

sulphate-reducing bacteria is in progress along two main lines: (1) field tests on different types of protective coatings, and (2) fundamental studies on sulphate-reducing bacteria in which the metabolism of these organisms is being investigated in the expectation that such knowledge may give a clue to a method of preventing corrosion.

A considerable amount of pure gallium metal has been recovered from flue dust by the Inorganic Group. This has been distributed to various research laboratories for examination of the properties. The electrical and thermal conductivities of the metal have been found to vary in a ratio of 1 to 7 according to the orientation of the crystal growth, and a striking demonstration of this directional difference in thermal conductivity was shown. The work of the Microanalytical Laboratory in this Group has developed rapidly during the year, and more spectrometric equipment, notably a grating spectrograph, has been acquired.

A section of the work of the Radiochemical Group is concerned with the separation of inorganic salts on paper strips or cellulose columns by organic solvents, and has been carried out in part in collaboration with the Inorganic Group. Many striking examples of the separation of various mixtures, including some of the well-known analytical group separations, were shown. Other exhibits related to methods used in treatment and control processes and to analytical methods developed for the examination of radioactive ores.

Modern physical methods such as ultra-violet, infra-red and mass spectroscopy are capable of analysing many multi-component mixtures of industrial importance; but, in general, these physical methods can only be used to express the results in terms of a percentage of a standard sample. It is not sufficient only to purify compounds to provide these standards; there must also be established criteria of purity such as density, refractive index, freezing point, ultra-violet and infra-red spectra. In addition to these physico-chemical measurements, there are a number of others which may be used in the search for improved or new processes. This type of work is in the province of the Purification and Measurement Section of the Organic Group. Work is being done at present on the heterocyclic bases in coal tar; but, now that the necessary apparatus has been assembled, further extensions of the work may be expected to include compounds of other classes.

There are two Organic Intermediates Sections within the Organic Group. The first deals mainly with aromatic compounds, and a study of the co-polymers of acenaphthylene with other unsaturated monomers has been completed. In another project the hydrogenation of pyridine and the examination of the higher boiling fractions of the product has yielded N-alkyl compounds having either (a) 'knock down' action or (b) lethal value when tested against *Calandra granaria* and *Blattella germanica*. Some of the constituents of these fractions have been identified and compared with synthetic reference compounds. The second Intermediates Section is concerned with research on the synthesis of organic compounds containing either heavy or radioactive carbon. In addition, the pure hydrocarbon, decosane, and a pure sample of stearic acid have been prepared for lubrication studies in the Engineering Division, National Physical Laboratory.

The work of the High Polymers and Plastics Section is largely concerned with a fundamental

investigation of the ion-exchange properties of synthetic polymers. Monofunctional exchangers, for example sulphonated cross-linked polystyrene or cross-linked polymethacrylic acid, are more suitable for study than earlier resins which contained two or more ionizable groups, in that there is no possibility of interference between different groups. The influence of polymer structure on exchange-rates and affinities is being examined with sulphonated cross-linked polystyrene. The technique of suspension polymerization enables this latter material to be prepared in the form of spherical beads.

In connexion with research on adhesives for aluminium alloys, it has been shown that a mild abrasive pretreatment of the metal surface gives more reproducible joint-strengths than the chromic acid-sulphuric acid pickle commonly used.

The workshop is now fully equipped with motorized machine tools, and a colour scheme has been adopted to improve illumination and environment and to reduce eye strain.

55f GROWTH-PROMOTING SUBSTANCES IN AGRICULTURE AND HORTICULTURE

THE discovery that the normal growth of plants is under the control of minute quantities of certain organic substances was the outcome of an interesting chapter in botanical research. Rapid developments on the chemical side followed the recognition of β -indolylacetic acid as a potent growth-regulating substance, and, at the present time, a wide range of synthetic materials capable of inducing growth responses is available. Some of the effects produced are of considerable agricultural and horticultural importance, and research on chemical, physiological and practical aspects is being vigorously pursued.

At a symposium held at the Imperial College of Science and Technology, London, by the Association of Applied Biologists on March 16, the results of recent work on "Growth-promoting Substances in Agriculture and Horticulture" were presented and discussed. Selective weed control was not included, this aspect having been recently and adequately reviewed¹.

