equally remarkable records of parasitological research on all sorts of animals from amoeba to man.

The significance of studies in parasitology is by no means limited to the fields I have been discussing. Such studies have been shown to have a direct bearing in individual cases on problems of pure science, such as phylogenetic relationships, distribution and the origin of the parasites and their hosts. Kellogg's work on Mallophaga ultimately led to the demonstration of relations between groups of birds which taxonomists had suspected but had not been able to establish on structural evidence. Metcalf's studies on Opalina, a parasite of the frog, forced him to conclude that a previous land connection had existed between South America and Australia. There has been found in the record of the parasites of the salmon, clear evidence that these royal fish are oceanic in origin and that the freshwater migration is a secondary episode in the history of the race.

In a remarkable paper, published after his death, our late deeply lamented vice-president, Dr. S. T. Darling, wrote on "Comparative Helminthology as as Aid in the Solution of Ethnological Problems." Darling advanced the view that it is possible to trace the origin and migration of races of mankind through a study of the species of hookworm which man has harbored in different regions on the earth's surface. The evidence adduced from a study of the two chief species of hookworm, species which in fact are confined to the human host, shows that their distribution depends on the migration of their hosts and not on climate or soil. The world-wide contact which Darling had had with the hookworm problem gave unusual opportunity for securing evidence on the distribution of these parasites in different races. He observed that pure cultures of one species tended to be found in certain ethnic stocks and in certain geographic areas as well. By a careful analysis of the data he traced the origins and movements of primitive peoples in a way that seems at once to confirm and to check the views of those who have attacked the problems from other sides.

HENRY B. WARD
UNIVERSITY OF ILLINOIS

THE SCOPE OF INORGANIC CHEMISTRY. II

PETROLEUM

The complex hydrocarbons which form the main constituents of crude petroleum belong to a section of organic chemistry at present too little explored. Although many millions have been made through the production and sale of petroleum products, it is safe to say that the percentage of profit devoted to research in oil products has been infinitesimal. It is true that in the United States large sums are given by the oil interests towards research in other subjects, but until quite recently none of these was, curiously enough, given for the purpose of improving our knowledge of the science on which the utilization and isolation of petroleum products depends. The reason is not far to seek. The apparently inexhaustible supplies of petroleum render it unnecessary to devise means for economical working. The crudest and most wasteful methods were employed, because economy and the conservation of the natural product were not paying propositions. This applies not only to the methods used in fractionization, but to those employed for the purpose of "cracking" the higher boiling fractions into liquids of lower boiling point. For at the present moment it is the fraction up to 200° C. which is the important product, because it is the "petrol" of the internal combustion engine. Time was, before the introduction of this particular machine, when the light fraction from crude petroleum was a drug on the market, and in many cases was actually set on fire at the refinery because no use could be found for it. In those days the chief product was the kerosene fraction which was used as lamp oil. At the present time the rapid increase in the use of the motor car for personal and commercial transport indicates that at no distant period, if progress continues to be made in the same direction, the amount of the "petrol" fraction will be insufficient for the world's needs. This point has already been reached in America, where approximately 70 per cent. of the world's consumption of petrol (gasoline) is effected. During 1925 the consumption of petrol in the U. S. A. approached 800,000,000 gallons a month, which is about twelve times the amount consumed in this country. It has been stated that one in every five persons in the States—men, women and children—possesses a motor car,[4] and, be this as it may, it is evident that to meet such a colossal consumption means have to be found to utilize the higher boiling fractions, and indeed even the residues from the distillation processes. This "cracking" operation is now carried out on an enormous scale by numerous processes, all subject to patents, but differing from one another but slightly on the question of principle. All depend on the well-established fact that hydrocarbons of high molecular weight will break down into those of lower molecular weight if they are subjected to the requisite degree of temperature. Pressure appears to play an important part in the character of the product, as does also the surface action of the container or material used in the container to promote surface action. All

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[4] Cars registered on January 1, 1925, were: U. S. A., 17,591,981; Canada, 638,794; Great Britain, 1,094,534.

