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EDITORIAL

Plans for the 1955 Conference are now well advanced. The venue chosen this year is a particularly attractive one and with the arrangements so far made we may look forward confidently to another extremely interesting and pleasant gathering. Just over 80 enrolments are to hand. Others are coming in steadily and the Committee expects that about 130 Chemists will be attending. So far accommodation preferences seem to be fairly evenly divided between the College Hostel and Hotels in Palmerston North.

An interesting range of papers has been offered covering various aspects of Physical and Organic Chemistry, Plant and Animal Biochemistry, Soil Chemistry, Water Treatment and Sewage Disposal, and Chemical Engineering. It is hoped to arrange two symposia, one dealing with recent advances in Protein Chemistry and the other with Water and Sewage. As usual various trade exhibits of scientific equipment will be on display throughout the Conference. A novel feature of the Social Evening will be a display of "scientific conjuring" under the title "Preview of Progress" and arranged by General Motors (N.Z.) Ltd.

The purposes of Institute Conferences are already well known and many of us look forward to them each year. And yet an expected attendance of 130 is a relatively small proportion of our total membership. Various circumstances will, of course, prevent some from attending, but may we remind others, particularly those who have not previously attended a Conference, of the opportunities these meetings afford for learning something of current chemical research in New Zealand (and this loses nothing in merit if the fields are not related to their own), of seeing and learning of new apparatus and methods of investigation, of meeting old friends and making new ones, and above all, of being able to discuss, usually in informal groups, many problems of mutual interest. Most scientific bodies, of course, hold annual conferences, but this Institute Conference is the only time that chemists can meet as a professional body. New Zealanders are often criticised for being "conference-minded", but in Britain and on the Continent the conference spirit is much more apparent in scientific circles than it is here. We do suffer scientifically through our isolation. Let us make the most of the opportunities we do have.

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MINERALS AND LIVING CELLS.

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(Based on a Lecture Delivered to the Wellington Branch, N.Z.I.C., on 7th April, 1955.)

During the last three decades the labours of biochemists have demonstrated that despite the infinite variety of form and composition of living cells, the performance of basic metabolic functions is largely mediated through key chemical compounds by enzymes which have wide distribution. Thus the respiratory process has been recognised to be mediated by a few well-characterised enzyme systems. Basic steps in the metabolism of fats, carbohydrates and proteins have been recognised to be common to many organisms. The biochemist of today is spurred on by the thought that his successors will be able to rationalise life itself as a detailed and well-defined metabolic pattern. Such a pattern would vary from species to species and from cell-type to cell-type only by evolutionary changes and by emphasis on particular sections of the pattern because of specialisation of function. It is the writer's purpose here to submit the viewpoint that a basic pattern is emerging for the interactions between minerals and cells—a pattern which is to be regarded on the same integrative level as those for the metabolism of fats, proteins or carbohydrates. The use of this philosophical approach will be illustrated with particular reference to aspects of the metabolism of minerals which are under investigation at Grasslands Division.

In the interaction of cells with any ion present in the environment, it is contended that three distinct processes may be operative:—

(a) An accumulation of ion occurs across a specialised lipoprotein membrane. Usually the ion will be moved against a concentration gradient, the necessary energy being derived from another phase of cellular metabolism. The process is termed *"active accumulation"*. There is abundant experimental evidence available showing that specific "carriers" are situated on the membrane surfaces. The carriers combine with the mineral concerned on one side of the membrane, the reaction being mediated by an enzyme resident in the membrane. Because of a difference in electrochemical potential the reverse process occurs on the inner surface of the membrane, with a consequent accumulation of the ion concerned. In the event of a carrier not being present for a particular ion, the ion is not secreted.

(b) The mineral *equilibrates* with the cellular protoplasm by diffusion and exchange processes. This is intrinsically a physicochemical phenomenon, but the pattern of exchange is subject to direct biochemical influence because of the lability of the ampholytic nucleoprotein system which constitutes protoplasm. The numbers and proportions of electric charges present on the proteins is believed to be directly related to the "energy status" of the protoplasm.

(c) The mineral may be stepwise assimilated into the protoplasm as a structural unit. For example, under normal conditions nitrate and ammonium ions are rapidly utilised in the elaboration of other nitrogeneous compounds which are in turn incorporated into proteins. This aspect of mineral uptake by cells will not be further considered here, since the minerals lose their identity during assimilation.

Because of fundamental cytological differences in the microbial, plant and animal kingdoms respectively, the sequence of occurrence of processes (a) and (b) varies, as does also the relative importance to be attached to each of them. Bacterial cells are to be regarded as being bounded by a membrane selective to ions, so that the accumulation of ions across the outer surface is the primary process. The equilibration of ions within the bacterial cytoplasm follows.

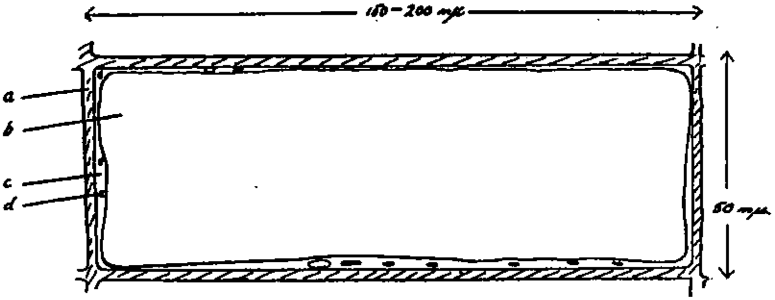

Fig. 1.—Idealised diagram of a mature plant cell showing the relative dimensions of a) the cell wall b) the vacuole c) the protoplasm and d) protoplasmic inclusions.

In the cells of higher plants, however, there is now clear evidence that the outer protoplasmic surface is readily penetrable by ions. It will be recalled that the mature plant cell (Figure 1) typically contains a large vacuole which is enclosed in a membrane known as the *tonoplast*. The protoplasm is present as a thin layer of thickness 1-2 microns enclosing the tonoplast and the living cell is enclosed within a wall composed of celluloses and pectates. The volumes occupied by these structures as a percentage of the total tissue volume are:—

Protoplasm	5-10%
Cell Wall	15-20%
Vacuole	70-80%

In addition, plant protoplasm may contain various types of particulate inclusions, such as chloroplasts, leucoplasts and mitochondria, ranging in diameter or length from 1-5 microns. These particles all seem to be capable of the performance of osmotic work, being bounded by a membrane which is selective for ions. Now evidence from the measurement of surface potentials and from studies of the kinetics of uptake of ions points to the conclusion that equilibration by process (b) is primary in plant cells, i.e., there is an equilibration of ions present in the environment with the polyelectrolytes present in protoplasm and cell wall. Process (b) takes the form of an accumulation of ions across the tonoplast membrane and particulate membranes; in mature cells the accumulation to the vacuoles is quantitatively very much more important than accumulation within particles.