In introducing the symposium, Prof. F. G. Gregory dealt briefly with historical aspects. The early experiments of Darwin (1880), in which the extreme tips of roots and shoots were shown to be receptive to light and gravity, led him to conclude that some influence was transmitted from these extremities to the part of the plant showing the response. These findings were carried further by Sachs, who indicated that there was produced in cuttings a substance which moved downwards and caused initiation of roots. Some thirty years later, Boysen Jensen demonstrated that the substance which accumulated under the influence of light in the tip of an *Avena* coleoptile would apparently pass through a gelatin barrier placed between the severed tip and base, and in 1927 Went, who did much to put the study of the natural auxins on a quantitative basis, showed that the substance could diffuse from the excised tip into agar. That auxins may also produce inhibitory effects was next recognized, Thimann showing that

the repressive influence exerted by the terminal bud of a shoot on the development of lateral buds is due to an auxin. Kögl's isolation of auxins *a* and *b* and, particularly, heteroauxin from human urine, stimulated Zimmerman and Hitchcock, among others, to synthesize and test a large number of organic compounds of comparatively simple structure. From such investigations have arisen the materials now proving of practical value to the agriculturist and horticulturist for such uses as selective weed control, rooting of cuttings, setting of certain fruits, prolonging the dormancy of buds and preventing the premature dropping of fruits. Haberlandt's demonstration that cell division is promoted by the presence of crushed cells led to the concept of wound hormones and paved the way to the isolation of traumatic acid by English, Bonner and Haagen-Smit. Attempts to isolate a flowering hormone from plants have so far been unsuccessful, though 2,3,5-triiodobenzoic acid has been shown to stimulate the production of abnormally placed inflorescences in the tomato plant.

After this introduction, Miss D. J. Osborne discussed attempts to produce parthenocarpic pears by the use of growth-substances. Some success in this connexion had been reported by Stuienberg, who treated frost-killed blossoms, and by Sereisky. Lewis induced parthenocarpy by frost treatment alone. At Wye, in 1947, a range of synthetic compounds, shown to be effective in producing parthenocarpic tomatoes, were sprayed on to emasculated flowers of Beurre Superfin and Dr. Jules Guyot pears. Sodium α -(2-naphthoxy)-propionate was outstanding in producing a high set, the initial rate of growth being higher than that of normally fertilized fruitlets. After some four weeks, however, development ceased, suggesting that the amount of growth substance supplied in one application was inadequate to stimulate growth of fruit to maturity. Accordingly, in 1948, a more extensive trial was carried out using the same compound on Dr. Jules Guyot and Pitmaston Duchess. Four methods were employed, each of which it was thought might provide a continuous supply of the growth substance to the developing parthenocarpic fruitlets. A successful treatment was spraying at three-day intervals with an aqueous solution of the growth substance. Abscission of fruitlets was thereby considerably reduced on both varieties, and on Pitmaston Duchess 37.5 per cent of the parthenocarpic fruit reached maturity. The single-spray treatment, however, gave the highest percentage yield of mature fruit on Dr. Jules Guyot. A few of the emasculated flowers, which had received water and wetter only, developed to mature parthenocarpic pears on both varieties, an interesting result which Miss Osborne intends to investigate further this year.

The use of growth substances to control the shedding of fruit was reviewed by Dr. M. C. Vyvyan. The heavy loss of fruits by abscission, just after petal-fall and in the 'June drop' which occurs in most fruit trees, tends to adjust the crop to the size of the tree and prevent disorders often associated with an unbalanced crop. Too light a shedding can be supplemented by artificial thinning. A complementary method is required when the loss is too severe and in order to check 'pre-harvest drop' which occurs in some varieties as maturity is approached. Considerable control of the latter, in many apple varieties, was achieved in America in 1939 with sprays containing up to 10 p.p.m. of α -naphthylacetic acid. Similar trials at East Malling and elsewhere² have given excellent results with several

varieties, including the apples, Beauty of Bath and Worcester Pearmain, and the pear, Conference, and have led to widespread use of these sprays. Control of 'June drop' has been disappointing, though some success has been achieved with Cox's Orange Pippin. Under certain conditions, a hastening of maturity of fruit can apparently result from these treatments, such an effect having been observed with some varieties in America. In trials with other growth substances, 2,4-dichlorophenoxy-acetic acid has proved effective with certain American varieties, but may cause damage to fruit or tree. Dr. Vyvyan emphasized that fuller knowledge is required about the abscission process, the natural hormones that apparently control it, and the general mode of action of synthetic growth substances.