are wasteful, because little or no research has been carried out on the true chemical nature of the cracking operation. Much permanent gas is always produced, consisting for the most part of ethylene and propylene. In the States the ethylene is allowed to go free, because its obvious utilization in the form of ethyl alcohol is attended with difficulties, but the propylene is usually absorbed in sulphuric acid, and thus converted into *iso*propyl alcohol, useful as a solvent. The production of these two unsaturated hydrocarbons provides a clue to the mechanism of the cracking process which is of some significance. If you break a long chain-saturated hydrocarbon one of your products must be an unsaturated hydrocarbon, and it is evident that cracked spirit contains a considerable proportion of such unsaturated bodies. Moreover, the cracking processes at present in use do not produce aromatic hydrocarbons, and it is on the presence of a proportion of these aromatic hydrocarbons that certain special properties of petrol depend. For example, the tendency at the present time is to produce for motor cars internal combustion engines of increased compression ratio, in order mainly to diminish the petrol consumption and thus increase mileage per gallon consumed. For some reason, which research has not yet ascertained, the use of petrol which does not contain the right quantity of aromatic hydrocarbons of the benzene type leads to "detonation," "knocking," or "pinking" when ignited in cylinders giving more than a small compression ratio. This detriment diminishes the value of cracked spirit as such for any but low-compression engines, and many have been the devices suggested in order to overcome this difficulty. A vast number of substances, selected more or less at random, have been tried as "anti-knock" materials, and as an outcome it has been found that one, namely, lead tetraethyl, possesses the property, when present in exceedingly small quantities, of preventing the "detonation" of the explosion mixture in the cylinder. For a time lead tetraethyl (ethyl gas) fell under a ban in the States owing to a fatal accident which attended the spilling of a certain amount in one of the American factories, but it is understood that further investigation has led to a revision of the view first formed, and that considerable quantities of "ethyl gas" are now being used. The writer remembers visiting Wilmington in 1924, when some five hundred gallons of lead tetraethyl were being made daily. Although there was naturally a strong smell of the material in the factory building, and he remained for some hours there, no ill effects were noticed. It is obvious that the conditions which produce "knocking" and the reason why certain substances are "anti-knock" compounds, and why the presence of aromatic hydrocarbons prevents the phenomenon, must be made the subject of systematic research.

The question is also one of national importance, because in the case of high-compression engines, such as those used in aeroplanes, it is essential that a petrol should be used containing a high percentage of aromatic hydrocarbons. In war time these aromatic compounds will be required for the manufacture of explosives, and it is quite certain that there will not be enough for both purposes.

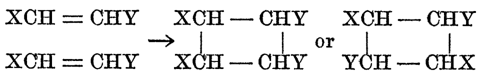
Nevertheless, it must be remembered that it is only at the moment that the low boiling fraction of petroleum is the chief marketable product. It is probable that progress in the future will tend more and more to produce a motor-car engine of the Diesel type, or one having a carburetor capable of effectively vaporizing the higher fractions of petroleum. In these circumstances it may well be that the low fraction will become the less important part of crude petroleum, and that, instead of having to resort to "cracking," a process of synthesis, by which the lower hydrocarbons can be converted into higher ones, will have to be adopted. As a matter of fact there are methods known by which this can be effected. Pure *iso*amylene can, for example, be converted into diamylene by interaction with stannic or aluminium chloride, and the process can be carried further, so that perfectly good lubricating oils can now be made by the polymerization of the lower unsaturated hydrocarbons.

Polymerization and depolymerization are, therefore, the two operations which the petroleum industry must investigate and establish on a firm scientific basis by research, so that it may be in a position to supply the public need for any particular form of engine which the engineer may evolve. Especially is it desirable to ascertain under what conditions polymerization leads to the formation of aromatic and naphthenic hydrocarbons. Considerable attention has been drawn within recent times to what may be termed in general the Bergius processes for depolymerizing organic substances. The operation, which consists in heating the material under high pressure in the presence of hydrogen, was introduced in the first instance for the treatment of coal. There can be no question that great and fundamental changes are brought about in organic substances by the treatment whether a catalyst is present or not, and that a wide field for research is opened up thereby, but it is doubtful if, at the moment, general operations of this type can be regarded as commercial propositions. The plant is exceedingly costly and the conditions subject to wide variations which are difficult to control. Actually it has been ascertained that in the "cracking" of the kerosene fraction of petroleum hydrogen is unnecessary, and can be replaced by nitrogen without affecting the character of the final product.