Turning now to animal cells, both orders of sequence of ionic interaction with cells can be discerned. In the cases of red blood cells, kidney glomeruli, the oxyntic cells of the gastric mucosa and frog skin, the presence of bounding membranes which are selective for particular ions is well established. With nerve and muscle cells, however, the presence of such a membrane cannot be demonstrated and Ling has put forward the view that the ionic selectivity of muscle is not a membrane property but "rather a result of the difference in magnitude of coulombic forces exerted upon various hydrated ions by spatially fixed charges". This corresponds to process (b) and it is complemented by the accumulation of ions across the membranes of mitochondria which are dispersed in considerable number throughout the protoplasm.

Therefore for all cells the uptake of minerals will be effected on the one hand by transport across selective membranes and on the other by equilibration with a labile, polyelectrolytic system. The common factors controlling these two major processes and the types of selectivity to be found in various species and specialised tissues will now be considered with reference to particular investigations.

Process (a): Metabolic Accumulation.

That aspects of the transport of ions across lipoprotein membranes show certain similarities in widely differing tissues seems to arise from the fact that the same cellular sources of energy are used. For instance, the transfer of energy from site to site within cells is largely accomplished by means of "energy-rich" phosphorylative steps, the most important being the conversion of adenosine-diphosphate to adenosine-triphosphate. It has been shown for a variety of mitochondrial preparations from plant and animal tissues and for mature plant cells that the phosphorylative inhibitor, 2-4-dinitrophenol, (which arrests the formation of adenosine-triphosphate without affecting respiration) also arrests metabolic accumulation. This suggests that the energy requirement for the ion transport is "delivered" as "energy-rich" phosphate moieties.

Again, a striking interrelationship between the cytochrome respiratory system and ion accumulation has been demonstrated in several plant tissues, in the oxyntic cells of the gastric mucosa and in animal mitochondrial preparations. Root systems of young plants and storage tissues are particularly suitable for such studies, because the vacuoles comprise ca 70% of the whole tissue so that the process of ion accumulation is quantitatively a very important one. Many plant physiologists have observed that respiratory inhibitors have a parallel effect on salt accumulation and it has lately been possible to show that the relationship is between the cytochrome component of the total respiration and ion accumulation. Since the cytochromes are all insoluble with the exception of cytochrome c, it is reasonable to expect that the respiratory system should be located in the membrane, being thus ideally situated to mediate the supply of aerobic energy from ion transport. In fact, the cytochrome system is universally present in mitochondrial membranes and there is *prima facie* evidence for its presence in tonoplasts.

It would appear then that the energetics of ion accumulation bear a general similarity in many tissues. On the other hand, it is clear that the selective properties of membranes for particular ions must be reflected in the presence of totally different "carrier" systems. Here it must be confessed that our knowledge of the nature of these carriers is still meagre. For the accumulation of phosphate ions by tonoplasts two systems are present. The enzymes hexokinase and adenosine triphospatase resident in the membranes mediate the combination of the "carriers" glucose and adenosine diphosphate with orthophosphate, forming glucose-6-phosphate and adenosine triphosphate respectively. The phosphate ion is then released on the inner surface. A similar scheme probably occurs in red blood cells. It has so far not been possible to demonstrate or even envisage similar carrier systems for the other major anions (sulphate and nitrate) and cations (sodium, potassium, calcium and magnesium). The mechanisms present for cation transfer are particularly baffling, although the existence of such a transfer is quite indisputable. The active accumulation of sodium can be demonstrated beyond any doubt in the kidney tubule and in frog skin; radio-isotopes of the alkali metals have been used to demonstrate the presence in barley root systems of two carriers which are selective for Li, Na and K, Rb, Cs. The further elucidation of the enzyme systems responsible for selective ion transport across membranes is the central research problem in this field.

In order that a membrane should perform osmotic work, it is only necessary that either cations or anions are transported actively; the movement of ions of the opposite charge is then dependent on the maintenance of overall electroneutrality. Thus in frog skin sodium is transported actively while chloride moves passively in either direction; no other cation except lithium is transported actively. On the other hand, tonoplasts exhibit partial selectivity for anions and cations so that the presence of a limited number of mechanisms, each concerned with the transport of one or a few related ions must be assumed.

Process (b): Equilibration.

Interest in the factors controlling the equilibration of ions with protoplasm arises from two main points of view. Firstly, this is the primary uptake process in cells which do not possess a bounding membrane selective to ions, e.g., most plant cells and muscle cells. Secondly, the equilibrium concentrations of ions in the protoplasm have intrinsic interest in themselves, since the activities of many enzymes are sensitive to the ionic environment.

In studying the kinetics of uptake of ions by root systems and storage tissues, it has always been found that following the introduction of a new salt (or a higher concentration of the same salt) into the bathing medium, the overall process of ion uptake can be resolved into a rapid uptake of the newly-introduced ion(s), usually complete in 15-30 minutes, followed by a lengthy accumulation over several hours or days. The latter phase can be demonstrated by inhibitor studies to be active accumulation; the initial phase corresponds to the equilibration process. It is convenient to express the equilibration quantitatively in terms of the "apparent free space" (A.F.S.) for the particular ion concerned. A.F.S. may be defined as that volume of the tissue to which the ion (or solute) appears to move by free diffusion, i.e., a partition co-efficient of unity is assumed for the ion in question between the outer medium and that volume of the tissue to which equilibration occurs (the "true free space"). Thus the A.F.S. is not a volume but an equilibrium ion concentration, which is numerically related to the "true free space" by the partition co-efficient for the ion concerned.

In an attempt to give a morphological interpretation to the "true free space" of root systems, the writer carried out determinations of the A.F.S. for mannitol, chloride and phosphate. The materials chosen (two anions and a neutral solute) and the concentrations used (10^{-3} to 10^{-2} M) ensured that the partition co-efficients would be close to unity because absorption and exchange processes would be quantitatively unimportant in comparison with the concentration of ion or solute which diffused into the "free space". Values for the A.F.S. ranging from 24% to 33% were obtained and it was considered that this was consistent with the view that the "true free space" was comprised of the cell walls and protoplasm of root systems.

This work is now being extended by measurement of the equilibration which occurs over a wider concentration range (10^{-5} to 10^{-2} M) for phosphate, sulphate, calcium and caesium ions. Wheat seedlings are germinated and grown for 4 to 7 days in a normal nutrient solution of the Hoagland type. The plants are then slowly chilled to 1° C when the nutrient solutions are replaced by single-salt solutions of the range of concentrations to be used in the experiment. At this temperature metabolism has been arrested considerably so that the protoplasm is not markedly affected by the change to an unbalanced medium. After allowing one hour for equilibration of the roots to the new solutions, samples of excised roots are transferred to flasks containing the single-salt solutions having the same range of concentrations and each containing the same dose of "carrier-free" radioactive isotope. The incorporation of the radioactivity into the root systems is then measured by the usual procedures and the counts obtained per unit mass of root are compared with the activity per unit mass of the single-salt solutions.