Dr. R. L. Wain followed with a contribution on chemical aspects of growth-regulating activity. The assessment of such activity, he pointed out, is complicated by such factors as polar transport, so that different values are often obtained for the same compound when examined by different tests. Koepfli, Thimann and Went in 1938 gave as minimum structural requirements for activity in the Went pea test, (a) a ring system with at least one double bond, (b) a side-chain containing a carboxyl or potential carboxyl group separated from the ring by at least one carbon atom, and (c) a particular space relationship between the ring and the carboxyl group. These requirements are fulfilled by most synthetic growth substances; but some activity is also shown, for example, by α -naphthylnitromethane and by 2-bromo-3-nitro- and 2-chloro-5-nitrobenzoic acids. Zimmerman and Hitchcock, and Veldstra are prominent workers in this field. At Wye, it has been found that replacement of the oxygen bridge of naphthoxy acids by —S— or —NH— or of the carboxyl by the sulphonic acid group gave inactive products. Substitution of one methyl group into the side-chain of various aryloxy-acetic acids usually led to an increased activity in tests based on tomato leaf epinasty and capacity to initiate development of unfertilized tomato ovaries. When two methyl groups were substituted, however, in all series examined, the resulting oxyisobutyric acids were completely inactive in both tests. These results indicate that, for certain activity, at least one hydrogen atom must be attached to the carbon atom adjacent to the carboxyl group. Dr. Wain stated that the Wye experiments are being extended both to include new series of compounds and further methods of assessment.

One of the widest uses of growth substances, up to the present, has been in the vegetative propagation of plants, and this aspect was dealt with by Dr. E. S. J. Hatcher. Following a comparison of natural and horticultural methods of vegetative propagation, the development of the growth-substance method in relation to cuttings was described. It was pointed out that while hundreds of species have responded to treatment, a number usually fail to do so. β -Indolyl-butyric and α -naphthylacetic acids are superior to the naturally occurring auxin, β -indolylacetic acid, in root-promoting power, and, of several methods of application, the concentrated alcoholic dip method is rapidly gaining in favour.

Factors influencing rooting response were then considered, and their operation was illustrated by experiments carried out at East Malling with fruit-tree rootstocks. The necessity of a comprehensive approach to the problem was emphasized, since factors such as species and variety, cultural relations

of source plant, portion of shoot used as cutting and time of planting are involved. Fruit-tree rootstocks, as a class, form one of the most difficult groups of woody species to propagate from cuttings; nevertheless, in suitable circumstances, a pronounced rooting response to growth-substance application is obtainable.

Finally, the effect of the growth-substance treatment on the cutting was discussed. This involved the question of whether the movement of internal substances of a hormonal nature is involved, and mention was made of auxin studies in progress at East Malling on shoots and on cuttings taken from them. There was evidence that varieties of apple and plum which contrasted markedly in their rooting capacity gave differing yields of ether-extractable auxin, greater amounts during dormancy being associated with the easier-rooting plum rootstocks.

"Fruit Drop in Relation to Seed Development in the Apple" was the title of a paper read by Dr. L. C. Luckwill. He described how, using the tomato ovary test, he had made a quantitative study of the hormone which occurs in apple seeds and its possible relation to fruit development and fruit drop³. The hormone apparently originates in the endosperm tissue of the seed, and variations in the amount of hormone in the seed can be correlated with endosperm development. The first appearance of the hormone in the seed, about thirty days after petal fall, corresponds closely with the change from free-nuclear to the cellular condition in the endosperm. Subsequent partial digestion of the endosperm by the rapidly growing embryo is accompanied by a fall in hormone content, which again rises as the embryo growth nears completion. At this stage, both endosperm volume and hormone content are at their maxima. In Lane's Prince Albert, embryo absorption in eighty per cent of the seeds results in seeds containing an abnormally large amount of endosperm and having a correspondingly high hormone content.

