JOURNAL OF THE NEW ZEALAND INSTITUTE OF CHEMISTRY

Vol. 27 No. 3
June, 1963

JOURNAL OF THE NEW ZEALAND INSTITUTE OF CHEMISTRY

Vol. 27, No. 3 JUNE, 1963

CONTENTS

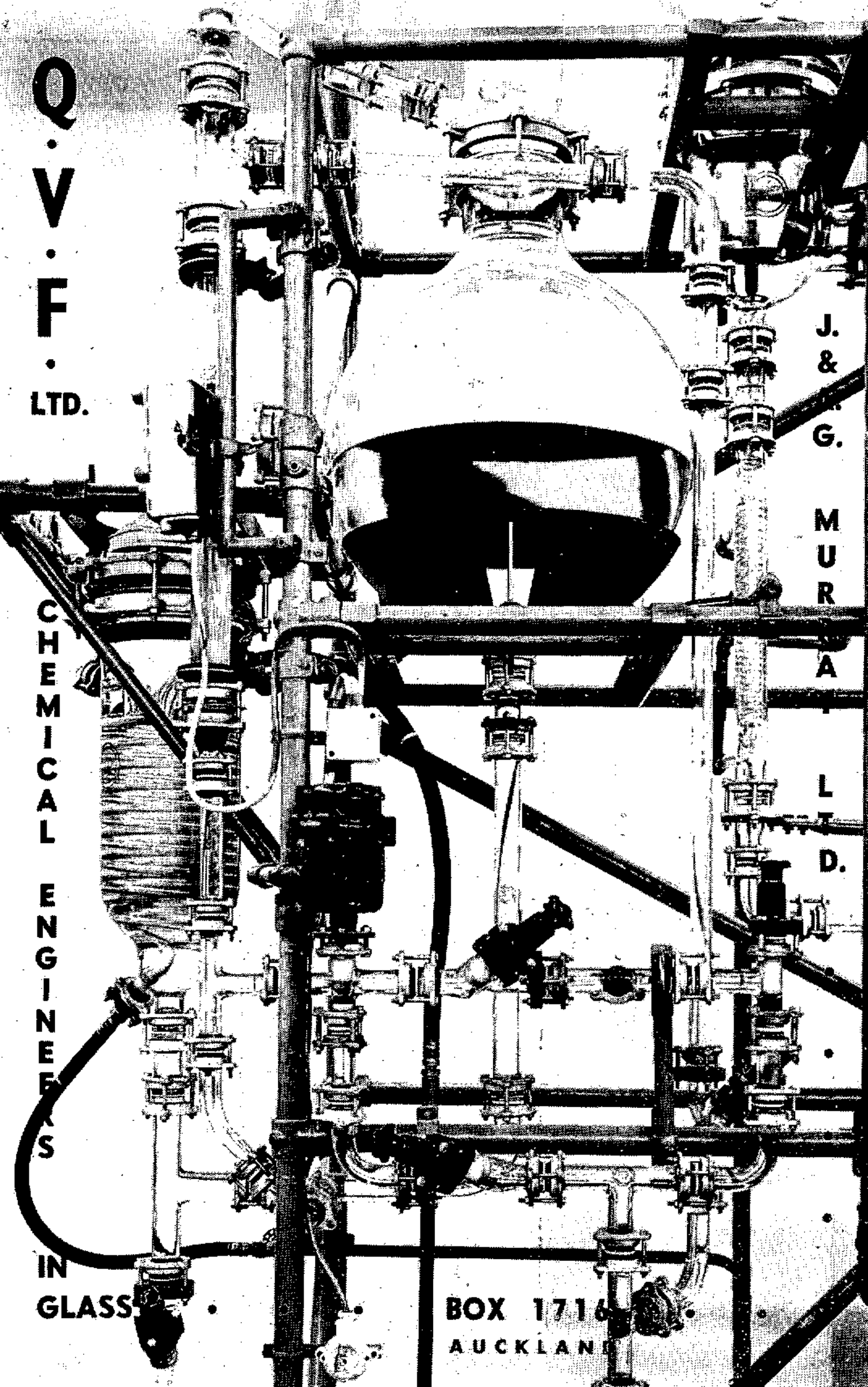
Published for the New Zealand Institute of Chemistry (Inc.), P.O. Box 250, Wellington, by

EDITORIAL SERVICES LIMITED
20 Binham Street. Telephone 51-416.
C.P.O. Box 2721. Wellington, N.Z.

Edited by N. T. CLARE
109 Cambridge Road, Hamilton, N.Z.

Registrar, N.Z. Institute of Chemistry (Inc.)
D. J. Hogan, P.O. Box 1926, Christchurch, N.Z.

Employment Officer
E. S. Borthwick, Shell Oil N.Z. Ltd.,
Box 2091, Wellington.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JOURNAL OF THE NEW ZEALAND
INSTITUTE OF CHEMISTRY

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CHEMISTRY IN INDUSTRY

The *Chemistry in Action* paper by Mr D. A. Watkins, published in this issue, reveals to students interested in a career in chemistry some of the opportunities for chemists in the future development of industry in New Zealand. As Mr Watkins points out, the number of chemists employed by industry has increased greatly in recent years, both by development of new enterprises and through expansion within old ones. There has been an increase not only in numbers but also in the proportion of industrial chemists to other chemists, as was demonstrated in comments on the occupation groups within the Institute in the August, 1960, issue of the *Journal*. With rising population, the need to diversify production and possible changes in the economic structure of this country, this trend is likely to be even more apparent in the future.

As a body, the Institute has offered no especial lead in this greater use of chemistry in industry, and it is doubtful whether it should attempt to do so. To set up an Institute committee on the potential of chemistry in industry would probably result in asking busy members to do, in the name of the Institute, what they are already doing through their posts in Government departments, research associations, or private firms.

There is one function, however, which Mr Watkins' paper may serve, in addition to the inspiration of sixth formers; it suggests subjects for a whole series of entries for the Chemical Essay Prize, in which some of the broader issues involved could be examined in the light of existing knowledge on processes, plant, local potentials, and demands. The present Essay Prize was indeed introduced for much this purpose as the *Industrial* Chemistry Essay Prize, and some of the earliest contributions dealt with industrial projects which have now been established.

Perhaps some of the kites which Mr Watkins has flown may be wafted to greater heights, or brought precipitously to earth, by our essayists in the next few years, with profit to the essayists, the Institute, and industry in New Zealand.

THE REGISTRY

Fellows

(Elected February 18, 1963)

BUTLER, Graham Wellesley, M.Sc., Fil.dr.(Lund.), Plant Chemistry Division, D.S.I.R., Palmerston North (Principal Scientific Officer).

LYTTLETON, John Westcoate, M.Sc., Ph.D.(Lond.), Plant Chemistry Division, D.S.I.R., Palmerston North (Senior Principal Scientific Officer).

RICHARDS, Edward Leonard, M.Sc., Ph.D.(Bristol), Biochemistry Department, Massey University College (Senior Lecturer).

Associates

(Elected February 18, 1963)

BLUCK, Ross Steele, B.Sc., Mobil Oil (N.Z.) Ltd., Wellington (Chemist).

JOHNSON, Colin Truscott, B.Sc., Southland Co-op. Phosphate Co., Invercargill (Chemist).

Leave of Absence

GUMBLEY, Janice; ROSS, Joan B.; THOMPSON, Megan.