TABLE 1:

EQUILIBRIUM CONCENTRATIONS OF PHOSPHATE, SULPHATE AND CALCIUM IN THE "FREE SPACE" OF WHEAT ROOT SYSTEMS.

External Concentration M.	Phosphate. A.F.S.	Phosphate. Moles Adsorbed.	Sulphate. A.F.S.	Sulphate. Moles Adsorbed.	Calcium. A.F.S.	Calcium. Moles Adsorbed.
1×10^{-5}	127	0.59×10^{-4}	28.7	1.7×10^{-6}	295	0.02×10^{-3}
3.3×10^{-5}	72	0.97	20.3	—	—	—
1×10^{-4}	69	1.74	20.8	2.8×10^{-6}	275	0.26×10^{-3}
3.8×10^{-5}	30	2.26	22.1	—	—	—
1×10^{-2}	22	1.50	19.3	8×10^{-6}	100	0.82×10^{-3}
3.8×10^{-4}	23.5	—	18.3	—	84	—
1×10^{-3}	20.2	8.3	18.6	1×10^{-5}	—	1.5×10^{-3}

The types of results obtained are presented in Table 1. It will be seen that for all three ions, the A.F.S. increases with decreasing concentration of the ion in the outer medium. This is equivalent to saying that the partition co-efficients for the ions between "free space" and outer medium vary inversely with the outer concentrations and it appears to be due to the presence of adsorption sites within the "free space" which assumes greater relative importance as the external concentration is reduced.

The relative proportions of the different ions which are adsorbed is also interesting. The concentration of phosphate in the soil solution is normally very low (10^{-7} to 10^{-6} M). It would appear that there is a physicochemical mechanism whereby the plant root achieves a considerably higher phosphate concentration within the "free space" and it is pertinent to investigate further the availability of this adsorbed phosphate for assimilation into the organic phosphate compounds of the plant. It is to be expected that calcium should be absorbed in greater amounts than the two anions because proteins are predominantly negatively charged at physiological pH values and the pectates of the cell walls would also bond calcium.

The establishment of the presence of a "free space" in root systems has an interesting bearing upon the question of exudation of organic materials into the soil solution. For it is clear that in the absence of a bounding membrane metabolites of low molecular weight produced in excess within the protoplasm are quite likely to be lost to the surrounding medium. The intimate association between the external medium and the "free space" of roots is evidenced by the observation that the viscosity of plant protoplasm is closely dependent on the cation balance of the outer medium and by the complementary observation that the amount of exudation is also dependent on the composition of the nutrient solution. In germinating seedlings and rapidly growing roots, nucleotides have been shown to be exuded in considerable amounts. Nodulated legumes grown in sterile sand culture exude substantial quantities of nitrogeneous compounds, particularly aspartic acid.

The factors which control the exudation of nitrogeneous compounds by clovers are of particular concern to N. O. Bathurst, and the writer at Grasslands Division because of the probable importance of an underground transference of organic nitrogen from clover to grass root systems in pastures. As is well-known, the New Zealand grassland farmer is mainly dependent on the ability of the nodulated clover plant to fix aerial nitrogen for the nitrogen "fertilisation" of his land. A knowledge of the relative importance of this process carried out by clovers and of the factors which influence the rate of exudation could well influence pasture management practices. The project under way has two objectives. Firstly, has the clover plant a greater capacity for exuding materials than the ryegrass plant, perhaps because of an inherent difference in the constitution of the "free space"? Secondly, is this capacity for exudation of nitrogeneous material really a property of the legume nodule? At present clover plants are therefore being grown under controlled conditions of light and temperature in sterile nutrient solutions as shown in Figure 2. The nutrient media are renewed weekly, the spent solutions being analysed for organic substances, particularly nitrogeneous compounds. In one set of experiments the clovers are being supplied with nitrate as nitrogen source. The other group is being nodulated so that the sole nitrogen source will be gaseous nitrogen. At the time of writing, two experiments, each over two months, have indicated that exudation of nitrogeneous material occurred throughout the growth period when nitrate was the nitrogen source. The total nitrogen exuded amounts to at least 15-20% of the total nitrogen incorporated into the plant. Furthermore, the composition of this nitrogen appears to be quite different from that reported in the literature for nodulated clovers, where aspartic acid and beta-alanine were the main products. Much of the nitrogen is uncharacterised; 5% is found to be free amino-acids and 20-25% is ammonia. Furthermore, the free amino-acid pattern, as shown by paper chromatographic methods, differs completely from that obtained from extracts of the same plant material. The predominant amino-acids are aspartic and the basic acids; glutamine and asparagine have not been detected. The more complete characterisation of this exuded nitrogen is being worked on and a comparison is being made with the exudation from clovers which have been nodulated by inoculation with *Rhizobia* bacteria. The amount of nitrogen exuded from sterile ryegrass plants will also be investigated in order to gauge the relative importance of the clover exudation.

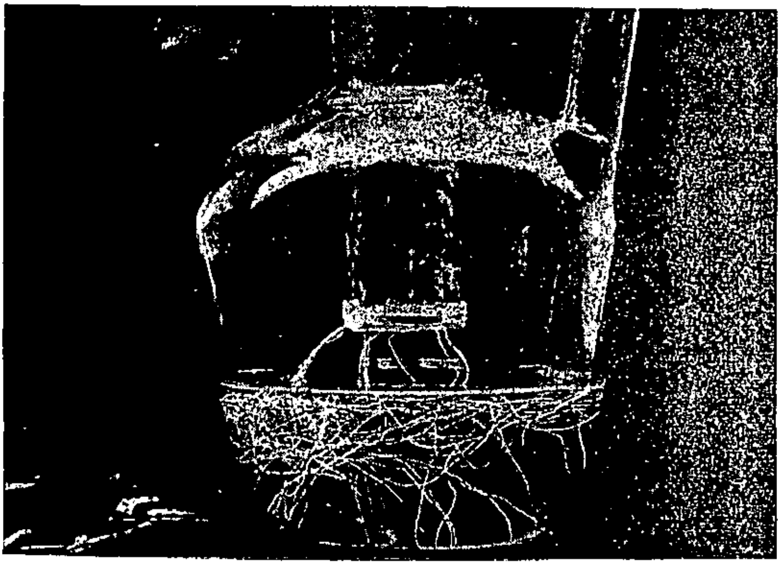

Fig. 2.—Clover plants growing under sterile conditions.

It is not only in plant cells that the concept of a "free space" would appear to have some value. Ling has recently developed a detailed theory for the explanation of the selective accumulation of ions by frog muscle cells, in which emphasis is placed on the *equilibration* process. He regards the incoming ions as being largely adsorbed on labile fixed charges on the protoplasmic proteins. On purely physicochemical grounds, potassium is selectively adsorbed relative to sodium because of the smaller radius of the hydrated potassium ion. Adenosine triphosphate is supposed to be strongly adsorbed to proteins causing unfolding of the protein chains and increasing the number of available fixed charges. The level of labile phosphate therefore controls the ion concentrations within the plasma.