Little is known of the constituents of crude petroleum, or indeed of the fractions into which it can be separated after purification and distillation. Some of the simpler hydrocarbons of the pentane and hexane type have been isolated and the presence of cyclic compounds has been established. Many of them are classed under the head of "naphthenes," but these are of uncertain structure. No doubt many are present in the crude oil, but it is certain that others are formed during the distillation process. It is clear that much opportunity for research work offers itself here, and it is probable that small alterations in the method of distillation may cause deep-seated changes in the character of the distillate, causing it to be of greater service for particular purposes. The occurrence of hydrocarbons of the naphthalene series in petroleum products has also been clearly established. The higher fractions which constitute the valuable lubricating oils also need attention, for it is now certain that viscosity bears no relation to oiliness, that is, the capacity for acting as an efficient lubricator. The addition of small quantities of "polar" substances of the type of fatty oils or acids confers increased oiliness on these compounds, and although we are now gradually reaching a stage when we know more about the effects of such ingredients, the field for research is still a large and important one.

The formation of free carbon occurs during both the distillation and "cracking" process, in some cases to a very considerable extent. The utilization of this carbon for the purposes of making electrodes is an important part of the industry, and the formation of carbon in a condition in which it can be used by the rubber tire manufacturers is also likely to become practicable as an outcome of the thermal decomposition of hydrocarbons.

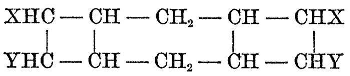
At present we know nothing about the structure of the hydrocarbons present in the lubricating oils. Indeed, it seems possible that these may not be long-chain hydrocarbon with which the organic chemist is familiar, but rather polymerized products formed from unsaturated components liable to be formed or destroyed under comparatively mild conditions. The relative ease with which the oil in the engine sump of a motor car loses its oiliness through continued use is not characteristic of the stability usually associated with an organic hydrocarbon. Recent researches on the formation of dimeric products of the simple type



$$\begin{array}{c} XCH=CHY \\ XCH=CHY \end{array} \rightarrow \begin{array}{ccc} XCH & - & CHY \\ | & & | \\ XCH & - & CHY \end{array} \text{ or } \begin{array}{ccc} XCH & - & CHY \\ | & & | \\ YCH & - & CHX \end{array}$$

shows that the ease of formation and stability of such systems depend on the composition of X and Y. In some cases stable complexes of this kind are formed which can be distilled without undergoing disruption, but which are broken down slowly on prolonged heating even at a moderate temperature.

In the complex hydrocarbons under discussion the letters X and Y represent hydrocarbon residues, probably themselves containing other unsaturated linkages, and under the conditions of high pressure which were probably present during the formation of natural petroleum it is possible that many of these four-membered rings are formed in a single molecule, for example:



$$\begin{array}{ccccccccc} XHC & - & CH & - & CH_2 & - & CH & - & CHX \\ | & & | & & & & | & & | \\ YHC & - & CH & - & CH_2 & - & CH & - & CHY \end{array}$$

an expression which, incidentally, indicates the manner in which the cyclohexane complex can also be produced by a similar process. So far as the chemistry of petroleum is concerned this is at present mere surmise, which must be investigated as soon as practicable. The view is, however, rendered plausible by the work which has been carried out at the Imperial College during the past five years, which shows conclusively that the formation and stability of ring systems depends on the character of the groups attached to the carbon atoms forming the rings, and is not merely dependent, as Baeyer supposed, on the tetrahedral angle of the carbon atoms involved. It is probable also that a similar explanation may account for the "naphthenes," and will provide a general explanation of polymerization and depolymerization upon which it will be possible to base improved technical processes.

