technique. The attack on such problems, to have a reasonable chance of success, must be organized on the basis of what is already known and what has already been achieved; nay, more, one has abundant ground for belief that the attack, so organized, is bound to succeed, even though it may be 'in the long run'.

In the last twenty years, the amount of directed chemical research in Great Britain has increased enormously. Industries of the most varied description have begun to realize the potential value of the trained chemist in solving their special problems and putting their manufacturing processes on a more rational basis. In this general movement the State, through the Department of Scientific and Industrial Research, has taken a prominent part by fostering research associations. The work of these organizations—such as those dealing with rubber; with paint, colour and varnish; with cotton or wool; with non-ferrous metals; with sugar confectionery—is in many cases largely chemical or physico-chemical in character. The research associations have not only shown how general problems affecting an industry as a whole can be solved by joint research efforts, but also their existence and activities have induced a notable degree of 'research-mindedness' in the individual associated firms. Financially, the work is based on co-operation between the State and industry, on the principle that the State helps those who help themselves.

The State itself has founded a number of organizations for the study of chemical problems of national importance, and has thus formally recognized the significance of directed research for the community. The work carried out at the Chemical Research Laboratory, Teddington, has included the study of synthetic resins and low-temperature tars and the exploration of chemical reactions occurring under high pressure, as well as research on metal corrosion, chemotherapy and water softeners.

Fuel and food are two notable cases in which State-aided investigation is being carried out, and problems connected on one hand with pulverized and colloidal fuel or the low-temperature carbonization of coal, and on the other with the storage of fruit or the preservation of fish and meat, are being intensively studied at appropriate centres. Reference might be made also to the work of the Building Research Station, where, amongst other matters, the factors determining the weathering qualities of stone are being studied. Other experts than chemists are naturally concerned in the investigation of these problems, but the chemical and physico-chemical aspects are frequently the predominating ones.

Again, the serious question of river pollution has been taken in hand with State help, and some years ago a chemical and biological survey of the River Tees was set on foot, the Tees being chosen for investigation because of the great variety of factory effluents discharged into it both in tidal and non-tidal reaches. Some of the newer industrial developments in Britain are presenting important problems in this direction. It has been estimated, for example, that if the waste waters from all the beet sugar factories in the country were discharged into our streams, they would cause as much pollution as untreated sewage from a population of four or five millions. The effluents from dairies and factories making milk products present a similar problem. Thanks, however, to research activity, largely at the instance of the Water Pollution Research Board, the disposal or purification of these and other trade effluents is being effectively achieved.

The question of river purification demands for satisfactory handling, as already indicated, the collaboration of other scientists with the chemist, and indeed the attack on many such problems, especially those affecting the health of the community, is likely to be successful only by the co-operation of teams of scientific workers from different fields. Smoke and fog, which not only present the scientific worker with interesting phenomena but constitute also a social and industrial problem of vital importance, concern the physicist, the physical chemist, the analyst, the fuel engineer and the meteorologist, and it is only when the knowledge and experience of these workers are pooled that there is any hope of interpreting the phenomena and solving the problem. Again, recent developments in cancer research make it clear that apart from the pathologist, who is mainly concerned, the chemist has a very definite contribution to make to our knowledge of this baffling disease. Some of the most fruitful scientific investigation, indeed, is co-operative in character.

Research, whether fundamental or directed, is by no means the only outlet for the chemist's knowledge and craftsmanship. The works control of chemical processes, the examination of factory products, the safeguarding of the purity of food, and the supervision of water supplies and sanitation, are examples of other activities of a more routine character in which large numbers of chemists are engaged. These are, so to speak, the general practitioners of the chemical profession, and their contribution to the smooth running of industry and to healthy living is far greater than most people suppose. I have myself been surprised, in a recent survey of the present occupations of my former students, by the extraordinary variety of the work in which chemically trained men may be engaged. This survey shows that photographic emulsions, beer, high-speed steel, printing ink, linoleum, dental cream, gramophone records, bank notes, and mineral waters, are a few of the materials with the production of which the chemist is concerned, either in the laboratory or the works. It is true to say that in the industry of the country the chemist is ubiquitous.

I have spoken of the 'chemical profession', and the phrase was used deliberately. A profession is a vocation demanding high educational and technical qualifications, and it connotes also the body of those who by virtue of their qualifications are able to serve the needs and welfare of society in some particular field. On all these counts, chemistry should have a place beside medicine, law and engineering. That the public is so slow in recognizing this claim may be due to the fact that the chemical profession is not yet unified to the same extent as the others mentioned ; but it is due also to a lack of realization of the fundamental and widespread character of the service which the chemist renders to the community.

A just estimate of the chemist's function is almost impossible for those who associate him chiefly with explosives and poison gas, and regard him as a particularly devilish kind of scientist. Such a picture is hopelessly out of relation with the facts. It is, of course, true that chemists have produced dangerous and poisonous substances, but most of these were discovered originally in the general quest for knowledge, and many have legitimate and valuable applications ; their use for destructive purposes is a perversion. Phosgene, for example, one of the so-called poison gases, was discovered more than a hundred years ago, and is an important material at the intermediate stage in the manufacture of certain dyestuffs. Nitrates, which are the basis for the manufacture of most explosives, play a prominent role as fertilizers in agriculture, and explosives themselves are indispensable in mining operations.