The Uptake of Micronutrients.

We have considered in the preceding two sections the significance which the processes of active ion accumulation and ion equilibration have as an integrative means of studying the interactions of the major minerals with cells. It is of interest at this stage to consider to what extent these processes will be applicable to micronutrients. It is obvious that the process of equilibration is unimportant for micronutrients because they will normally be present in small amounts relative to other ions. On the other hand, active accumulation is obviously important in certain tissues, e.g., in the secretion of iodide from the blood stream by the thyroid gland. In cases where there is "luxury" absorption of micronutrients by plants it is probable that accumulation to plant vacuoles has occurred. Thus in experiments on the absorption of manganese chloride by beetroot disks it was found that the uptake of abnormal quantities of manganese followed the normal course for active accumulation.

It appears likely, however, that assimilation into the protoplasm determines the uptake of most micronutrients; in most cases the functions of micronutrients are still incompletely understood, but it is probably reasonable to consider that the amount of micronutrients retained by an organism is in direct relationship to the requirement of enzymes for the micronutrient.

An interesting difference in a micronutrient level was found recently by Miss J. Johnson, of this Division, in that the iodine level of certified white clover (which is high in cyanogenetic glucosides) was found to be fifteen times higher than the level for glucoside-free nucleus stock white clover. The plants were growing on the same soil type and the difference was observed several times during the growing season. The circumstances which give rise to such a difference in the capacity of related strains of the same species to absorb iodide are obviously of considerable interest, and are under further investigation. The nature of the genetic linkage of this difference to the difference in glucosides is being investigated and an attempt will also be made to partition the iodine chemically in the high-iodine plants.

Conclusion.

The main purpose of this article has been to point out basic similarities which exist in the processes of mineral uptake by all cells—similarities which justify the consideration of mineral metabolism as an entity having the same order of coherence as the metabolism of other groups of biochemicals such as fats, proteins and carbohydrates. It will be noted that the similarities which have been referred to are due on the one hand to similar paths for the provision of energy within biological membranes and on the other hand to a similar physiochemical constitution of protoplasm in all cells. It is the pious hope of the writer that the "carrier" systems spattered so blithely through the manuscript will also prove classifiable into a small number of distinct enzyme systems—if only so that thyroid glands and certified white clover should have something in common.

In particular research problems it will often be possible to regard either process (a) or process (b) as being the main mechanism of interest. For instance, in plant cells the metabolism underlying the transport of the major minerals across tonoplasts is quantitatively the key process when one is considering the question of the factors regulating the gross mineral composition of the plant. This is because of the size of the vacuoles and the high salt concentrations attained within them. For muscle cells it would appear from Ling's work that equilibration of ions within the soluble protoplasm is more important than mitachondrial accumulation in determining the type of cation selectivity encountered in this tissue. We may conclude that for any biological system capable of absorbing ions the recognition of the relative importance to be attached to these two basic processes will aid in obtaining a clearer insight into the particular problems involved.

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THE SUPPLY AND TREATMENT OF VEGETABLE OILS FOR EDIBLE PURPOSES.

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(Based on a paper presented at the Eighth Science Congress of the Royal Society, held in Auckland in May, 1954.)

The amount of vegetable oils and corresponding oil seeds entering world trade now equals the pre-war quantity and the fact that prices have a falling tendency shows that buyers have confidence that supplies will be maintained in the immediate future. The long-term picture is more complex and several features may be mentioned.

(1) *Effect of rising standard of living in tropical countries.*—With a rising standard of living and population, producing areas will consume a larger proportion of their own production. The exportable surplus of peanut oil from India has fallen from 800,000 tons per annum (as oil or equivalent nuts) prior to the war, to 80,000 tons at present, though production has been maintained at 1,500,000 tons. At the same time the proportion of peanut oil production which has been exported by all the producing countries of the world has fallen by one half.

(2) *Possible new sources.*—Many plants have still to be investigated as possible large-scale sources of oil. The Babassu nut of Brazil contains an oil similar to coconut oil. It is available in very large quantities, but there are difficulties in the mechanical crushing. In South Africa, great possibilities have been seen for the plant *Strychnos innocua* which supplies an oil similar to peanut oil but a yield per acre of almost twice as much. It may be mentioned that efforts are at present mainly directed towards annual crops to avoid the delay while trees grow to maturity: the trees, however, such as the coconut palm, are heavier producers and with more settled conditions they may be looked to as oil sources.

(3) *Possibilities in temperate zones.*—There are possibilities in the large-scale production of oil in temperate zones outside the Continental countries such as China and U.S.A., both large producers of peanuts and soya-beans. In Sweden, with official encouragement, large quantities of rape seed have been produced for oil and it is the considered opinion of experts there, that margarine could be made using this oil alone. By hydrogenating to various melting points, and mixing the products in varying proportions, a mixture with a good plastic range can be obtained. On the other hand attempts to grow sunflowers for seed on a large scale in Britain have not been successful because the seeds mature too late for mechanical harvesting and it is certain that the tropics must be the main source of supply for many years to come.

(4) *Effect of synthetic detergents.*—The increased use of synthetic detergents and the presence of surpluses of animal fats will help to ease the demand for vegetable oils at present preferred for margarine and shortening. There are no theoretical or technical obstacles now to the improvement of animal fats including the better grades of what is at present classed as "inedible" so that they can replace a proportion of the vegetable fats used. A recent American patent involves the rearrangement of the fatty acids in the glycerides of lard to give a product comparable with vegetable shortening. Other examples could be quoted.

To give some idea of the relative usages of the various kinds of edible fats, the following figures for U.S.A. in 1953, are of interest:—

	Tons	Per cent. of total.
Margarine made entirely of vegetable fats	575,000	16.1
Margarine containing some animal fat	16,000	0.4
Butter	502,000	14.2
Other vegetable oils, including shortening, salad oils, cooking oils, etc.	1,572,000	43.9
Compounds containing animal fat	164,000	4.5
Lard	758,000	20.9

(*References*:—National Association of Margarine Manufacturers, quoted in Agric. and Food Chem. 1, 1240 (1953); U.S. Dept. of Agric., quoted in Nat. Provisioner, January 30th, 1954, p. 41; Inst. Shortening and Edible Oils, quoted in the National Provisioner, various issues.)

It will be seen from these figures that only one-fourth of the vegetable oil is consumed as margarine. The chief vegetable oils used for edible purposes are peanut, soyabean, cottonseed, coconut, palm and palm kernel, and to a lesser extent, cocoa butter, sesame, rape seed and sunflower seed oils. It should not be overlooked that these oils fulfil many purposes for which butter is unsuited. The great bulk of vegtable oil sold for edible purposes in this country is in the form of hydrogenated coconut oil for use in confectionery.