The composition of petroleums varies in accordance with their origin. Some are rich in aromatic hydrocarbons, and some are practically sulphur free; others contain so much of the last-named element as to render them unfit for use. The Kimmeridge shale oils are instances of the latter type, although doubtless if it were a paying proposition the sulphur could be readily eliminated from these products. The oil from the Persian, Mexican and Ohio fields contains sulphur which has to be eliminated during the process of refining. Among the sulphur compounds present mercaptans and thioethers have been identified, although whether they are present in the crude oil as such, or whether they are formed during the refining process is still an open question. Their removal by washing with liquid SO_2, an operation which is now carried out on a very large scale at the refineries at Skewen, is of interest.

It is clear, therefore, that the need for systematic research into the character of petroleum products is urgent, and it is gratifying to note that the Anglo-

Persian Oil Company has established a research laboratory at Sunbury-on-Thames, in which the important principles underlying the industry have been and will be studied.

DYESTUFFS AND INTERMEDIATES

Prior to the war Germany manufactured three fourths of the dyestuffs required for the world's markets. Of the remaining one fourth, one half was made from German intermediates and was, therefore, dependent on Germany. Switzerland, although without a domestic source of raw materials, ranked second with about 7 per cent. of the world's production. Great Britain produced about one tenth of her requirements, and France produced in French-owned and operated plants from 10 to 15 per cent. of her consumption. In order to meet the patent requirements of France and Great Britain, German manufacturers operated plants in those countries where the final assembling operations were completed. The small dye industry of the United States was almost entirely dependent upon German intermediates. At the present time Great Britain produces 80 per cent. of the dyestuffs required for our own use, and we are, therefore, in a position to review the conditions which have led to this remarkable change and to consider the procedure necessary to strengthen it. It can not be said that any fundamental advance in the chemistry of the dyestuffs has been made since Bohn discovered indanthrene in 1901, although great advances have been made since then in the preparation of new colors belonging to this and other known series. Consequently, the research work necessary in order to establish our position as a dye-making country has been mainly along known lines, involving the extension of reactions which had already been established rather than the discovery of new ones. Nevertheless it is no inconsiderable achievement for our research chemists to have established a position such as that indicated above in so short a space of time, for many of the preparations, the details of which could only be found in the patent literature, had to be worked out *de novo* and the correct conditions found for their adaptation to the technical scale. It is probably along the lines of decreased cost of production that research work in the immediate future will be mostly engaged, and especially is this the case with the intermediate products from which the dyestuffs are derived. Moreover, the intermediate products are of the greatest importance for other industries, for example, the fine chemical industry, the perfumery and the explosives industries, and any improvement in the processes for their manufacture or the production of new compounds having enhanced value from the commercial point of view is of the greatest importance to all these industries alike. The parent substances of the intermediate products are the hydrocarbons of coal-tar or the coke oven by-products. The operations required to convert these hydrocarbons into the finished intermediates often involve many stages, any one of which depends for its cost on the purity and yield of the product. When large quantities are involved a difference of 1 per cent. in the yield may lead to a considerable difference in the cost of production, and it is obvious that reactions which yield their products in a state of purity sufficient for the market or further stage production without subsequent treatment make for reduced cost in production. There is thus a wide field for research into the improvement of technical methods which may well occupy the attention of our dyestuffs chemists for some time to come. On the other hand the question of fundamental research into new processes, both for the preparation of new intermediates and new dyestuffs must not be lost sight of. The intermediate determines the character of the dyestuff, and it is always possible that a new intermediate may be discovered which will yield a dyestuff with just that difference of shade as to catch the public fancy, and which will lead to the replacement of the older dyestuff on the market. The sulphonic acids of the naphthol, naphthylamines and amino-naphthols are cases in point. These substances are used extensively for the preparation of azo dyes. There are a great number of these compounds theoretically possible, but only a few have found technical application owing mainly to the high cost of producing the others. The high cost is nearly always caused by poverty of yield, an objection which may be at any time removed by the discovery of an improved process. The same argument holds good for the dyestuffs themselves. It is futile to say that the vast field of organic chemistry has been thoroughly explored for the production of new types. At any moment one or other of the men or women engaged in fundamental research may repeat Bohn's discovery of 1901, and obtain a new compound which will be the forerunner of a new series of dyestuffs. It is perhaps too much to ask an industry which is struggling to hold its own to expend large sums on the prosecution of abstract research, most of which will be of no use to it, but it is not too much to expect that the industry will take every means to foster and encourage abstract research in our university institutions, and even to give some lead as to the direction in which its experience leads it to think that advances may be made. There is at present no organization which can bring the manufacturers of dyestuffs and intermediates into touch with the work being carried on in our university laboratories, and it is possible that if at the present time a valuable discovery were to be made it would be unrecognized as such, and, following the usual course of academic research, would be published and thus lost to the country. What is required is a lead from manufacturers which will indicate the matters which they regard of importance, but which they do not consider as likely to yield results sufficiently quickly to justify them in employing their own research staff for investigating them. This aspect is of all the more importance at the present time, when organic chemistry is entering on a new phase which will undoubtedly revolutionize many of the existing processes of manufacture. It is now recognized that the presence of a small quantity of a catalyst may either alter the course of a reaction or may lead it to proceed to completion where otherwise a totally inadequate yield would be obtained. The catalyst may either be added or the containing walls of the reaction vessel may act in this capacity. The well-known example of the oxidation of naphthalene to phthalic anhydride by vanadium pentoxide is an example of this, but similar cases are continually recurring, and it has only recently been found that the classical method for preparing ketones by the distillation of the calcium salt of the appropriate acid can be utilized in the most unexpected directions if the thorium salt instead of the calcium salt is employed. It is perhaps appropriate to conclude this section by the following quotation from the United States Tariff Commission Report, No. 32:

