THE MELLON INSTITUTE, PITTSBURGH

THE fifty-first annual report of the Mellon Institute, Pittsburgh, covering the year ended February 29, 1964*, includes the usual list of publications and records expenditure on independent and sponsored research amounting to 6.4 million dollars. At the end of the year the Institute had a staff of 541, including 347 professional and technical workers. During the year arrangements were made for much closer working with the Carnegie Institute of Technology and the University of Pittsburgh: a non-profit corporation was formed under their joint sponsorship, with the major objective of promoting closer contact and co-ordinated efforts among members of the staffs and local industry.

In theoretical chemistry, the judicious application of the principles of molecular orbital theory and its simplification, ligand field theory, can yield a striking clarification of the various colours exhibited by transition metal ions with the architecture of the crystal lattices housing them. Work on the nature of a chemical binding in transition metal cyanides has been resumed and a general investigation initiated of the relative placement of energy-levels in other families of transition metal elements. In continuum physics, mathematical methods were developed for finding the restrictions which the Second Law of Thermodynamics places on constitutive equations and solutions have been obtained for some unsteady flow problems in the theory of a second-order fluid, a fluid the behaviour of which approximates that of general viscoelastic fluids in slow flows. The coefficient of thermal expansion was determined for several copper germanium alloys with hexagonal close-packed structure by investigating their lattice spacings as a function of temperature between 24° and 600° C. The influence of temperature, strain rate, and interstitial impurities on the plastic deformation of polycrystalline niobium has been investigated, and results from a thermal activation analysis supported the view that the mechanism controlling the rate of flow of dislocations at low temperatures is that of overcoming the Peierls-Nabarro barrier by the nucleation of kinks on dislocations. Electron spin resonance investigations continue to provide very detailed information on the structure of free radicals. An investigation of internal rotation in molecules by low-frequency

infra-red spectroscopy has taken two new directions, one involving torsions of methyl groups attached to a phenyl ring, and the other, torsions round the central single bond in the butadiene glyoxal and acrolein systems.

A new vacuum ultra-violet spectrophotometer with low dispersion is being used to obtain the absorption spectra of systems which have electronic transitions of interest beyond the range of most commercial instruments. Studies on the chemical bonding of *tris*-2,2-dipyridyl complexes with transition metal ions in unusual low oxidation states continued, while an investigation of the different intermediate products isolated during the chemical or electro-chemical reduction of solutions containing tungstates was started. In a direct investigation of hydrogen content of acidic catalysts, it was found the total hydrogen content could be accurately determined by exchange with deuterium. The isomerization of cyclopropane to propylene has been examined over series of alumina and silica-alumina catalysts, and spectroscopic investigations of the chemisorption of triphenylmethane and of polynuclear aromatic hydrocarbons continued.

Other work was concerned with the total synthesis of diterpenes and diterpene alkaloids, and the effect of ring size on the nuclear magnetic resonance shifts of the saturated cyclic hydrocarbons from cyclopropane to cycloheptadecane was investigated. A survey of the chemical and physical characteristics of the asphaltic fractions of some 40 crude oils and other bituminous materials was completed, while a broad research programme of the separation, concentration and identification of volatile components of potential food flavour import was continued. A soluble poly-cyclopentadiene of relatively high molecular weight has been obtained using a new homogeneous catalyst system conveniently formed *in situ*, and the theoretical investigation of branched polymers in dilute solution was extended to include a statistical mechanical calculation of the second virial coefficient in the equation of state for 'comb' molecules. A detailed investigation was undertaken of the crystallization, kinetics and morphology of poly (tetramethyl-*p*-phenylene) siloxane. A rapid method of electrophoresis on cellulose acetate strips has been found for developing the electrophoretic components of bromegrass mosaic virus.

* Mellon Institute. Fifty-first Annual Report of the Institute for the Fiscal Year ended February 29, 1964. Pp. 39. (Pittsburgh, Pa.: Mellon Institute, 1964.)