Before discussing the extraction and treatment of vegetable oils, it may help to put the matter in the right perspective if we consider the rather startling fact that under modern conditions the only way we consume fats in their natural state is in raw nuts, in unpasteurised milk and in our mothers' milk. Butterfat is subjected to a variety of mechanical processes which profoundly change its physical state and environment to produce butter. All other fats are consumed in cooked foods or separated from their natural sources by various processes of rendering, pressing or solvent extraction.

Extraction of Vegetable Oils.

(1) *Hydraulic Pressing.*—In this process the coarsely crushed seed is wrapped in canvas cloths subjected to hydraulic pressure of up to 1,850 lb. per square inch. The highest qualities of oil are obtained from cold seed, but larger yields are obtained if the seed is heated.

(2) *Use of Screw Presses or Continuous Expellers.*—In these the crushed, heated seed is forced by means of a huge threaded rod through a "cage" built up of steel bars with spacer bars between them, giving openings of about 1/100 inch. As the seed passes through the cage, it is subjected to an increasing pressure which may rise to 40,000 lb. per square inch, which forces the oil out through the bars while the residual oil-cake drops from the end of the cage.

(3) *Solvent Extraction.*—Here the crushed seed is in various ways intimately mixed with a solvent such as light petroleum. The solution of oil is filtered and the solvent evaporated to recover the oil. Petroleum is often replaced with trichlorethylene which is not inflammable, but is considered by some authorities to leave a toxic residue in the oil-cake. Solvent extraction is much used on soya-beans which have a low oil content, but a forepressing with expellers lowering the oil to 10-15% followed by solvent extraction is becoming popular. Pre-packaged units combining both processes and with a total capacity of 400 tons per day are available in the United States. Solvent extraction gives the highest yield of oil but the small amount of oil left in by expellers increases its value as a stock meal and the ruling price for this meal naturally influences the economics of the process. This is underlined by the fact that Messrs. Bibby's Ltd., one of the largest oil-crushers in England, are primarily producers of stock meals which they buy in from other crushers and mix with their own product to give a total production of meal of up to 14,000 tons per week. The largest oil mill in Europe is at Hamburg; it processes 5,000 tons of oil seeds per week.

Refining of Vegetable Oils.

The treatment of vegetable oils prior to their use in margarine, shortening or as salad oils frequently starts with "degumming", an operation in which the oil is agitated with water containing a little caustic soda or salt and allowed to settle. The chief impurity removed is lecithin—a valuable by-product.

The second operation is neutralising the free fatty acids with caustic soda to form soap. This process requires considerable experience to get a soap which settles well and carries down the other impurities such as protein which would interfere with subsequent operations. To do this the operator may vary the strength of the caustic solution, the excess of caustic over that theoretically required to neutralise the free fatty acids, and the temperature to which the oil is heated. These factors are usually decided by trial refinings in the laboratory.

After neutralising, the soap is allowed to settle by gravity for several hours after which the oil is siphoned off the top and washed free of soap. Neutralising may also be done continuously in plants which may operate for weeks or months on the one type of oil. Centrifuges are used to separate the oil and soap and, because of the much cleaner separation achieved, less neutral oil is carried down with the soap, giving higher yields of oil. To this may be added the advantage of continuous processing. Per contra, the process is inflexible and is not suitable where different oils must be treated or where there is much variation in the same kind of oil, and the very large capital outlay involved is only justified where very large quantities of oil are handled. At Mrs. Tuckers' Foods, Sherman, Texas, centrifugal methods are used entirely. The plant can handle 36 million lbs. of oil at one time and it is claimed that these methods have reduced the refining loss by 20%. A further 15% may be saved by using soda ash instead of caustic soda. The soap is treated with sulphuric acid which converts it to fatty acids and separates the water. The product is sold as acid oil.

Bleaching.

The oil is now bleached to remove the last traces of soap, colour and protein. Properly carried out it improves the keeping quality of the oil and is frequently essential if the oil is to be hydrogenated. It is achieved by stirring the oil with about 1% of its weight of fuller's earth, bleaching clay or carbon or a mixture of these, together with a similar quantity of diatomaceous earth to aid filtration. The bleaching materials are activated before use by treatment with acid which enables them to absorb much larger quantities of impurities. The bleaching operation is usually conducted under vacuum and at its conclusion the oil is filtered and sent to the deodoriser or the hydrogenation plant.

Hydrogenation.

The rationale of hydrogenation is that oils and fats contain unsaturated linkages in the fatty acids which are places where decomposition starts leading to off-flavours and oxidation. By adding hydrogen to these linkages this defect may be overcome; at the same time the melting point is raised which is usually a concomitant advantage and the process is frequently referred to as "hardening". The hydrogenation reaction requires a catalyst and the one used commercialy is finely divided nickel specially prepared from nickel salts and supported on diatomaceous earth which assists the catalyst and enables it to be filtered out at the end of the process. About 1 part in 1,000 of nickel based on the weight of fat is used and it can be re-used several times. Continuous processes of hardening have not proved popular and batches of up to 10 tons are usual. In the process the oil is first dried by heating under vacuum and the catalyst mixed with oil drawn into the vessel. The hydrogen is then admitted until a pressure of about 100 lbs. is built up and the progress of the reaction gauged by the fall in pressure and finally checked by determining the iodine value or refractive index of the oil in the laboratory. At the right stage, the oil is filtered and sent to the deodoriser. The reaction often goes so rapidly that heat is developed and water must be run through the coil to avoid a burnt flavour in the oil.

Deodorising.

To remove undesirable flavours, the chemical nature of which is largely unknown, the oil is heated under vacuum while live steam is passed through to carry off the smelly constituents into a condensing system. The amount of steam required varies from 3 to 10 per cent. per hour based on the weight of oil being treated and up to 10 hours may be required to obtain a bland flavour as judged by samples withdrawn from the deodoriser from time to time. In America, temperatures of 475deg. F. are usual, resulting in economies of steam and of time but requiring special equipment. European practice favours temperatures of about 340deg. F., as it is considered that higher temperatures give a burnt flavour to the oil. Generally 6 mm. is the desired absolute pressure obtained with a three-stage jet condenser and no great advantage is obtained by going below this. At the end of the time the oil is usually transferred to a separate vessel where it is cooled under vacuum to about 150deg. F. Antioxidants, to improve the keeping quality, may be added at this stage. Deodorising may be done in batches of up to 20 tons.

Considerable thought has been put into the design of deodorisers in order to secure the greatest economy of steam and the minimum loss of neutral oil which may be hydrolysed by too prolonged treatment or thrown over into the condensing system by the violent agitation caused by the steam passing through the oil. On the other hand, the deodoriser should be so designed that the volatile material being carried over with the steam does not condense on the upper parts of the vessel and drop back into the oil.