Laboratory Assistant's Certificate

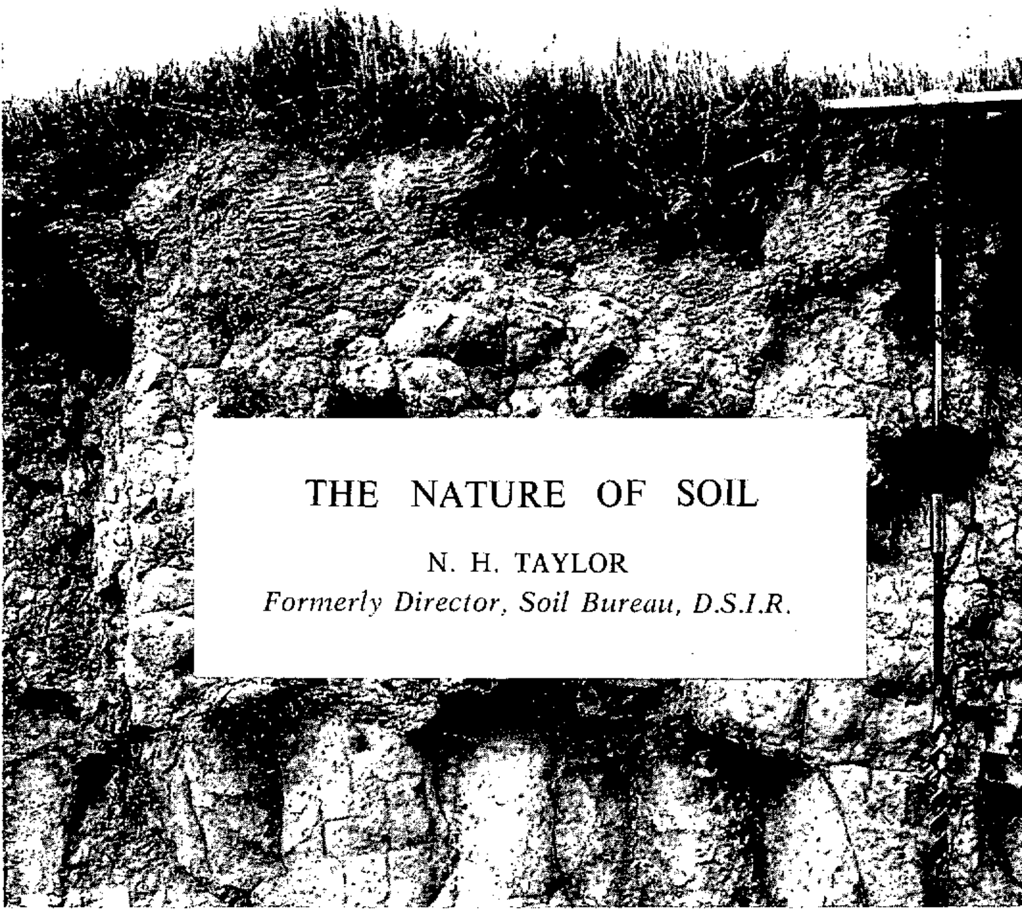
ASHBEY, Florence Marcia, Dominion Laboratory, Christchurch.
GRAHAM, Jenyfer Gwen, Wellington.
GYLLENBERG, Barbara Mary, Lower Hutt.
LOWTHER, Anthony John, Lincoln College, Christchurch.

SURVEY OF TESTING FACILITIES

The Department of Industries and Commerce, in consultation with the Department of Scientific and Industrial Research, is conducting a survey of testing facilities in New Zealand which are available for such purposes as the development of new products, the routine testing of production and the official testing against standard specifications for compliance certificates. This survey has been widely circulated to individual research organizations, consultants and others. If any members have test facilities which they are prepared to make available, and have not been circularized, on their request to the Director, Development Division, Department of Industries and Commerce (Private Bag, Wellington), they will be supplied promptly with details of the information whch is being sought.

CHEMISTRY IN ACTION

The three papers published in this issue are based on the 1963 "Chemistry in Action" addresses arranged by the Canterbury Branch and delivered to sixth form pupils in Christchurch earlier this year. These papers will be issued in booklet form for sale to secondary schools.



THE NATURE OF SOIL

N. H. TAYLOR
Formerly Director, Soil Bureau, D.S.I.R.

Students of science commonly have a good appreciation of the rocks that form the crust of the earth and of the plants that cover its surface, but few have a real appreciation of the intermediate layer — the soil. Probably this is because pedology, the scientific study of soil in its own right, is a relatively young science and still in its formative stage. Pedology had its beginning in Russia towards the close of last century when Dochuchaiev formulated the doctrine that soil as a natural body was the product of five soil forming factors: parent rock, climate, living organisms, relief, and time.

A simple example will illustrate how these factors work together to form soil. Wherever rock is exposed to the effects of climate, the uppermost parts crumble and decay, forming a mass of rock waste. As rainwater trickles down through this waste it leaches from it calcium, potassium and other elements needed by plants and carries them away to the drainage water. Where temperatures are high and rainfall is heavy, this process is particularly active and tends ultimately to cause extreme soil poverty. Living organisms, however, do much to offset this wasting effect of downward moving water. For example, in the forest, as plant nutrients are washed down through the soil they are absorbed by the roots of the trees, built up into the stems and leaves and ultimately returned to the soil surface as the forest litter decays, owing to the action of microbes and other organisms such as soil-dwelling insects and worms. This process is known as the organic cycle; it is the means whereby a topsoil is built up as distinct from the subsoil below.

Whether the topsoil beneath the trees is fertile or impoverished depends largely upon the ability of the tree to return nutrients to the surface. So we arrive at the soil paradox — "The more a plant takes from the soil the more fertile the topsoil becomes" — a statement which is essentially true if the natural cycle is complete but one which breaks down when the harvest is removed and the potential fertility transferred to another site. On the farm, the organic cycle is controlled by the farmer and his skill in this direction affects both soil formation and farm production. On grazing land, for example, if a farmer grows the highest fertility demanding pastures possible, and utilizes them completely in such a manner as to occasion an even spread of animal dung and urine, then he will be both maintaining his soil fertility and sustaining a high level of animal production.

So far we have considered three of the soil forming factors: parent rock, climate, and living organisms. The fourth factor, relief, modifies the soil in many ways. The soil on a steep slope, for example, will differ from the soil on a flat because it will be more subject to erosion — to surface washing, to soil creep, and to slipping — generally it will be shallower, drier and less developed. In hollows the soil may receive additions of material washed or blown from adjacent areas, and it will tend to be wetter than the soils of steep slopes, both because it receives water from adjacent areas and because the watertable may be close enough to the surface to seasonally waterlog the subsoil.

Obviously the length of time that these various processes operate affects the degree of soil development as can be readily seen on a flight of stream terraces, especially where little dust is blown up from the flood plain of the river. The lowest terraces commonly have the least formed soils, while on the successive terraces the distinction between topsoils and subsoils is more and more pronounced.

It is thus easy to see that the soil is, in essence, a dynamic system, continually changing in response to external conditions, as shown by the short-term seasonal changes that affect plant growth and the long-term changes that are reflected in the kinds of topsoils and subsoils that are formed. It is an open system to which things are added and from which things are lost, but is in part cyclic, largely owing to the action of organisms. The soil as an active system is readily appreciated by the soil chemist when he finds, for instance, that after topdressing a soil with superphosphate water draining from the soil is enriched with magnesium sulphate.

It will now be appropriate to examine briefly the chemistry of some of the processes already mentioned.

ROCK WEATHERING

Rock weathering is of two main kinds — physical and chemical. Physical weathering is the breaking of rocks to finer particles as a result of such forces as expansion and contraction with changing temperatures, the disruptive action of freezing water confined in crevices, and root wedging. Chemical weathering or rock decay involves the transformation of rock forming minerals into new chemical substances, of which the most interesting are the clayey substances — secondary products of fine texture with particles less than 0.002 mm and in large part colloidal. Rock minerals are for the most part complex silicates and the general trend is for these, under the action of water, carbon dioxide and oxygen, to break down into simpler compounds.

Some dark coloured rock minerals in rocks contain ferrous iron which in the presence of air and moisture is oxidized to hydrated ferric oxide.

For example:

$$4FeSiO_3 + 6H_2O + O_2 \longrightarrow 2Fe_2(OH)_6 + 4SiO_2$$

It is the ferric oxides that give the common brown colours to so many well drained soils (fig. 1).