> The acute shortage of dyes arising in the various dye-consuming markets, due to the disappearance of German dyes shortly after the beginning of the war, was soon followed by prices of unprecedented levels, while certain dyes were not to be had at any price. This dye famine threatened the activities of the vast textile industries, as well as other industries dependent upon dyes for their operation. The manufacture of dyes was soon entered upon in the United States, Great Britain, France and Italy, and each of these countries has developed a dye industry capable of supplying from 80 to 90 per cent. of its requirements and has, in addition, exported significant quantities of dyes since the war. As a result of this remarkable period of expansion and development the world's present capacity to produce dyes is nearly double that of the pre-war period. This existing capacity to produce over and above normal requirements is resulting in an era of severe competition in the world's markets which may eliminate many of the plants now in operation. The German industry has certain advantages over the industries of the new producing countries, including cumulative experience, unified organization for buying and selling, and lower manufacturing costs. The high post-war price levels of dyes exported from Germany would appear to indicate a strong probability of price reductions during the next few years. The commercial warfare which is likely to follow may involve the utilization of such methods as full-line forcing and dumping, such as was practiced by the German chemical industry prior to the war. The retention of a tariff and other protective measures by the new producing countries will doubtless lead the German industry to form affiliations to establish branch plants in those countries. The war made clear the relationship of the coal-tar dye industry to the production of munitions, war gases, medicinals and other essential products, and demonstrated the desirability of home dye production as a means to prevent shortage in times of war. This will probably result in an effort by the large industrial nations to retain dye industries of sufficient size to meet peace requirements and to provide for war emergencies. Reduced production costs and constructive research will be vital factors in the maintenance of their competitive place in the world's trade.

This seems to sum up the situation with which we are at present faced.

PUBLICATIONS

Our chemical publications grow apace—already they have outstripped in number and size those produced prior to the war. If one may take the *Journal* of the Chemical Society as representing a standard example, it may be noted that the number of pages published in 1914 was 2,909, whilst in 1923 the number was 3,441. This was reduced in 1924 to 2,698 pages, but rose again in 1925 to 2,986 pages. The drop in 1923–1924 was not, however, due to lack of material but to the exercise of necessary economy because the costs of printing have increased by 70 per cent. since the war, and the funds of the society could not carry the increased expenditure. Until new sources of income could be created economy had to take the form of asking authors to cut down their papers to the greatest possible extent, and this had the effect of checking the advance for that year. Nevertheless during 1925, although authors continued to cooperate and still expressed their views and results in as small a space as possible, the steady rise in the amount of research work carried out in the country led to an increase in that year, showing that the new matter was due to new research and was not the outcome of any remissness on the part of the publications committee.

The increase is still continuing, and is a welcome sign of the healthy condition in which research in chemistry stands at the present time. Still it means a journal of well over 3,000 pages for 1926, and represents a condition of affairs which is shared by many other scientific societies.