Continuous deodorisers have found a good deal of favour in America. By passing the outgoing oil through a coil immersed in the incoming oil, considerable economies are achieved, but like continuous neutralising the process is inflexible and it is a matter of days to change from one oil to another. A successful compromise is the Girdler semi-continuous deodoriser which consists of five trays, one on top of the other, inside a vacuum vessel. Each tray holds about one ton of oil. In the two top trays, the oil is heated without any open steam being passed in; on the third and fourth trays there is open steam without any heating; in the fifth tray the oil is cooled. At predetermined intervals, usually 30 minutes, the oil is pumped from the bottom tray out of the deodoriser. This tray is then refilled from the tray above and so on upwards and the top tray is filled with fresh oil. A changeover to another kind of oil can be made at the end of any cycle. The process is therefore flexible and yields very good results, particularly on animal fats where prior refining may be eliminated with this process. The final fat has an acidity of .02% and a higher stability test than before.

Fractionation of Vegetable Oils.

Finally, a process which is likely to become of increasing importance is the separation of vegetable oils into two fractions having different uses. These oils belong mainly to the semi-drying class and for edible purposes have the disadvantage of "flavour reversion"—acquiring a painty or beany odour on standing even after the most thorough refining. Such an oil is soya-bean oil which by treatment with petroleum naphtha and furfural (a chemical available in large quantities in U.S.A.) can be separated into 60% of oil with an iodine value of 150 and 40% with iodine value 110. The first is a better oil for paints than the original, while the second is more suitable for edible purposes as it is less subject to flavour reversion.

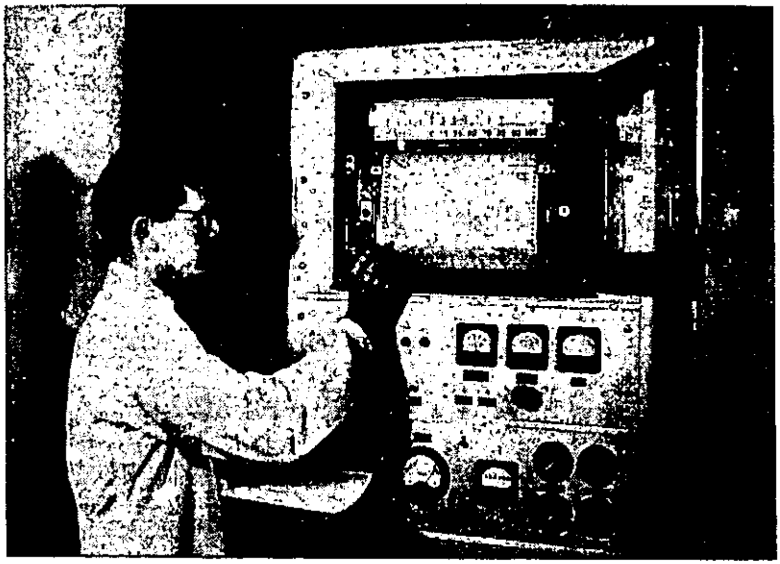
Solidification of Vegetable Fats.

The final stage which may be of interest though outside the scope of this paper, is the running out of the deodorised product as margarine or shortening. In the Votator process which originated in America and is used a good deal in Europe also, the oil mixed with milk and other ingredients as desired is rapidly chilled by passing through a tube externally cooled by direct expansion of ammonia. From this tube it passes through a second tube (called B unit) with no refrigeration where latent heat is removed. The product finally passes to a machine which automatically fills packages of any desired weight. For a shortening the process is similar but the B unit is fitted with a series of intermeshing pins which give the fat a plastic texture.

Other continuous processes much used in Europe cool the margarine by dropping it in a thin film on to a revolving drum also cooled by direct expansion. The margarine solidifies in flakes which are scraped from the drum and fall into a continuous worker operating under vacuum. As with the Votator the product then passes to automatic packers.

NEW APPARATUS.

The first analytical ultracentrifuge to run in New Zealand is now in operation in the Plant Chemistry Laboratory at Grasslands Division, D.S.I.R. This instrument, which has been developed and constructed over a period of some years by Dominion Physical Laboratory, is of the air-turbine type, but differs from the usual model in that the spinning rotor is suspended from a single ball-bearing rather than being supported by a series of air jets. At normal operating speed the eight-pound rotor spins in a vacuum at 60,000 r.p.m., at which speed a centrifugal force of some 280,000 g. is exerted on the sample of solution being studied.



Dr. J. W. Lyttleton examining the recorder trace at the end of an ultracentrifuge run.

This sample is held in a metal cell with quartz windows in order that a beam of light may be able to pass through the solution while it is spinning. The movement of the molecules in the solution modifies the refractive index causing deflection of the light beam. Thus the rate of sedimentation can be observed by means of a suitable optical system. The size and shape of a molecule determines the time taken to travel the length of the cell (1.5 cm.). A small protein molecule of molecular weight 50,000 takes about two hours; heavier molecules naturally sediment more rapidly. For very heavy molecules such as some plant viruses a slower speed of rotation is used producing approximately half the centrifugal force.

The centrifuge, although elaborate in construction, is conveniently simple in operation. The rotor accelerates at about 2,000 r.p.m. per minute to either 42,000 r.p.m. or 60,000 r.p.m. where it is automatically held at the chosen speed to an accuracy of better than 0.1%. The temperature of the supporting bearing and the oil glands for the vacuum seal, as well as the speed and the degree of vacuum, are printed on a recording millivoltmeter and if any of these variables departs greatly from normal the air drive is automatically cut off and the reverse air drive applied to bring the rotor to a standstill.

Besides the analytical rotor, which carries only 0.5 ml. solution for sedimentation studies, a preparative rotor is available which will carry 100 ml. at speeds up to 60,000 r.p.m. Because of its smaller radius the centrifugal force reaches only 200,000 g., but this is adequate for separation of molecules of molecular weight greater than 250,000. When lower centrifugal fields are required, the speed of the rotor may be manually controlled at all values up to 60,000 r.p.m.

This instrument, in conjunction with an electrophoresis apparatus, is allowing extensive studies to be made on the physical chemistry of proteins extracted from pasture plants. —J.W.L.

LETTER TO THE EDITOR.

The Editor,
Journal of the N.Z.I.C.,

Sir,—You have rightly stressed the question of speakers at branch meetings in your last issue, and the idea of building up a fund with the object of bringing overseas lecturers to New Zealand will commend itself to most of our members. At the same time there are other measures which could be adopted to consolidate the Institute and improve the standing of our profession, and in this direction it would surely be worth while for the Council to provide funds so that the President could visit all the branches during his term of office. Meetings could be held at which the President should deliver a scientific address on some topic in his own field, and these could be in conjunction with some sort of social function where the President could meet members informally and perhaps discuss domestic matters of Institute business. So far, we have had a succession of Presidents who have been capable of carrying out this task very well, and we surely have many men coming on who would do as well and be prepared to make the necessary sacrifice of time in the interests of the profession, and it would be up to the Institute as a whole to provide the necessary finance. —S. G. BROOKER.

NEWS AND NOTES.