The common rock mineral orthoclase or potash feldspar, which occurs as hard white crystals in granites and many other rocks, has a formula which may be conveniently written as $K_2O.Al_2O_3.6SiO_2$. In a classic experiment designed to study rock weathering, 3 kilograms of it were agitated for 200 hours with water. At the end of the experiment it was found that there was 2.52 grams of K_2O in the solution and an insoluble clay product in suspension, thus proving the power of water to effect chemical weathering of rock substances. Water becomes partly dissociated, particularly if carbon dioxide be present, and thus acts as a weak acid.

In nature under certain conditions the decomposition of orthoclase is probably presented by the following equation.

$$K_2O.Al_2O_3.6SiO_2 + CO_2 + 2H_2O \longrightarrow Al_2O_3.2SiO_2.2H_2O + K_2CO_3 + 4SiO_2$$

(orthoclase) (kaolin or china clay)

In humid regions, where much water passes through the soil, the silica and the potassium carbonate are lost to the drainage water. In drier regions the products of decomposition are less completely fractionated and soil clays containing higher proportions of silica and potassium are formed.

This production of clay depends largely upon moisture and temperature and hence it proceeds fastest in the humid tropics and slowest in cold arid regions. The climatic control of the process is reflected in the overall trend of content of clay in the soils of various zones in the world. For example, the soils of Canterbury commonly contain 15 to 20% of clay whereas the soils of North Auckland commonly contain 50 to 60%.

According to the kind of rock material, the environment conditions and the time that weathering has been proceeding, different kinds of clays are formed. They may be classified in three main groups — the amorphous clays, the layered crystalline clays, and the crystalline oxides. In New Zealand amorphous clays have formed in many of the younger soils from volcanic ash which contained much finely broken volcanic glass. These clays are simple compounds with structural units so fine that they cannot be detected with the ordinary microscope. The general formula of the best known example — allophane — is $Al_2O_3.SiO_2.n\ H_2O$. It is generally recognizable in the field by its greasy feel when wet and its fluffy consistence when dry and its ability to absorb large amounts of water.

The layered crystalline clays have a platy form, the various groups of elements being disposed in sandwich-like layers. These clays, which may be recognized in the field by their plasticity, have a greater silica content than allophane. Typical examples are kaolin, which has been mentioned previously, and montmorillonite, a sticky unctuous clay $Al_2O_3.4SiO_2.H_2O$.

Clays containing significant amounts of crystalline oxides, such as hydrated aluminium oxide $Al_2O_3.3H_2O$, lack both stickiness and plasticity and indicate an extreme stage of rock decomposition. They are most common in the humid tropics where weathering proceeds at a faster rate than in temperate regions and where time for weathering has been longer as it has not been interrupted by the ice age.

CONDITIONING OF WEATHERING BY ORGANIC MATTER

The organic cycle not only causes mineral elements to be returned to the surface of the land, it also causes the topsoil to be enriched in organic matter — compounds of carbon and nitrogen. These compounds are built up primarily by plants which are able to use, in a direct way, the energy of sunlight. As they are broken down, the energy released makes possible the reversal of many of the processes of weathering previously discussed. Thus in waterlogged soils, where soil oxygen is in short supply, microorganisms, in the presence of organic matter, reduce the ferric hydroxides and related compounds, as is evidenced by the grey subsoil colours commonly seen in such situations. This process is known as gleying and the soils so affected are said to be "gleyed".

Under certain trees, such as kauri, rimu, kamahi and hard beech, organic matter with a low content of calcium and other bases accumulates on the surface of the soil and decomposes slowly. The resultant humic compounds reduce the iron, assist in the decomposition of silicate clays and form with the released aluminium and iron oxides mobile organic complexes which are carried down into the subsoil where they precipitate to form pans, leaving the surface enriched in silica. This process, which is known as podzolization, is a clear example of the reversal of the more normal trend of weathering (compare Figs. 1 and 2).

SURFACE CHEMISTRY OF SOILS

The soil clay and the decomposed organic matter together form the most reactive part of the soil and this is occasioned by the enormous amount of specific surface due to the fine state of subdivision and to the complex structure of the compounds involved. If we take a cube of solid material we can easily measure its surface area, but if we were to grind the cube into fine powder and then try to calculate the surface area by measuring around each particle, we would find the total surface area to be very great indeed. Now it is in the nature of all solid substances to consist of molecules and atoms linked on all sides by

C. S. Harris photo.

Fig. 1: A brown soil under tussock, Banks Peninsula.

A. J. Metson photo.

Fig. 2: A podzol with grey silica-rich horizon and subsoil pan of iron oxide and organic matter. Formed under rimu forest, Westland.

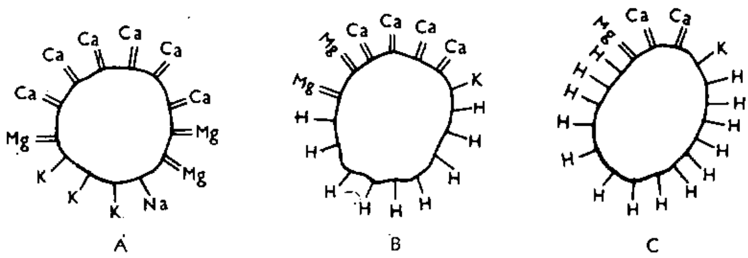


Fig. 3

other molecules and atoms, except of course at the surface where such an arrangement is impossible. Here at the surface the arrangement is incomplete and at certain sites cations and anions can be exchanged without altering the essential composition of the solid itself. This phenomenon is the cause of the ability of such simple clays as allophane to retain phosphate and other ions. Some more complex clays such as the layered crystalline ones (*e.g.*, montmorillonite) have additional electrical charges expressed at the surface owing to electrical imbalance of atoms in their internal structure.

In soils the most important manifestation of surface chemistry is *base exchange* (or cation exchange, as it is more properly called), for soil clays in the presence of water react as if they were weak acids. Diagrammatically you may imagine a particle of soil with a large number of negative charges at the surface to which cations such as Ca, Mg, K, Na, and H may become attached. Where, as in Fig. 3A, these charges are all satisfied with bases, the soil is said to be base saturated, and since the principal base in this example is calcium the soil will be near neutral in reaction. Where, as in B, some of the charges are satisfied with hydrogen, the soil is 59% base saturated and will be slightly acid. Where, as in C, hydrogen ions occupy a larger proportion of the surface, the soil is but 30% base saturated and markedly acid, a common condition in soils of heavy rainfall districts where leaching of bases by water percolating through the soil is a more or less continuous process.

These diagrams are, of course, simplifications. Hydrogen in particular does not exchange as simply as indicated; it initiates more complex reactions with the aluminium ions at the clay surfaces.

THE PROBLEM OF FERTILIZING SOILS

It will now become quite clear that the soil is not a passive medium to which we can add nutrients needed by plants in a thoughtless manner. Every fertilizer we add to the soil invokes a chain of reactions, some of which are far removed from what the farmer desires or expects.

Let us take as an example the simple operation of adding superphosphate to the soil, this being the most common fertilizer practice in New Zealand. Superphosphate, as you know, is manufactured by the action of sulphuric acid upon rock phosphate.

$$Ca_3(PO_4)_2 + 2H_2SO_4 = CaH_4(PO_4)_2 + 2CaSO_4$$

Let us consider the calcium sulphate first. By base exchange the Ca ion attaches itself to the soil clay generally replacing an Mg ion.

$$[Soil]{=}Mg + CaSO_4 \longrightarrow [Soil]{=}Ca + MgSO_4$$

The soluble magnesium sulphate is readily lost in drainage water.

The fate of the acid phosphate is more complex. It may become attached to calcium ions or adsorbed on the soil clay. When first adsorbed in concentration it is readily available to plants but as it diffuses thinly over the surface of the clay particle it becomes more and more tightly held. Some of it becomes linked with soil aluminium and iron to form phosphates that are not readily available to plants, and as these crystallize and form nodules the phosphate is locked away.