MIRIDS AND OTHER INSECT PESTS OF COCOA

IN view of the common problems which prevail in the field of agricultural research in West Africa, the Governments of the then British and French Territories decided to institute a series of conferences on cocoa (*Theobroma cacao* L.), oil palms, rice, groundnuts and other crops to which the Belgian, Liberian, Portuguese and Spanish Governments would be invited. The first of these conferences was on cocoa and was held at the West African Cocoa Research Institute (now Cocoa Research Institute (Ghana Academy of Sciences)) at Tafo in Ghana in December 1953 (ref. 1). Apart from a conference on Cacao Breeding², held in Ghana in 1956, no further conferences on cocoa occurred in this series until August 1963, when a conference on Cacao Mirid Control^{3,4} was held in Ghana. At this conference information was released on the existence within Ghana of populations of the mirid (= capsid) *Distantiella theobroma* (Dist.) (Hemiptera; Miridae) resistant to lindane (gamma-BHC) and to other cyclo-diene insecticides.

At the same conference, data suggesting the existence within Nigeria of a similarly resistant mirid, *Sahlbergella*

singularis Hagl., were presented. *D. theobroma* and *S. singularis* being the most important insect pests of cocoa in West Africa, it was the feeling of the 1963 conference that the problems of resistance and control should be the subject of another meeting in March of the following year when the results of experimental work in the intervening season of high mirid populations would be available. The opportunity was also taken to include other insect pests of cocoa, and the conference was held during March 24-27, 1964, at the West African Cocoa Research Institute (Nigeria) at Ibadan, Western Nigeria. In view of the prevalence of mirid attack on cocoa in many producer countries outside Africa and of other common entomological problems, this conference was given an international bias.

The emphasis of the conference was naturally on mirid resistance and control, but Mr. P. F. Entwistle and Mr. A. Youdeowei presented a general, but preliminary, world review of cocoa mirids. Attack on cocoa by a mirid (*Helopeltis antonii* Sign.) was first noted in Ceylon in 1863 (ref. 5), and since then at least 34 more species have

appeared on cocoa throughout the world. The only significant producing area which appears to have remained entirely free from attack is the Caribbean archipelago. New adaptations of mirids to cocoa have occurred in recent times; for example, during the past ten years, five species have appeared on cocoa in the Territory of Papua and New Guinea (1954-57), one species in Madagascar (1960), and two species in the State of Sabah (Malaysia) (1961-62). In addition, *H. antonii* appears to have been completely replaced on cocoa in Ceylon by *Helopeltis ceylonensis* De Silva, a species not described until 1957. *S. singularis*, which at one time appeared to be the dominant species in Ghana, has, since the wide-scale use of lindane, become much less common than *D. theobroma*⁴. This dynamic situation extends to behaviour within the crop; for example, *D. theobroma*, which now attacks both mature and seedling trees, was at one time restricted to seedlings. It is not easy to make a world assessment of the status of mirids as pests, but there is little doubt that attack is most severe in West Africa. In the New World, attack tends to be locally restricted, and this is also true of Papua and New Guinea and of Sabah, but not of Ceylon and Java, where attack is by species of the genus *Helopeltis* (which have a very wide host-plant range).

Mr. G. R. Conway reported that in Sabah a hitherto undescribed mirid species, *Platygomirioides apiformis* Ghauri, and *Helopeltis clavifer* Walk. (which first attacked cocoa in Papua and New Guinea in 1954), has recently begun to attack cocoa. *P. apiformis* initially confined its attacks to pods, but later began to damage stems severely and is considered a potentially more serious pest than *H. clavifer*. Mr. G. S. Dun submitted notes on a list of 249 cocoa pests in the Territory of Papua and New Guinea, prepared by Dr. J. J. H. Szent-Ivany, among which were five species of mirids which did not begin to attack cocoa until 1954.