Dr. F. B. Shorland, Director of the Fats Research Laboratory, has been invited to present the Liversidge Lecture at the forthcoming A.N.Z.A.A.S. Conference at Melbourne. The late Professor Liversidge, who was largely responsible for founding A.N.Z.A.A.S., directed that the lecture "shall be such as will primarily encourage research and stimulate the lecturer and the audience to think and acquire new knowledge by research. . . . The Lecturers appointed shall be the most suitable and eminent men procurable in their respective branches of knowledge." The title of Dr. Shorland's lecture will be "New Trends in Fats Research".

Mr. W. J. Blackie, until recently Deputy Director of Agriculture at Suva, Fiji, has been transferred to the post of Director of Agriculture, Fisheries and Forestry, Colony of Hong Kong.

Mr. R. I. Appleyard has been appointed Head of the Works Laboratory of National Carbon Pty. Ltd., Wellington.

Dr. R. H. Locker, who has been awarded a Massachusetts Institute of Technology Summer Studentship, has left for the United States, where he will spend four months. Dr. Locker will work at the Institute of Technology under Professor E. Schmidt, where he hopes to continue his work on muscle protein structure. While in Massachusetts, Dr. Locker will attend the summer seminar of biochemical and biophysical cytology which is to be held at the Institute. He will also attend the American Association for the Advancement of Science Conference at New Hampton in June, where he will present a paper on his work on myosin.

Mr. R. Sinclair, senior chemist of the Paint Research Section of the Dominion Laboratory, has left to study recent overseas developments in paint testing and research. He will spend four weeks in the United States and six weeks in the United Kingdom, where he will visit several laboratories. Mr. Sinclair will also attend the Biennial Conference of the Oil and Colour Chemists' Association which is to be held at Llandudno.

At the request of organisations interested in fertiliser production (who are paying expenses), Mr. W. M. Billinghurst, of the Dominion Laboratory, Gracefield, has left to spend a month to six weeks in Japan. With Mr. R. B. Tennent, of the Department of Agriculture, and Mr. R. B. Wharburton, of the East Coast Fertiliser Company, he is to gain information on the practical and economic aspects of the large-scale manufacture of calcium-magnesium phosphate for use as a fertiliser. Japan, the only place where this fertiliser is made in great quantities, is climatically and topographically similar to New Zealand and the delegation will also collect information on the application of the fertiliser, its suitability to different types of soil, under various climatic conditions.

Mr. D. F. Sandys Wunsch has been appointed a member of the Commission set up by the Minister of Health to investigate fume nuisance in the southern part of Auckland City.

Mr. R. Macintyre, formerly of Christchurch, has taken up the position of Chemist at the Korma Mills, Auckland.

Mr. C. J. Mathieson, Assistant Chief Chemist to N.Z. Forest Products, Ltd., Auckland, leaves next month for an extended business trip abroad. He intends visiting the United States, the United Kingdom and the Continent, and will be away for several months.

This year the Wellington Branch Committee has inaugurated a series of special meetings which have been held weekly during the first university term. These are not intended to replace or compete with the regular monthly meetings, but to allow members who are particularly interested in various branches of chemistry, to hear accounts of, and to discuss recent and current investigations. Subjects covered have ranged from 'New Phosphate Fertilisers' to 'Gas Liquid Chromatography' and 'Geothermal Chemistry'. Judging by attendances, the lectures have proved of interest to members and it has been decided to continue the series until later in the year.

CONFERENCE PROGRAMME

Conference this year is from midday Tuesday, 23rd, to midday Friday, 26th August. The programme has not yet been finalised but will be along the following lines:—

TUESDAY:—

Afternoon:	Registration and Opening Ceremony followed by papers.
Evening:	Presidential Address by President, N.Z. Section, R.I.C.

WEDNESDAY:—

Morning:	Papers.
Afternoon:	Annual General Meetings of N.Z.I.C. and N.Z. Section, R.I.C.
Evening:	Social Function.

THURSDAY:—

Morning:	Papers.
Afternoon:	Papers.
Evening:	Free for informal group discussions, etc.

FRIDAY:—

Morning:	Papers. This will conclude the more formal part of the Conference.
Afternoon:	Visits will be arranged to the laboratories, experimental areas and farms of Massey College, the Dairy Research Institute and the Grasslands Division, D.S.I.R., and the Factory and Laboratories of Glaxo Laboratories (N.Z.) Ltd.

BOOK REVIEWS.

METHODS OF QUANTITATIVE MICRO-ANALYSIS (Second Edition), compiled and edited by R. F. Milton and W. A. Waters. Published by Edward Arnold (Publishers) Ltd., London, 1955, 742 *pages,* 200 *illustrations. Price (U.K.)* 70/-.

One of the chief merits of this book is that each of its 8 parts clearly discusses principles underlying its special methods and apparatus and then considers their relative advantages and limitations. These are followed by details of some of the more commonly used procedures and many references to others. The illustrations (sectional diagrams and a few graphs) are clearly presented. Another good feature is that methods described and apparatus employed are relatively simple and free from the complications which sometimes appear to be mere virtuosity on the part of their originators. The parts (with numbers of pages allotted) are:—

I.—Gravimetric apparatus and general microchemical techniques (55); II.—Micro-analysis of organic compounds (76); III.—Volumetric analysis (93); IV.—Colorimetric analysis (191); V.—Electrochemical methods (99); VI.—Gasometric methods (76); VII.—Chromatographic analysis (76); VIII.—Biological methods of micro-analysis (31). There is an adequate index of authors and subjects, 25 pages in all.

Eight specialists have co-operated in preparing this book. The original parts (I. to VI.) have been extended by 20 pages and a number of new references (to 1953) have been inserted. The two later chapters are thoroughly up-to-date (to 1954). The book is both text-book and laboratory manual. An enormous amount of information is compressed into some 700 pages by the commendable method of dealing with principles and outlining specific methods in tabulated summaries at the end of each section.

—C.R.B.

NUCLEAR GEOLOGY.—A SYMPOSIUM ON NUCLEAR PHENOMENA IN THE EARTH SCIENCES, edited by Henry Faul. Published by John Wiley & Sons, Inc., New York. 7 dollars.

The purpose of the compilers of this symposium is set down in the Preface as being an attempt "to introduce the graduate student and the practising professional geologist to a new approach to some questions of the earth". The "new approach" is, of course, the application of the techniques and theory of nuclear physics to geological problems. After a necessarily sketchy survey of nuclear theory and experimentation, nine chapters are devoted to particular topics in nuclear geology. Of particular interest to chemists are chapters on the distribution of uranium and thorium, the formation of hydrocarbons through the effects of radio-activity and the determination of absolute age. Other topics range from geophysical exploration by nuclear methods to the origin of the earth. The contributions are authoritative and while the symposium does not cover all phases of activity in this rapidly expanding field of knowledge, it can be recommended as a useful collection of information which has hitherto been widely dispersed in the literature.

—G.W.B.