A part of the phosphate is detained in the soil organic matter, for well-decomposed humus consists of approximately 100 parts of carbon, 10 parts of nitrogen, and one part each of phosphorus and sulphur. This phosphorus ultimately becomes available as the humus decomposes but such a process may take many years. On many of our farms only one-twelfth of the phosphate added to the land can be shown to be utilized in produce. The remainder is either not taken up from the soil or is returned to it in the dung and urine of farm animals or by organisms which die or which shed dead parts such as grasses do with leaves and shoots. Although much good scientific work has been done on aspects of this problem, no one has yet been able to use phosphate fertilizer really efficiently.

THE FOOD HUNGRY WORLD

Ever since about 7000 B.C. when men first discovered how to grow plants and so provide themselves with an assured food supply, soil has been to each nation a priceless possession. The stability of civilizations through the ages has depended to a large extent on the ability of the people to discover new ways to raise the fertility of the soil so that adequate food might be grown to support the increasing population. In a great many lands this, for one reason or another, has not been done and this is the basal cause of the "food hungry world".

Today, because of the industrial revolution which began in Western Europe, modern science has made possible new ways of increasing food production from the soil and we are fortunate enough to be in the forefront of those benefiting. In many other lands the farmer is ignorant of the new knowledge and he is so desperately poor that a new train of social events must be put in progress before he can avail himself of its benefits. In the name of humanity and of world peace, it is our duty to continue to assist these less fortunate peoples with their difficult task. For it is not simply that the population is too large, but rather that knowledge is lacking as to ways and means of making the soils more productive. Soil scientists from all countries have a purposeful part to play in this great adventure.

In New Zealand itself the importance of soil science hardly needs to be stressed. It is obvious that the more we know about our soils the more efficiently will we be able to produce the farm and forest products that are so vital to our economy.

A CHEMICAL PROCESS INDUSTRY FOR NEW ZEALAND

D. A. WATKINS
Managing Director, Ivon Watkins Limited, New Plymouth

Those who intend taking up the profession of chemistry are naturally very interested in what opportunities there are likely to be in local chemical industry. To understand fully the present position in New Zealand it is necessary to review past development and the overall resources of this country and finally to make some assessment of the future.

PAST DEVELOPMENT

Settlements in New Zealand by the white man were initiated by the opportunity for whaling and for the use of timber of a type suitable for the masts of the sailing ships of those days. The discovery of gold brought an influx of population and with the establishment of quartz crushing plants, notably on the Thames Peninsula, the need for assayers arose and these men were among the first to carry out commercial chemical analyses in New Zealand. As settlement increased, the potential of the land for dairying and sheep farming was recognized and when refrigerated shipping became a reality, a large export trade in dairy products and meat became possible. From then onward the national effort has been concentrated to a large degree on increasing the quantity and quality of these products.

When the land was initially brought into pasture it contained adequate plant nutrients, but after a few years farming production fell off. This was traced to a general deficiency of phosphorus compounds in the soil. To overcome this deficiency phosphatic fertilizers had to be imported, mainly in the form of superphosphate. When adequately supplied with phosphorus, with its plentiful and well distributed rainfall and even temperature, New Zealand has been able to grow grass more efficiently than any other area in the world.

The present state of our grassland farming was not easily achieved and the need to import phosphatic fertilizers tended to hold back development. However, in the 1880's, Kempthorne established a small chamber sulphuric acid plant at Green Island (near Dunedin) with the object of acidulating a local deposit of phosphate rock to produce superphosphate for application to the land. It transpired that the deposit of phosphate rock was totally inadequate, and suitable rock had to be imported. Local production, however, was still cheaper than imported superphosphate. Production expanded rapidly, and the prosperity of our farms continues to be largely dependent on regular application of available phosphate. The firm of Kempthorne Prosser Ltd. is still actively engaged in superphosphate production.

Sulphuric acid is a basic chemical and finds application on an industrial scale in most useful chemical transformations. There is a saying that the consumption of sulphuric acid per head of population of a country is an index of its prosperity. This is illustrated by the following table.

CONSUMPTION OF SULPHURIC ACID PER HEAD OF POPULATION

More than 75 lb	High standard of living	U.S.A. and N.Z.
10 to 75 lb	Medium standard of living	Greece
Less than 10 lb	Low standard of living	Turkey

NEW ZEALAND'S RESOURCES FOR CHEMICAL INDUSTRY

Before a country can be said to have a great potential in chemical industry, the following basic requirements are necessary:

(1) A supply of sulphuric acid based on sulphur or sulphide ores.
(2) An alkali industry based on common salt — producing caustic soda, chlorine and hydrogen.
(3) A supply of fixed nitrogen, *viz.*, ammonia or nitric acid.
(4) A local source of organic raw materials and/or inorganic raw materials, *viz.*, metallic ores.
(5) A cheap source or sources of energy.
(6) A market for the products made.

Few countries are so well blessed as to have all these requirements fully satisfied but a great deal can be done with limited resources.

What is the position of New Zealand in relation to these requirements?

(1) A SUPPLY OF SULPHURIC ACID

The sulphuric acid industry, thanks to the superphosphate demand, is well established and both chamber and contact acid are obtainable, and oleum should shortly be available. Admittedly, it is based on imported sulphur but even so, in comparison with world prices, relatively cheap sulphuric acid is available. The importation of bulk quantities of sulphuric acid into New Zealand would not be practical and local production is protected by freight costs and the hazardous nature of the material. No substantial deposits of either sulphur or sulphide ores have been found in New Zealand.

(2) An Alkali Industry

An alkali industry is of more recent introduction into this country and is dependent at present on utilization by the forestry industry. Plants have been established at both Kinleith and Kawerau for the production of bleached pulp. Here again, in spite of the relatively high cost of suitable salt, production is economic. Both the alkali and chlorine are used, but the hydrogen is wasted. This captive use of the caustic soda and chlorine does not allow of a cheap and easily available source of these materials to industry in general. In fact, practically all the caustic soda used in other industry is still imported; in other words, although two plants are operating in the country, the products are not readily available to industry as a whole. Until the demand in other directions for caustic soda and chlorine rises sufficiently to justify a third plant, New Zealand will lack this basic requirement.

(3)A Supply of Fixed Nitrogen

Fixed nitrogen in the form of ammonia or nitric acid is also an industry basic to the development of an elaborate chemical industry. Up till now, New Zealand has been fortunate that her farming has been pastoral and that nitrogen-fixing plants of the clover species have provided a source of nitrogenous fertilizer. With increase in population, however, cropping will become more important and the demand for nitrogenous fertilizer will rise. It would be of great benefit to have a small fixed nitrogen plant in this country as soon as economics permit. At present, importations of nitrogenous fertilizers amount to approximately 20,000 tons and, in addition, all other nitrogenous compounds are imported — notably explosives which have a steady demand for constructional and other purposes. Our local source of nitrogenous compounds is restricted to animal residues and a small quantity of ammonia from coal gas plants.

(4) A Source of Raw Materials

Every country is endowed to some degree with raw materials which, when modified, can be converted into useful products. These raw materials will be either organic or inorganic in nature and will remain in this state until effort is expended to convert them to products satisfying human needs. This country, while considered by some to be poorly endowed with raw materials, does offer many avenues for development. Of organic raw materials we have coal and, more recently, petroleum products in the form of gas and condensate have been found in commercial quantities in Taranaki. Both these raw materials have traditionally been the raw materials for chemical industry, but to date in New Zealand little has been done with coal, except to use it as a source of energy. Further, many useful products are derived from farm crops which can be said to be a source of raw materials. So far these products, such as wool, meat and dairy products, are at best only semi-processed before export overseas, and here lie many opportunities for future gainful employment of our increasing population. Before the benefits of further processing will become available, however, courage, hard work and initiative will be required, particularly in the case of those people whose training in science has equipped them for this work.

We grow only a portion of the wheat we require. Why do we not grow our total requirement and save overseas funds? Have we thoroughly examined our native plants for potentially useful products, and what crops could we grow here which could be exploited commercially? Recently, trials have been started in Southland and Taranaki to assess the possible potential of sugar beet as a commercial crop. If we look into the matter carefully other possibilities may be found to exist.