Mr. M. Wessel presented a paper on the climate of the cocoa-growing areas of Western Nigeria, in comparison with some other producer countries in West Africa, which provided a necessary background to discussion of species distribution and the design of regionally adapted spray programmes. M. J. E. Decelle and Dr. G. Nonveiller reported there was no resistance in the Ivory Coast or Cameroun, though one population of *D. theobroma* in the Ivory Coast showed a bimodal distribution of kill when exposed to cyclodiene insecticides. Mr. J. N. Telford said *D. theobroma* was found to be resistant in a large area of Ghana comprising a portion of Ashanti and Eastern Region and also in a number of smaller isolated areas within these two Regions. The intensity of resistance had not been fully measured, though three areas tested contained 90-100 per cent resistant individuals. While no indication of resistance in *S. singularis* had been found in Ghana, Mr. Entwistle reported that a population of this species containing resistant individuals has been located in Western Nigeria. *D. theobroma* occurs sparingly within the area of resistance of *S. singularis* in Nigeria, but does not itself appear to be resistant.

In the Ivory Coast, M. Decelle reported that nine phosphoric esters were tested in the laboratory on cocoa mirids and the action of dichlorovos (DDVP) was noted to be particularly fast, though in comparison with 'Sumithion' it gave poor control in field trials at 0.3 per cent. Mr. G. Prins described the laboratory assessment of 16 organophosphates, five carbamates, one vegetable and one vegetable insecticide plus a synergist sprayed on to various parts of anaesthetized fourth and fifth instar nymphs of *D. theobroma* in Ghana. He assessed his results by the

$$\text{'Index of effectiveness'} = \left(\frac{\text{oral LD50 to rats}}{\text{LD50 to insects} \times 1,000} \right)$$

which is an attempt to combine safety to humans with insecticidal activity, and is used primarily by the United

Nations World Health Organization. He found eleven compounds to have a higher index than lindane. Dr. B. M. Gerard suggested that 'index of acceptability' would be a better name and thought it best to ignore the index altogether when the insecticide is 'obviously safe', and to consider only its efficiency and cost. On this basis, and from some additional data, Dr. Gerard considered only seven or eight of these candidate compounds worthy of field tests.

Dr. D. G. Peterson and Mr. E. F. Bond described the final phase of their field control experiments in Ghana with 'Sumithion' and carbaryl ('Sevin 85-S') which, when applied by motor-powered knapsack machines adjusted to deliver 0.19 gal. per min, were equally effective, in contrast to laboratory findings which suggested that, when applied in acetone solution, carbaryl has eight times the efficiency of 'Sumithion'. In Nigeria, Mr. Entwistle, Mr. Youdeowei and Mr. W. Eguagie conducted trials with these two insecticides applied with pneumatic knapsack machines fitted with spray lances 5 ft. long, a type which many farmers already possess. These machines have a shorter distance of throw (about 5 ft. with the model used) and distribute the spray deposit less satisfactorily than motor-powered ones. Two oz. carbaryl or 1 oz. 'Sumithion' in 5 gal. water per 100 trees gives approximately 86 per cent control. At the same toxicant level, but at lower volumes, less control was achieved, and increasing the toxicant by 50 per cent, at the 5-gal. rate, did not appear to improve control. Hence volume, probably as coverage, seems to be the limiting factor.

Dr. G. E. Marshall commented on some of the problems inherent in the conduct of mirid control trials. Among variables are the mechanically disturbing effect of counting on mirid populations, recorder and spray application efficiency and differences in coverage resulting from the use of different types of machine. He pointed to the necessity for developing both intra- and inter-nationally standardized experimental procedures which will allow a comparison of findings. There is a need for developing additional screening steps between purely laboratory assessment and full-scale field trials.