There were many national scientific shortcomings revealed by the war, but it is probable that those in the chemical sciences loomed largest because they were the ones which had to be rectified by makeshift arrangements at the time, and although our national aptitude rose to the occasion, and we blundered through in our usual manner, yet when time for thought occurred the contrast between our state of unpreparedness and the complete scientific equipment of our enemies was very marked, and gave cause for earnest consideration. The result has been a great increase in the numbers entering our chemical research schools and the consequent output of an increased amount of new knowledge, all of which has to be recorded. The burden of publication has fallen, therefore, heavily on the societies dealing with chemistry, and more particularly on the Chemical Society, which is the chief means by which, through its journal, new knowledge is published to the world.

The remedy is not obvious. The societies can not increase their subscriptions without inviting loss of membership. Neither does it seem that much is to be gained by amalgamation, because each society deals with some branch of chemistry, and there is little or no overlapping or duplication. Amalgamation of the societies would not, therefore, decrease the costs of publication nor materially diminish the subscriptions necessary to meet these costs.

You can not curtail papers beyond the point which enables the work described to be repeated, otherwise publication is valueless. You can not say within wide limits that new knowledge is not worth recording, or that views expressed are best suppressed. The criticism has been raised that the modern tendency to issue short communications at frequent intervals leads to premature publication, and that much that is published has to be corrected in later papers, and it can not be denied that recent experience has shown this criticism to be partly true. But it has been the custom of societies to accept short papers with more avidity than long ones, and in consequence authors have come to realize that the short communication stands more chance of acceptance than longer ones. The policy is in a sense wrong, because a series of short papers on the same subject necessarily leads to redundancy and frequently to a revision of the views expressed in earlier parts as the work progresses. The trouble seems to lie in the custom which requires an introduction to the series, the aim of which is to give the reader who has no interest in the experimental details a readable account of the scope of the work. If this "introduction" were abolished and a "summary and conclusions" placed at the end of the paper or series of papers, it would no doubt crab the literary style of the author and detract from the value of the communication as bedside reading matter, but it would most certainly shorten the paper and would no doubt enhance its value from the scientific standpoint.

When it is remembered that there are some 23,000 scientific periodicals published throughout the world the mind stands appalled at the prospect that will confront civilization even in so short a time as 100 years hence, unless some general method of curtailment is agreed on. The space occupied by our ever-increasing libraries must cause alarm to those who contemplate the possibilities of the future. The agreement between the various societies dealing with chemistry to form a joint library at Burlington House means at the present time an increase of something like 800 volumes yearly—an increase which will augment as time goes on. In the not far distant future the library will occupy the whole of the space available in the society's apartments, and the same problem has to be faced by every other scientific society. Indeed, civilization seems to be confronted with two ever-growing problems—the increase in its cemeteries and its libraries. The former, no doubt, will be solved by cremation. Is it too much to hope that a judicious exercise of this method may also be applied to our libraries?

J. F. THORPE

SCIENTIFIC EVENTS

THE INTERNATIONAL GEOLOGICAL CONGRESS AT MADRID[1]

THE fourteenth session of the International Geological Congress was held in Madrid towards the end of May last. It was presided over by Senor D. César Rubio y Munoz, under the honorary presidency of His Majesty King Alfonso. Senor Rubio is the president of the Board of Mines and was formerly president of the Geological Institute, entrusted with the preparation of the geological map of Spain. His successor, Senor D. Domingo de Orneta, who was to have taken an active part in the meeting, died shortly before it was held.

The Geological Congress is almost the sole survivor of the scientific congresses which formerly played such an important rôle in international scientific comity. It is still open to men of science of all nations, a distinction to which the scientific unions constituted under the International Research Council can lay no claim.

After a preliminary meeting of the government delegates on the previous day, the congress was formally inaugurated by the King on Monday, May 24. The total number of members was more than a thousand. Many of these had already taken part in excursions to the Canary Islands and Morocco, or to Huelva, famous for its cupriferous pyrites, or other places of geological interest in the south of Spain. Toledo, Aranjuez, Almaden with its mines of mercury and

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[1] From *Nature*.