The truth is that the employment for other than beneficial ends of the substances discovered by the chemist is due, not to his especial wickedness, but to the weakness and backwardness of the human spirit. Like other scientists, the chemist normally has a constructive point of view, and he cannot but deplore the fact that, as Sir Alfred Ewing once said : "The command of Nature has been put into man's hands before he knows how to command himself". I think I speak for the vast majority of my fellow-chemists in saying that we dislike intensely the present world-wide prostitution of knowledge and skill to destructive ends. The sooner this is eliminated, and the less call there is for lethal and devastating materials, the greater will be our satisfaction.

There are, indeed, welcome signs that scientific workers are increasingly impatient at the extent to which their knowledge is made to serve inhuman ends. The possibilities before humanity have been fairly set out by a recent historian, H. A. L. Fisher: "The developing miracle of science is at our disposal to use or to abuse, to make or to mar. With science we may lay civilization in ruins, or enter into a period of plenty and well-being, the like of which has never been experienced by mankind". To the clearing of this conflicting situation, the scientific worker has not always made the constructive contribution which he might have done: he has been content to adopt an objective and detached attitude, suggesting sometimes complete indifference to the wider human issues at stake, assenting too readily to the misuse of his knowledge and skill. Impelled by patriotic motives, most men of science have put themselves freely at the disposal of the State in time of need, but many are hesitating to admit that patriotism must always override considerations of humanity. Whatever be our individual attitude in this matter, it is time for chemists and scientists in general to throw their weight into the scale against the tendencies which are dragging science and civilization down and debasing our heritage of intellectual and spiritual values.

Obituary

Prof. A. P. Karpinsky

PROF. ALEXANDER PETROVICH KARPINSKY, the greatest of Soviet geologists, president of the Academy of Sciences of the U.S.S.R., of which he had been a member for fifty years, died on July 15 in his ninetieth year. He was a foreign member of many learned bodies; the Geological Society of London elected him a foreign member in 1901 and awarded him the Wollaston Medal in 1916.

An entire epoch in the history of Russian geology, following that of Murchison (the forties of the past century), is connected with Karpinsky's name. Karpinsky compiled a new, much more detailed geological map of the European part of the U.S.S.R. and the Urals. This map was the ground-work of the Russian geological service, of which he was one of the creators, and which was then known as the Geological Committee. Being during many years practically the head and leader of that institution, the staff of which was mainly composed of his pupils, Karpinsky was the creator of the new stratigraphy of Russia. This, however, does not exhaust the significance of Karpinsky's work in the history of geology. He was the last of those geologists who embraced the whole of geological science, working with equal skill in every branch of it.

Karpinsky's personal field-work in stratigraphy concerned all the systems and various regions of the European part of the U.S.S.R., but mainly the Urals; he was the first to solve the enigma of the eastern slope of the latter. His contributions which demonstrated the tectonic structure of the Russian platform were only completed, never reconstructed by later explorers, and were of immense value. He first established the regularity of movements of the earth's crust. Only much later did his ideas receive wider development in the theory of geosynclines.

Karpinsky's palæontological studies are of no less importance. Of his works on invertebrates the most remarkable are those concerning the palæozoic ammonoids. He was one of the first to apply the ontogenetic method, and not to single forms, but to a whole fauna. This led to most important conclusions both zoological and geological (he proved the evolution of the Artinskian fauna *in situ*, whereas it was considered immigrant). A most remarkable study is that on *Helicoprion*, a primitive shark, to the study of which he applied the histological method with brilliant results.

Particular attention may be directed to his monograph on Trochilisks—tiny Devonian algæ. To write this monograph, Karpinsky had to become a botanist. It is curious to note that in a controversy with botanists who did not share Karpinsky's opinion of these fossils, the victory went to Karpinsky. In petrology, besides special studies by which began his scientific activity, it is worth mentioning that he was the first in Russia to introduce the microscope in the study of petrographic slides.

From the very beginning of his scientific activity, Karpinsky was interested in deposits of useful minerals. He forecast the discovery of salt at Bakhmut, he advanced the view that petroleum deposits exist in the Urals; this has been brilliantly confirmed by recent prospecting for petroleum at Ishimbaievo, exactly in the Artinskian deposits established by Karpinsky, as well as by that at Krasnokamsk in the Middle Carboniferous. Karpinsky was particularly interested in the problem of the origin of platinum deposits; he studied some iron deposits and so on. He may be justly called the founder of the practical geology of the Urals.

Karpinsky continued working to his last days, and on his death bed he asked for paper to write down a new idea. In Karpinsky we lose not only the greatest Soviet scientist, but also an excellent man and citizen. Despite his high position, he never ceased to be modest, simple, accessible to everyone, especially to young students, at whose disposal he readily put his knowledge and experience. Injustice and untruth alone aroused his anger, and he frequently expressed his sympathy with the Soviet Government, which he used to call "the most just in the world".

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