Extension work in mirid control was described by Mr. J. O. Akinwolemiwa for Western Nigeria, where 600,000 farmers have been trained in mirid control during 1956-63, and by Dr. Nonveiller for Cameroun, where the 1964 anti-mirid campaign is designed to treat 350,000 acres.

Dr. J. Miyamoto reported that the poorer penetrability of 'Sumioxon' than methylparaoxon (the oxygen analogues of 'Sumithion' and methylparathion) to brain, together with the poorer formation of acid-precipitable phosphorus therein, were assumed to be the main factors in reducing the toxicity of 'Sumithion'. M. Decelle reported that carbaryl and 'Sumithion' caused no alteration in cocoa flavour, but that "three or four tasters", out of a total of "22-24", showed slight allergic reactions after tasting the 'Sumithion'-treated samples.

Mr. Youdeowei reported on progress in the development of artificial methods of rearing mirids (particularly *S. singularis*) in Nigeria, work which is of importance not only for the investigation of the genetics of resistance to insecticides, but which could also provide a supply of mirids for laboratory work at times of the year when they are scarce in the field.

Experiments in Ghana, where most of the cocoa is grown beneath the shade of forest trees, have shown that shade removal leads quickly to greatly increased yields⁶. Dr. Gerard presented a paper on the insect pests of unshaded cocoa in Ghana and advised that before widespread shade removal is recommended its side-effects should be investigated on large trial plots.

Mr. W. R. Ingram described the development of injurious infestations of the aphid *Toxoptera aurantii* B. de Fon. on seedlings in nurseries in Uganda, which he thought might be partially attributed to the previous use of DDT

to control caterpillars. Menazon, a systemic insecticide, applied at 0.25 per cent, gave excellent control.

Mr. C. O. R. Everard assessed the rodent problem on cocoa in West Africa. Most losses were of pods from the trees rather than during drying or in storage. Under conditions of good husbandry pod losses should not normally exceed 3 per cent. The use of the most efficient traps available would be unlikely to reduce losses appreciably, and probably the best means of protection lies in the use of relatively non-toxic repellents applied directly to the pods.

The working session on the final day of the conference concerned itself mainly with plans for the future, and it was agreed that entomologists at present concerned with experiments in mirid control in West Africa would communicate further with the view of developing standardized systems for evaluating candidate insecticides in the field and, if possible, for sharing some of the labour involved in the conduct of tests designed to provide fermented and dried samples of beans for taint and toxic residue tests. An appeal was made to the manufacturers to develop methods which would allow the use of smaller samples in taint tests, and embody greater accuracy. Some problems could not be dealt with on a joint basis, for example, testing candidate insecticides for their effects on popula-

tion-levels of other insect pests. Insects normally of only minor importance have been known to increase to pest status on cocoa following applications of insecticides⁷. While several of the species involved occur throughout West Africa, parasite and predator complexes of some of these have been shown to differ regionally. Population increases resulting from the removal of such biological restraints will vary with the effect of insecticides on the particular species complex concerned.

Delegates to the conference visited the Institute's experimental station at Gambari, twelve miles from Ibadan, where spraying machinery and methods in use in Nigeria were demonstrated and local entomological problems illustrated in the field.

The *Proceedings* of this conference will shortly be available from the Secretary, West African Cocoa Research Institute (Nigeria), P.M.B. 5244, Moor Plantation, Ibadan, Nigeria. P. F. ENTWISTLE

¹ Anon., *Proc. W. Afr. Internat. Cocoa Res. Conf.*, 1953 (1953).

² Anon., *Proc. Cocoa Breeding Conf.*, 1956 (1957).

³ Gerard, B. M., *Nature*, **201**, 353 (1964).

⁴ Dunn, J. A., *Nature*, **199**, 1207 (1963).

⁵ Wright, H., *Theobroma cacao or Cocoa, its Botany, Cultivation, Chemistry and Diseases* (Colombo, Messrs. Ferguson, 1907).