Mining of ores in New Zealand has not had a very successful past. No large ore bodies in a form easily exploitable have been found. Some small deposits have been worked over in the past — *e.g.*, mercury in North Auckland and manganese near Auckland — but apart from gold and coal no project of this nature has in the past made much contribution to our welfare. However, large deposits of iron ore in the form of ironsands exist and from the report of the Development Company set up by the Government it would appear that there is a good chance of establishing an iron and steel industry to work these deposits. This would be of immense value to New Zealand as to date all steel used has had to be imported. But apart from this possibility, which is now receiving attention, have we really examined properly the large deposits of various types of clay which exist in New Zealand and used them to full advantage? Admittedly, some use has been made of these by the ceramic industry, but even today relatively large tonnages of clay products, such as talcs, are still being imported for various purposes.

(5) A Source of Energy

In all industrial operations energy is required to carry out any kind of processing, and, naturally, the cheaper the energy that is available, the lower the costs of production. Some industries consume relatively large amounts of power which make it a significant factor in the costs of production. New Zealand is relatively well blessed with sources of energy, having coalfields and cheap electric power. Shortly a further supply of energy in the form of natural gas should become available; on the other hand, up to the present, no significant amount of locally-produced petroleum products exists, and, even when the refinery at Whangarei is operating, at least half the crude oil required will have to be imported. However, for those industries requiring a large amount of electric power, the country is well provided for, and a considerable further potential remains to be exploited. Consequently industries of this type should receive careful consideration. Certain chemical industries are in this class, notably those depending on high temperature reductions, *e.g.*, aluminium, and those depending on electrolytic processes, *e.g.*, production of chlorine and caustic soda from common salt.

Manpower is an all-important factor in industrial development and in this respect New Zealand is well served. The general level of intelligence is high and as for physical strength our people are the equal of those of any other country. It is, however, unfortunate that many of our most intelligent people leave New Zealand for countries where their talents and opportunities are more fully recognized. Nevertheless, those who have remained here and who have devoted themselves to the problems of the country have demonstrated outstanding ability, and the present high level of our agriculture is in no small measure due to the efforts of past and present scientists working in this field. Our universities have maintained a generally high standard in turning out graduates capable of independent thought, but, if a criticism may be offered, it is that the universities as a whole, with one or two notable exceptions, have looked on industry as a poor field of endeavour for their graduates. This may have had some basis in the past in as much as industrialists did not appreciate fully the value of trained scientists in their organizations. I believe, however, that this day is past and I sincerely hope that the universities will realize this, and will see that industry can offer attractive and challenging positions for their graduates. In my own organization, for example, a wide range of graduates are employed, including four with doctorates, and I am sure that an increasing number of firms in New Zealand will soon come to realize the value of scientifically trained personnel. Chemists and engineers are the scientific personnel mainly required in industry, though opportunities do exist for those trained in other disciplines such as physics and botany.

It is most important, at present, that New Zealand should take steps to correct the critical state of her overseas exchange position. This can be achieved by more exports and/or less imports; the achievement of results will be a challenge calling for considerable research and development. The current exchange position is not a passing phase; it will continue to exist as a challenge to our initiative.

(6) A Market for the Products Made

Bound up with manpower is the problem of marketing, particularly in overseas markets. Our own market, while growing, is relatively small, servicing as it does only 2½ million people. This in itself has constituted a barrier to the development of certain types of industry, including certain chemical industries. But there are many chemical products which could be produced from intermediate compounds to service the local market and perhaps have export potential in certain areas. Export marketing is a specialist occupation and is not so far well developed by New Zealand. The need exists and no doubt considerable progress will be made in this field over the next few years. Assuming this will be the case, there is urgent need for active research, particularly with regard to raw materials which can be produced locally and which by suitable research can be converted into new products. If the situation is examined it will be found that, apart from stable foodstuffs, most of the products on the market today were unheard of twenty years ago.

FUTURE DEVELOPMENT

It is now appropriate to consider in a little more detail the opportunities which exist and which will develop over the next few years. The latest survey by the New Zealand Institute of Chemistry records that 205 chemists out of a total of 550 are employed in industry in New Zealand. Similar surveys made in 1937 record 66; in 1947 — 119; in 1950 — 135; in 1954 — 180. These chemists are distributed among the following industries listed in approximate order of importance: foodstuffs, dairy industry, wood products, freezing works, fertilizers, petroleum products, textiles, paints, general industrial chemicals, tanneries, rubber processing, breweries, gas industry, ceramics, metallurgy, cement and soap. When one considers the value of production of these industries, the number of chemists employed is very small and further opportunities for employment of chemists must develop if these industries are to maintain the progress essential to their welfare.

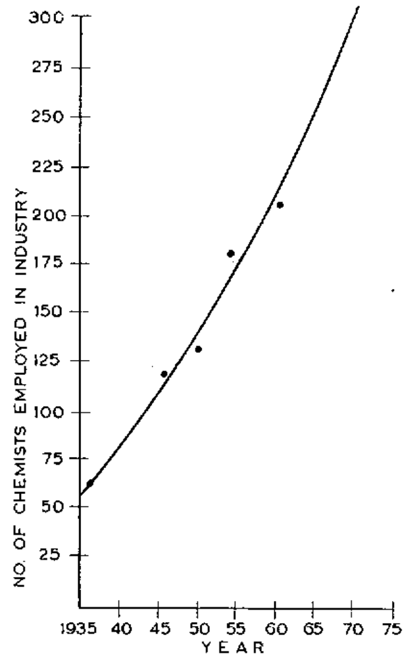


Fig. 1

If a graph is made of the chemists employed in industry given in these various surveys and the graph is projected until 1974, a total of 300 chemists should be employed in industry if the present rate of development continues (Fig. 1). Any major development of chemical industry in the country would, of course, accelerate this increase.

Some of the problems facing the industrial development of New Zealand, and the ways in which chemists can assist in solving them, may now be considered.

It has been traditional in New Zealand to produce butter, cheese, casein, dried milk, etc., as the main products of the dairy industry. Owing to various marketing problems, however, the prices obtained for products in this state are not always particularly attractive. In the past some attempt has been made to produce specialist products; this has been particularly noticeable in the case of cheese where various types apart from the traditional cheddar cheese, such as blue vein, have been developed and a satisfactory but limited market obtained for them.

Butter has always been a problem product to market because of the high cost of materials required for production in relation to margarine and other edible fat products. Should not some attention be given to converting butter into a product which can satisfy a larger market? I suggest that New Zealand should seriously consider the blending of butter with cheap to produce vegetable fats a high quality margarine which could be sold at a lower price than butter and thus widen the overall demand.

Casein has enjoyed a varying market and at present the price is very low. Are there any outlets for casein other than the traditional ones for the production of glues and plastics? This problem has been given some attention by the Food Technology Department of Massey University College which has been able to hydrolyze casein and to make a product very similar in all respects to soy sauce which enjoys a considerable market in Asian countries. If this should prove to be an economic outlet for casein, it could be of very considerable benefit to this country.

The production of sugar of milk (lactose) is a thriving industry in Taranaki. The product is sold as sugar of milk on the world's markets. Is there any modification of this product which would increase its general acceptance, or could it be converted into some other product which would be of economic value?

Various opportunities for further elaboration of the products of the meat industry as a whole obviously exist. Has everything possible been done to present meat products to the market in the best possible way? One of the major by-products of the meat industry is tallow. This used to be in good demand for the production of soap but with the rapid development of synthetic detergents the price of tallow has fallen and it is now a problem product. What are the opportunities for modifying tallow in such a way that new markets can be developed? Can the tallow molecules be altered to make the modified product desirable or more desirable as a detergent raw material? Many glandular products are collected in the freezing industry and are sent frozen to pharmaceutical companies overseas for extraction of the active ingredients. Could not this be done here and in this way save the cost of freight of the unwanted residues and provide employment for a few more New Zealand citizens?