AUSKUNFTSBUCH FUR DIE CHEMISCHE INDUSTRIE, by H. Blucher. 18th Edition by A. Ernst and L. Neumann. 1386 pages, 1954. Walter de Gruyter & Co., Berlin. D.M. 98.

The German industrial chemist is fortunate in having a number of reference books on technical chemistry of reasonable compass and price. Here we have the third work of this type we have seen recently which has no real counterpart in English. The work is a one-volume dictionary of applied chemistry containing over 5,000 headings alphabetically arranged, with an index containing a further 4,000 references. Most of the articles are naturally short, but that on coal tar dyes covers 24 pages. The longer articles give references to all the relevant books which is a valuable feature. A final table shows sources of supply for various chemicals. It is no wonder that this work has gone through eighteen editions. We must either brush up our German or persuade the publishers to issue an English edition.

—S.G.B.

THE THEORY OF THE PHOTOGRAPHIC PROCESS (Second Edition) by C. E. Kenneth Mees. Published by The Macmillan Company, New York, 1,133 pages, 416 figures. 21.50 dollars.

The interests of many chemists extend into the photographic field, but owing to the diversity of journals in which the material is published, it is often difficult to obtain up-to-date information about the theories behind the various processes involved. This superbly produced book provides just the type of information so frequently sought. The first edition, published in 1942, has become the recognised text on this subject. To cover the extensive development since that time, this second edition is completely revised and largely rewritten. A number of new chapters have been added. Five Parts now deal with the various aspects of the photographic process:—The Photographic Material; The Action of Radiation; Optical Sensitising; Development and After-processes; The Physics of the Photographic Process. To these parts, chapters have been contributed by a great many of the author's colleagues in the Kodak Research Laboratories both in Rochester and in Harrow. Each chapter contains a useful bibliography and the book is well indexed.

—W.A.McG.

THE ELEMENTS OF CHROMATOGRAPHY, by T. I. Williams. Published by Blackie & Son, Ltd., London, 90 pages. Price 9/6.

Chromatography has developed enormously since the well-known "Introduction to Chromatography" was published. Although "The Elements of Chromatography" is described as a completely new book, its format is similar to the "Introduction" which it virtually revises and brings up-to-date. After a short historical introduction, the various forms of chromatography, adsorption, partition and ion-exchange, are briefly dealt with followed by short chapters on the treatment of colourless substances, the process of development, and chromatography in industry. In such a small volume this treatment is necessarily sketchy and the bibliography is very limited. Nevertheless for its price the book is well produced and illustrated, a number of the plates being in colour.

—W.A.McG.

CHEMISCHE TECHNOLOGIE, Vol 4 (Organic Technology 2). Edited by K. Winnacker and E. Weingaertner. 1,191 pages, 1954. Munich, Carl Hanser Verlag. DM. 95.50. This series of five volumes is now complete and forms a very useful intermediary between the one-volume students' texts and the encyclopaedic works of Thorpe and Ullmann. The whole set (priced at DM. 327—about £28) forms a series of 4,201 large octavo pages, and the coverage in most cases is excellent. Except for the field in which one is specialising, there should be all the information likely to be required. The printing and binding are good, and the schematic diagrams showing much detail in a minimum of space call for a special word of praise.

The publishers are also issuing sections of this work separately—e.g., a 67-page reprint from volume 5 on "Power Supply for Chemical Processes", by Rudolf Quack. Such sections may be useful to those who cannot afford the whole work.

—S.G.B.

STATISTICAL ANALYSIS (in Chemistry and the Chemical Industry) by Carl A. Bennett and Norman L. Franklin; John Wiley and Sons, Inc., New York; 1954. 724 pages, eight dollars. This product of Anglo-American co-operation has been sponsored by the Committee on Applied Mathematical Statistics of the National Research Council. Bennett, Chief Statistician of the General Electric Co., and Franklin, Lecturer in Chemical Engineering, University of Leeds, have collaborated to produce a very useful volume in which the statistical method is developed in sufficient detail for those not fully acquainted with such methods to be able to follow their development and thus judge their suitability for application to their own problems. The book is written specifically for chemists and is illustrated with examples taken from the chemical industry. Numerous references are given but except for amplification of a specific problem they are not required as the book is complete in itself. There has been a need for a book on statistical method which can be applied directly to chemical problems. This book amply fulfils this requirement.

—G.M.W.

OUTLINES OF ENZYME CHEMISTRY, by J. B. Neilands and Paul K. Stumpf. Published by John Wiley, Inc. (New York and London), 1955, 315 pages. Price 6.50 dollars. One of the objects of this book, according to the preface, is to provide background material for research workers in fields other than enzymology. It is fitting therefore, that it should be reviewed by a worker in a field other than enzymology. The need for this type of approach is becoming well recognised with the growth of scientific literature but it is seldom that authors have assessed and fulfilled this need so adequately. The book is not, like so many reviews, merely a catalogue, but attempts to give a general outline of the subject bringing into focus the whole field of enzyme chemistry from its early development to trends in future research. Thus over half the text deals with properties of enzymes in general covering isolation, criteria of purity, characterisation, etc., the physical chemistry of enzyme reactions, reaction rates, energetics, and the enzyme-substrate complex. This is followed by a concise section on enzyme classification and a section on metabolic patterns covering the role of the enzyme in the living cell and dealing specifically with the enzyme systems involved in a number of reactions such as glycolysis, the tricarboxylic acid cycle, oxidative phosphorylation, and fatty acid oxidation. This section concludes with an interesting chapter on the synthesis of enzymes. The book is very fully illustrated and well referenced. It can be most strongly recommended to chemists interested in developments in enzyme chemistry and it is hoped that it will be only the first of a series of texts fulfilling similar demands in other fields of biochemistry.

—W.A.McG.

SYNTHETIC RUBBER, by G. S. Whitby, editor-in-chief and 38 other contributors; John Wiley and Sons, Inc., New York; 1954. 1,044 pages. 18 dollars. In view of the increasing importance of Synthetic Rubber in industry, the appearance of this treatise will satisfy an urgent need. The book has been prepared under the auspices of the Division of Rubber Chemistry, American Chemical Society, and represents the contribution of 38 authors for the 26 chapters. After an introduction in which the current extent of the industry is outlined, there follows an historical review, chapters on the manufacture of the basic monomers, chapters on polymerisation, chemical structure, physical properties, compounding, processing and reclaiming of G.R.S. and then chapters on the more specialised synthetics and their applications. It is a very useful book and an excellent companion to the treatise on Natural Rubber published before the war. There has been minor overlapping which is inevitable in such a volume and some of the contributors have left out details which would have been helpful in their discussions, but these are only small failings.

To the rubber chemist and technologist, the book is one that must be on his bookshelf, but its usefulness goes beyond this for it should be available to chemists and engineers in the industrial and consulting fields as the information it contains on the uses of properly compounded rubber-like synthetics should be considered whenever new equipment or products are being designed.

—G.M.W.