These changes in the hormone content of the seed appear to be reflected in the periods of fruit abscission, the peaks of hormone production, in particular, corresponding with the temporary cessation of fruit drop. Seeds from dropped fruitlets have been shown to have a lower hormone content than seeds from attached fruitlets. These results suggest that one of the functions of this endosperm hormone is to control fruit drop. It appears to play no part in the initiation of fruit growth, but the well-known correlations between seed and fruit development in apples suggest that it may influence the later stages.

The contributions made in this symposium and the points raised in the subsequent discussion focused attention on the potential economic value of growth-regulating substances. The marked specificity in response between plant species and growth substance, however, well demonstrated, for example, in pre-harvest drop, weed-killing and rooting effects, indicates that where success has not been achieved, the appropriate compound may still await discovery. Undoubtedly, much further fundamental and applied research is required in this field, before these chemicals can play their full part in crop production.

¹Symposium held by Agricultural Group of Society of Chemical Industry and Society of Public Analysts on February 15, 1949. *Chem. and Indust.*, No. 11, 173 (1949).

²Vyyyan, M. C., *Tech. Comm.* No. 18, Imper. Bur. Hort. Plant Crops (1946).

³Luckwill, L. C., *J. Hort. Sci.*, **24**, 32 (1948).

OBITUARIES

Prof. F. S. Kipping, F.R.S.

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THE death of Frederic Stanley Kipping on May 1 in his eighty-sixth year has removed one of the last links with what may be termed the later classical era of organic chemistry in Britain. His name will always be associated with the chair of chemistry at University College, Nottingham, where for thirty-nine years he directed a small, but extremely productive, school of research. His work gave to the College, which he served so faithfully, university status in the eyes of his contemporaries forty years before the receipt of its University Charter in 1948. He received the Longstaff Medal of the Chemical Society, the Davy Medal of the Royal Society, delivered the Bakerian Lecture and on his retirement in 1936 received the degree of D.Sc. *honoris causa* from the University of Leeds.

Kipping studied at Owens College, Manchester, and afterwards in von Baeyer's laboratory in Munich, where he worked with W. H. Perkin and was a contemporary of J. B. Cohen. The strain theory of von Baeyer owed much to the experimental work of Perkin, and Kipping's early outlook seems to have been influenced by this environment. On his return to England, in continuation of his work on ring systems, he prepared the cyclic bases hydrindamine and methylhydrindamine, resolved them and studied the isomers exhaustively. In 1907 the second of these bases was found to be the only one which was capable of resolving Kipping's first asymmetric compound of silicon, although numerous other bases were examined. This work attracted much attention at the time. He also collaborated in stereochemical work with Pope, whom he met in Armstrong's laboratory in South Kensington.

In 1910 Kipping brought his remarkable skill in the manipulation of unpromising material to bear on the diphenyl- and dibenzylsilicane diols, which he had encountered in the course of his synthetic work. In collaboration with Robert Robison several crystalline condensation products of the original diols were eventually isolated and their structure determined. During this and similar work many viscous residues were obtained, the further examination of which appeared too daunting even to the master, whose mere presence in the laboratory was popularly said to induce the process of crystallization.

Recently these 'silicone polymers' have achieved world-wide recognition as plastics, insulating materials, lubricants and in other connexions. Those who exploited these substances recognized their indebtedness to Kipping, and his pupils welcomed the industrial applications. Kipping's enduring reputation rests, however, on his brilliant investigations in 'academic' chemistry (which received the highest recognition at a time when 'plastics' were almost unknown) and on his skill as a teacher.

In 1936, on the publication of Part 50 of "Organic Derivatives of Silicon", his staff and former students entertained him to dinner. Robison, the discoverer of the mechanism of calcification of cartilage, was in the chair. It was a most happy occasion; the respect and affection in which Kipping was held were manifest in every word which was spoken. The dry, humorous remarks, the caustic comments, the rather gruff encouragements stored for many years in the memories of his pupils were then released. Happy is the man who can inspire such regard.