New Zealand wool is sold to overseas markets in a greasy condition. Would it not be possible to carry out preliminary processing of wool and produce spinning tops and develop a lanoline industry from the wool grease?

In forestry, a very considerable local industry is now being developed and good quality paper is being produced. How far, however, have the by-products of this industry been developed? A considerable quantity of turpentine is produced and also a considerable quantity of tall oil. Can these by-products be worked up to produce other valuable products?

New Zealand is famous for its grasslands. No country in the world can grow grass as efficiently as New Zealand. This then becomes a major product and one which should command our attention. Feedingstuffs for stock in many countries are limited and large quantities have to be imported into many of these countries in order to maintain their livestock population. Has New Zealand given sufficient attention to the harvesting and processing of grass to convert it into a product which could supply some of the demand for the world's feeding stuffs requirements?

Apart from grass, New Zealand grows crops quite efficiently and this has resulted in the development of a large canning and freezing industry in Hawke's Bay and in certain other areas. In Canterbury wheat is grown but it supplies only a proportion of New Zealand's requirements. Is there not some way whereby wheat crops can be increased and so make this country less dependent on overseas wheat supply? A considerable amount of good work has been done by the Wheat Research Institute but I would not feel that its work is finished until it can perfect varieties and have them produced in sufficient quantities to satisfy the New Zealand market which, of course, is growing every year with the increase in population.

Apart from the commercial crops which are at present produced, what other crops could be produced economically in New Zealand? At present, much attention is being given to the possibility of producing sugar beet and processing it into sugar. This is a project which, for the first time, will be properly investigated by the development companies operating in Southland and Taranaki. There must be, however, a number of other crops which it would be worth while to evaluate. Can soya bean be grown in New Zealand, and how successfully?

Another field which should be investigated is the growing of crops for pharmaceuticals. A certain amount of this was done during the war in the Hawke's Bay area but was dropped at the end of the war. Are there any opportunities for commercial production of pharmaceutical materials? Certain of these materials, such as hemlock, grow prolifically in New Zealand and have been declared noxious weeds.

Our fishing industry has not been developed to the same extent as in many overseas countries, though the fish available here are of good quality. Should not more attention be paid to this industry and fish farmed in a more efficient manner? It has been suggested that compounded sea water could be used for the farming of fish which could be fed on waste dairy products with a phosphate supplement.

These then are a few ideas highlighting the problems of New Zealand industry from the point of view of naturally-produced products. However, there are many other possibilities for development. In the chemical industry itself it should be possible in many cases to import intermediates and convert them into final products for the market. This is being done to some extent by a few companies; for example, synthetic resins are being produced for the paint industry, synthetic detergents and synthetic glues are being made in New Zealand. Certain types of weedkillers are being produced from intermediates, also paint driers and waterproofing materials. A firm in Napier is producing hydrochloric acid from salt and sulphuric acid.

To anyone who studies overseas chemical literature, a number of further interesting possibilities present themselves. For example, New Zealand imports a phosphate rock and converts it to superphosphate. There is, however, a fairly substantial demand for various other types of phosphates, namely the sodium phosphates for use in the production of baking powders and for use in detergent mixtures. Just recently some work carried out in Israel showed that, by the acidulation of phosphate rock with sulphuric acid to produce phosphoric acid, this phosphoric acid could be extracted by means of butanol, purified and then re-extracted with caustic soda to produce a range of sodium phosphates. Is such a process an economic possibility for New Zealand?

The literature overseas gives some prominence to various additives for road sealing which are claimed to improve the life of highways and to reduce maintenance by causing better bonding of the aggregate with the bitumen. Does this not open up a possibility for the use of some material in New Zealand to produce a similar result?

In general, New Zealand is blessed with cheap power and it would seem that an aluminium industry eventually will be established in Southland. Could not the possible production of other metals or concentrate ores from imported material be considered at the same time? For example, would there be a possibility of taking the nickel ore from Noumea, bringing it to New Zealand and roasting and concentrating it either by means of natural gas or electric power?

Sooner or later it should be possible to establish in New Zealand further basic chemical units. This will depend on increase in population and the demand for products such as plastics and nitrogenous products. The day will come when it will be possible to establish either a synthetic nitrogen plant or plant for the production of acetylene, ethylene or some other simple starting material for a range of products. When this occurs a chemical complex will develop and will give considerable stimulus to chemical industry as a whole in this country. If ammonia could be produced economically it could be converted to nitric acid and also be used for the production of sulphate of ammonia or combined with nitric acid and lime to produce calcium ammonium nitrate fertilizer. The availability of cheap nitric acid would no doubt give rise to a number of other possible industries. Ammonia itself could be used as such by the refrigeration industry. It could be converted into nitric acid by the present chamber sulphuric acid plants to act as a catalyst in this process and thus avoid the importation of Chilean saltpetre. The production of acetylene likewise would constitute a starting material, together with chlorine, for the production of vinyl chloride, leading to PVC, a plastic which is already in considerable demand. Likewise, the production of ethylene could result in the same product and give rise to quite a number of others. The production of synthetic methanol also opens the way for oxidation to formaldehdye which, combined with urea, gives rise to another series of plastics. By further oxidation it can be converted to acetic acid and could therefore make possible the production of polyvinylacetate products. These are a few of the possibilities.

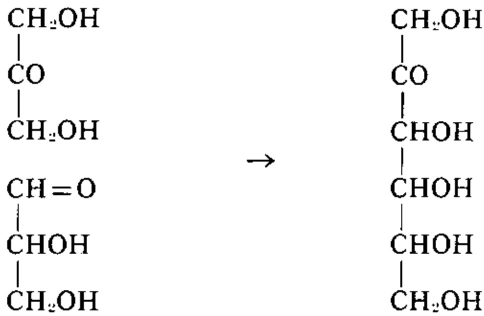
Thus it can be appreciated that the challenges and possibilities which present themselves through chemistry are considerable. Chemistry is a demanding profession, but one which can be most satisfying to those who are prepared to develop initiative and who have the patience to apply themselves and not watch the clock. The prospects are exciting and the achievement will be satisfying for those who will enter industrial chemistry in New Zealand.

CHEMISTRY AND BIOLOGY

W. E. HARVEY
Senior Lecturer in Chemistry, Victoria University of Wellington

Organic chemists, given sufficient knowledge, time, patience, skill, ingenuity (and sometimes, luck) can synthesize molecules of great complexity. Nevertheless their efforts appear rather crude when one considers the tremendously involved molecules constructed with such apparent ease by living systems. One cannot help comparing the processes which can be brought about in the laboratory only by means of violent reaction conditions, or treatment with brutal reagents, with those that take place in cells where the environment is largely water, the pH is relatively close to 7 and the temperature not far different from room temperature. That biological systems can accomplish these incredibly complex transformations is of course largely owing to the presence of enzymes — organic catalysts which not only facilitate reaction but often display remarkable specificity, a specificity frequently with no parallel in conventional chemical systems. Enzymes will, of course, given a suitable environment, catalyse reaction in *non-living* systems, and many enzymes have been isolated in pure form and studied in great detail. A single enzyme does not normally bring about catastrophic changes in a molecule and the building up or breakdown of large molecules will, in general, proceed by a more or less lengthy series of relatively simple steps each or many of which may be catalysed by a different enzyme. It is with these small steps that this paper will be concerned.