⁶ Cunningham, R. K., and Lamb, J., *Nature*, **182**, 119 (1958).

⁷ Entwistle, P. F., Johnson, C. G., and Dunn, E., *Nature*, **184**, 2040 (1959).

SOIL-PLANT-ANIMAL COMPLEX

A MEETING of the Nutrition Society was held in the University of Reading on July 17 under the chairmanship of Prof. R. G. Baskett (National Institute for Research in Dairying, Shinfield). This meeting took the form of a symposium entitled "The Effects of Soils, Fertilizers and Environment on the Yield and Nutrient Content of Plants". In his introductory remarks, the chairman mentioned that the subject of the symposium was something of a departure from the range of subjects normally discussed by the Nutrition Society, but it was clear from the reactions of members and guests throughout the meeting that they considered it entirely appropriate that nutritionists should concern themselves with problems of food production.

The first paper of the day was one by Prof. J. N. Black (Edinburgh) on "The Ultimate Limits of Crop Production". He began by reviewing the major factors limiting the yield of plants which have been emphasized in the past—soil fertility, including nutrient status, temperature, water supply, pests and disease and the genetic make-up of the plant. He continued by asking the question "If it were possible to remove all the factors acting to maintain yields at a low level, what would then determine yield and what might the yield then be?". The significance of this question lies in the fact that, if answered, it would provide a yardstick with which to measure the efficiency of an agricultural system and the rate of progress of improvements in technique. Recent work on the efficiency of the photosynthetic process was then discussed, culminating in the conclusion that, in the absence of other limiting factors, the productivity of crop plants is determined by the amount of solar radiation available. The complex interrelationship between solar energy, leaf area index (the ratio of leaf area to ground area) and crop-growth rate and ultimate yield was emphasized, and the necessity for interpreting the results of field trials, involving fertilizer and other treatments, in the light of these relationships was stressed.

In his paper on irrigation as a factor in increasing food production, Dr. H. Olivier (Sir Alexander Gibb and Partners) surveyed the history of irrigation practices from pre-historic times up to the present day, followed by a critical assessment of the potential increase in food production in selected countries and regions in relation to their land and water resources.

The vital role of increased irrigation in increasing crop production in arid and semi-arid countries was emphasized. Nevertheless, doubt was expressed as to whether present nutritional standards could be maintained in many of these countries if the present-day population forecasts turn out to be correct, even if potentially irrigable land and water supplies are fully exploited. The considerable value of supplemental irrigation for increasing crop production in countries such as the United States and Western European countries, including the United Kingdom, is much less generally recognized and it is a technique which no country in the humid zone can afford to neglect.

Dr. Olivier ended his paper by considering the present outlook for food production and concluded that no reliable estimate of world potential was possible at present owing to a lack of basic information on such vital matters as potential agricultural land and effective rainfall, particularly in areas where the most serious food shortages occur. He stressed the need for the extension of soil surveys, for the reorganization of meteorological observations to make them more meaningful for agricultural purposes and for the compilation of statistical data on crop yields by region and by soil types.

The relationship between plant nutrient content of soil and leaves and crop yield was discussed by Dr. C. Bould (Long Ashton Research Station). He began by summarizing the present state of knowledge concerning the factors affecting the availability to plants of the inorganic ions in the soil and outlined the difficulties inherent in chemical methods of assessing the nutrient status of soils. A biological method, namely leaf analysis, has been shown to provide a more reliable assessment of plant nutrient availability. It is possible to establish for many species a range of nutrient concentrations at specific stages of growth associated with gross deficiency, marginal supply and sufficiency, based on crop yield. However, it is not yet possible to predict how much fertilizer is required to raise the nutrient status of a crop from deficiency to sufficiency, although this may be possible when more precise information relating soil nutrient status to plant nutrient content is available for different soils and crops.

Prof. A. H. Bunting (University of Reading) read a paper on "Effects of Organic Manures on Soils and Crops"