Speculation as to the mechanism of biosynthesis dates back almost to the time when the structures of naturally-occurring substances were first elucidated, although almost all the worthwhile developments have come in the last 50 years, and indeed many only in the post-war period. Some of the earliest experiments were in the field of carbohydrates. The best known of these substances, such as glucose, fructose, lactose (milk sugar) and sucrose (cane sugar) may be regarded as polymers of formaldehyde — the simplest hydrate of carbon — and in 1861 Butlerow found that formaldehyde in the presence of a weak base did yield a sugary product which was called formose or methose. Later, in 1887–90, Emil Fischer established that six-carbon sugars could be formed under mild conditions from three-carbon compounds as indicated by the equation:

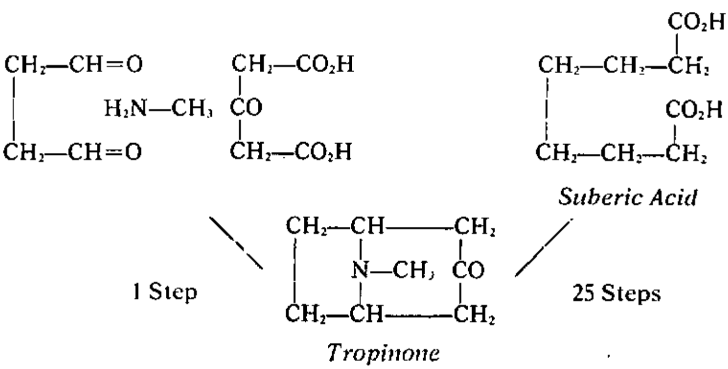


Reactions such as these, although they proceed under mild conditions, do not, however, occur in plants, and it is now known as the result of the work of, in particular, the Nobel prize-winner Melvin Calvin, that glucose is formed by a complicated series of reactions which overall can be expressed by the equation:

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2 \quad - 673{,}000 \text{ cals.}$$

This illustrates an important general principle, namely, that the mere fact that a reaction proceeds under "physiological" conditions is not in itself proof that the particular reaction does in fact proceed in a biological system. Nevertheless investigations of such reactions may provide valuable clues to biogenetic pathways.

The classic example of such a biogenetic-type synthesis is the elegant production of tropinone in one step by the route devised by Robinson in 1917 not so long after Willstätter first synthesized tropinone by a conventional procedure involving some 25 steps from suberic acid.



The development of tracer techniques following the availability of isotopes such ^{13}C, ^{14}C, ^{2}H (deuterium) and ^{3}H (tritium) provided chemists and biochemists with a powerful new tool which could be applied to the problem of elucidating biological pathways of metabolism and catabolism. For the first time it became possible to follow an atom, or more accurately a parcel of atoms, through a complex series of reactions by virtue of the "label" attached to the parcel. This is most readily accomplished with the radioactive isotopes such as carbon-14 and tritium because of the relative ease of detection and quantitative measurement, but can also be applied to non-radioactive isotopes such as carbon-13 and deuterium using the techniques of mass spectrometry. Carbon-14 decays by the emission of an electron from the nucleus, which becomes that of nitrogen-14. The electrons which are ejected can be detected and counted with suitable devices such as the G.M.-tube or a scintillation counter, and in this way radioactive atoms can be not only detected but also estimated quantitatively. The mathematics of radioactive decay are such that the same *proportion* of the radioactive atoms in a sample decay in a constant interval of time, *e.g.*, in the case of ^{14}C, half the atoms decay in about 5,600 years — the half-life. With ^{3}H the half-life is only 12½ years, but in both cases these times are long in comparison with the times involved in most experiments and it can be assumed that the radioactive tracer is decaying at a constant rate during the experiment. Tracer techniques make it possible to work with exceedingly small amounts of materials since the "label" is easy to detect and therefore very prominent. If we have a matchbox and give it a label the size of a roadside hoarding we could mix the matchbox with a million others and still easily see the "label". This is in effect what is done with radio-tracers. We can in fact work with quantities of material too small to see or weigh, detecting and measuring these small amounts by their radiation.

To illustrate the type of methods one can employ and the kind of results obtained I have selected examples of rather widely differing types of molecules, some well known, some not so well known, but all of importance in plants, animals or microbes.

Fatty Acid Biosynthesis

Fats are constructed from glycerol and fatty acids: the latter are long straight-chain compounds with usually 14 to

20 carbon atoms. It has long been known that among naturally occurring fatty acids those containing an even number of carbon atoms are common, those with an odd number, rare. This suggests that fatty acids are built up in a stepwise manner by a process involving the successive addition of two-carbon units to a gradually lengthening chain. The reverse happens when fatty acids are broken down, the carbon atoms being eliminated two at a time. One of the simplest two-carbon compounds is acetic acid (itself a "fatty acid") and it seemed possible that the long chain acids were built up by linking together acetate units one after the other. In fact if ^{14}C-labelled acetate is administered to animals the radioactivity is incorporated into the fatty acids. The complete details of the conversion of acetate to long chain acids have not yet been worked out but many of the enzymes involved have been purified, or at least concentrated, from such sources as pigeon or chick livers, and the last few years have seen significant progress in filling in the picture. Acetate units as such do not link together directly, but rather the coenzyme A derivative of acetic acid combines with the corresponding derivative of malonic acid, the latter in turn being formed from acetyl coenzyme A and carbon dioxide. This carbon dioxide is eliminated and can in effect be re-cycled.

$$CH_3COSCoA + CO_2 \rightarrow HOOC\text{–}CH_2\text{–}COSCoA$$

Acetyl coenzyme A *Malonyl coenzyme A*

$$HOOC\text{–}CH_2\text{–}COSCoA + CH_3COSCoA$$

$$\rightarrow CH_3\text{–}CO\text{–}CH_2\text{–}COSCoA + CO_2 + CoASH$$

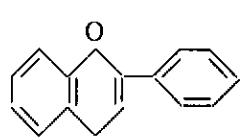
|

$$CH_3CH_2CH_2COSCoA$$

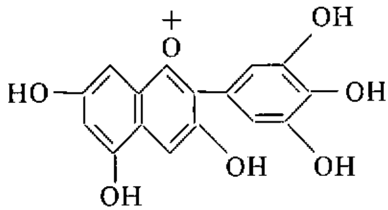
Butyryl coenzyme A *Coenzyme A*

Flavanoid Compounds

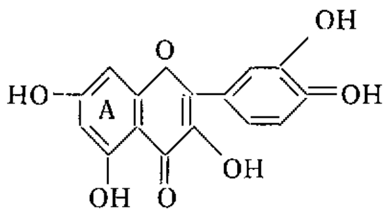
Many of the yellow, orange, red, and purple colouring materials in flower petals belong to the class of compounds known as flavanoids, having the general skeleton:



For example, delphinidin, which occurs in the petals of delphiniums, and quercitin, which is widely distributed, have the formulae:



Delphinidin



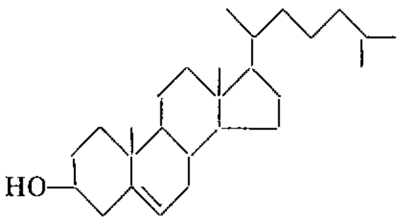
Quercitin

These compounds all contain two benzenoid rings which, however, almost always have a different oxygen substitution pattern and this fact may suggest that these two rings are constructed in different ways. This is indeed the case and it has been established that the A-ring is derived from acetate units, while the other ring and the three-carbon unit joining the two benzene rings are derived from carbohydrates. In plants, of course, carbon dioxide, assimilated photosynthetically, is the major, if not the sole, source of carbon compounds, and the sugars which are the primary products of photosynthesis are subsequently transformed into a whole host of products, including "acetate units".

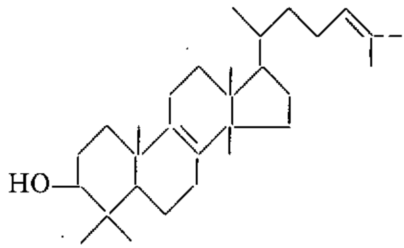
Isoprenoid Compounds

The five carbon unit C–C–C–C characteristic of the sub-
C (attached to the second carbon)

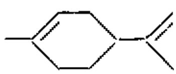
stance isoprene occurs in widely differing types of natural products including rubber (from which isoprene was first obtained), the terpenes (which are the major constituents of most essential oils, *e.g.*, turpentine, camphor), the carotenoid pigments and vitamin A, and, in modified form, in steroids such as cholesterol, in lanosterol (which occurs in wool grease), and in certain mould metabolites.



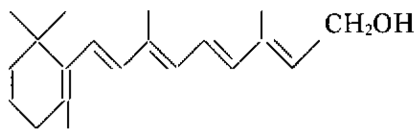
Cholesterol



Lanosterol

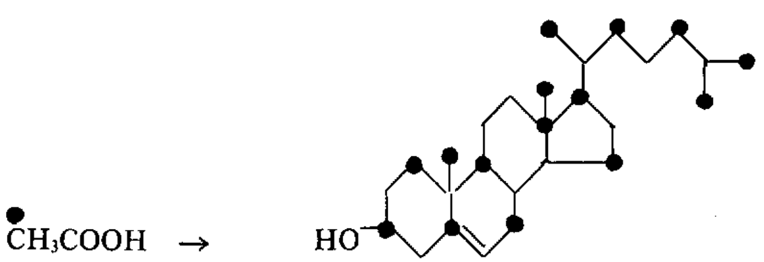


Limonene

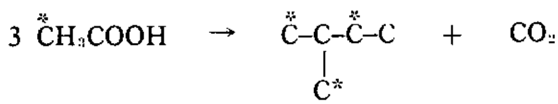


Vitamin A

Lanosterol is a precursor of cholesterol, a sterol which occurs in all animals, concentrated in the brain and nervous tissue, and which has received some publicity of late because it has been implicated in certain arterial diseases. Cholesterol is synthesized in the liver from acetate units and if radioactive acetate is injected into a rat, and some hours later the liver cholesterol is isolated, it is found to be radioactive. The cholesterol molecule can be broken down stepwise by a very lengthy and involved series of reactions, and the labelling pattern can be determined. If the acetate injected into the animal is labelled in the methyl group, the resulting cholesterol molecules are labelled as shown:



Almost all of the steps involved in the conversion of acetate into this very complex molecule are now known. Each isoprene unit in the cholesterol precursors is in fact derived from three acetate units, the "extra" carbon atom being eliminated as carbon dioxide thus:



This pattern is common to all isoprenoid compounds.

Although the examples I have chosen illustrate a wide range of types of compounds, I have only scratched the surface and it would have been possible to spend all the space at my disposal several times over discussing any one of these examples in detail. I have considered these problems from the viewpoint of a scientist trained in pure chemistry, for this is the approach most familiar to me. However, biochemists and perhaps to a lesser extent botanists and zoologists, have made their contributions to knowledge in this field, while the physicists, who provided us in the first place with the tracer materials that are used so extensively, must not be forgotten.

COUNCIL MINUTES

MINUTES OF A MEETING OF THE STANDING COMMITTEE OF THE COUNCIL OF THE NEW ZEALAND INSTITUTE OF CHEMISTRY (INC.) HELD IN WELLINGTON, FEBRUARY 18, 1963.

Present

W. G. Hughson (President), Miss Joan Mattingley and Dr W. E. Harvey (Hon. General Secretary).

Procedure

It was agreed that the Minutes of meetings of the Standing Committee should have the same distribution as the Minutes of Council Meetings.

Professional Status Committee

Mr J. R. Beck has been transferred to Auckland, but it was agreed to ask him to continue to act on the Professional Status Committee. If possible, an additional member will be appointed to the committee from the Wellington area.

Mr O. H. Keys in a letter drew attention to the fact that the N.Z. Electricity Department has advertised for a "Station Chemist" at Meremere Power Station using the words "a recognised chemistry qualification is desired", but the appointment being in the General Division of the Public Service. It was agreed to write to the State Services Commission on this matter.

Overseas Visitors

Professor Shoppee: It was resolved that the Institute pay £5 6s. 0d. towards Professor Shoppee's expenses in Wellington. The Wellington Branch will pay the balance of £10 0s. 0d.

Visitors for 1963: Negotiations are proceeding to bring Professor P. V. Danckwerts, Professor of Chemical Engineering at Cambridge University, to New Zealand at the end of September following his tour of Australia. Professor A. E. Alexander of Sydney University will be in New Zealand as the guest speaker at Conference and will probably visit the main centres.

Changes to Rules

The proposed changes to the Rules have been collected together incorporating as far as possible the branch suggestions. This draft has been forwarded to the Rules Revision Committee for comment, and will then be circulated to branches.

Associateship by Examination

The Committee considered a draft regulation submitted by the Examination Committee. A number of suggestions and comments were made and these will be forwarded to the Examination Committee for consideration.

National Research Council Bill

A letter from Mr S. G. Brooker about the Bill introduced into the House at the end of last session was received. It was agreed that if the Institute is to make further representations to the Government it would be desirable to work in with other bodies such as the Royal Society and the Secretary agreed to communicate with Dr Fleming to ascertain the Royal Society views.

Standards Council

It was agreed to nominate Mr G. A. Lawrence for re-appointment to the Standards Council.

I.U.P.A.C.

There will be a meeting of I.U.P.A.C. in London in July, 1963, and it was considered desirable that someone, closely associated with

Institute affairs if possible, should attend the meetings (though they would have no official status).

The Secretary would be pleased to hear of any members who will be in London at the appropriate time.

W. E. HARVEY, *Hon. General Secretary.*

UNIVERSITY OF CANTERBURY
CHRISTCHURCH, NEW ZEALAND
Lecturers (2) in Chemistry

Applications are invited for two positions as Lecturer in the Department of Chemistry. Applicants should have special qualifications in inorganic, structural, or physical chemistry. The salary range is £1,250 (×£75) to £1,700 and commencing salary will be in accordance with qualifications and experience. Approved fares to Christchurch will be allowed for an appointee, his wife and children; in addition, actual removal expenses will be allowed within specified limits.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the Brtiish Commonwealth (Branch Office), Marlborough House, Pall Mall, London, S.W.1.

Applications close in New Zealand and London on August 31, 1963.

G. G. TURBOTT, Registrar

P.O. Box 1471,
Christchurch,
New Zealand.

VICTORIA UNIVERSITY OF WELLINGTON
NEW ZEALAND
Appointment of Research Fellow

Applications are invited for appointment of a Research Fellow under a United States Air Force Contract. The appointee will undertake full-time research under the direction of Professor J. F. Duncan (Professor of Theoretical and Inorganic Chemistry) on the chemical applications of the Mossbauer effect. Applicants should have previously worked in the fields of radiochemistry, N.M.R., crystallography, solid state, or general inorganic chemistry.

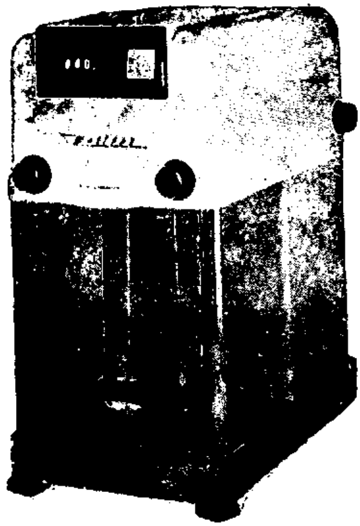
Term of appointment for a maximum of two years; salary range £N.Z.1,000 to 1,300 depending upon the qualifications and experience of the appointee.

Conditions of appointment obtainable from the Registrar of any University in New Zealand or from the Registrar, Victoria University of Wellington, P.O. Box 196, Wellington, with whom applications close on July 17, 1963.

L. O. DESBOROUGH, Registrar.

NEW ZEALAND MEDICAL RESEARCH COUNCIL

A vacancy exists for the position of Senior Chemist with the Dental Research Unit, New Zealand Medical Research Council. The successful applicant would be employed in the laboratories of the Dental Research Unit, Wellington, and would be expected to work on the analytical programme relating to an investigation of micro-elements in soils and dental caries. Salary for the position is £1,750 to £2,000 p.a., commencing salary to be dependent on qualifications and experience. Annual leave is 3 weeks, study leave is available after not less than 6 years' service, and superannuation benefits are available. Applications, describing age, marital status, qualifications and experience, should be forwarded to the Director, Dental Research Unit, P.O. Box 3155, Wellington.



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