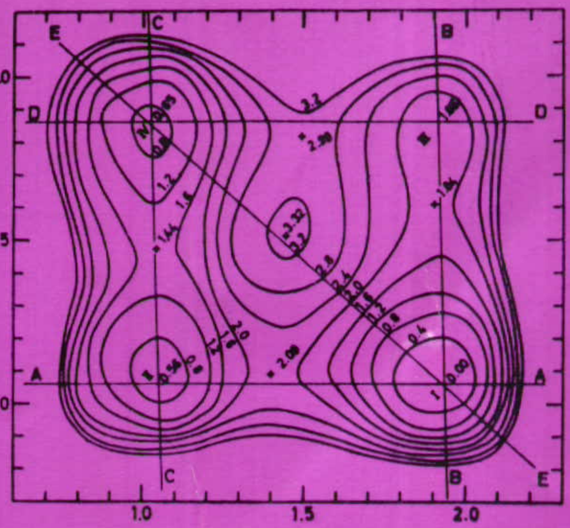
chemistry

in new zealand



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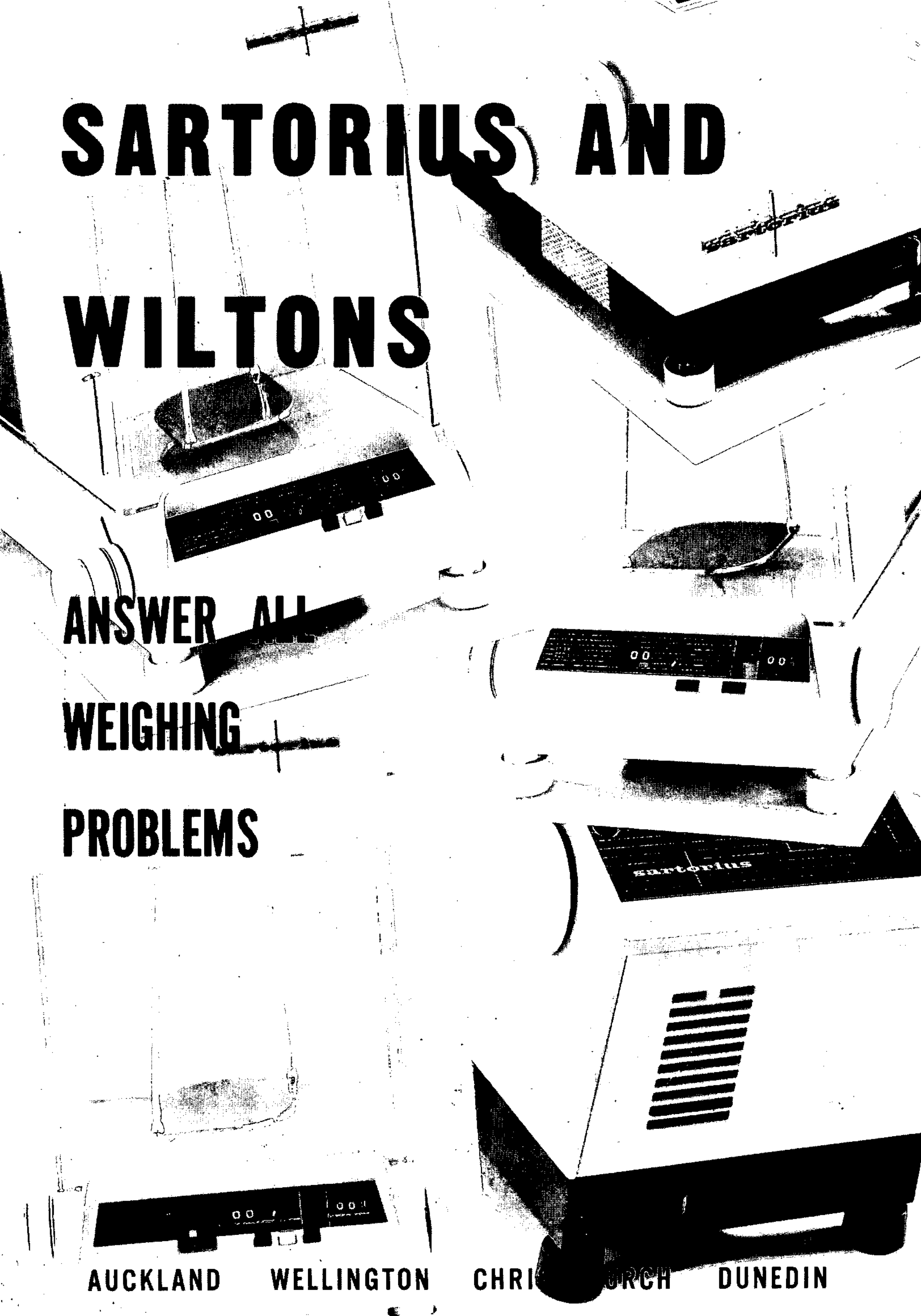
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chemistry in new zealand

Journal of the New Zealand Institute of Chemistry

Winning Student Papers.

Regular features . . .

Cover

Energy contour diagram for guanine-cytosine base pair. See Watson-Crick-Lowdin Theory of Mutations in DNA.

EDITOR
Joan Mattingley
P.O. Box 250 Wellington.

ADVERTISING MANAGER
D. Howard
P.O. Box 250 Wellington.

DISTRIBUTION
D. J. Hogan
P.O. Box 1926 Christchurch.

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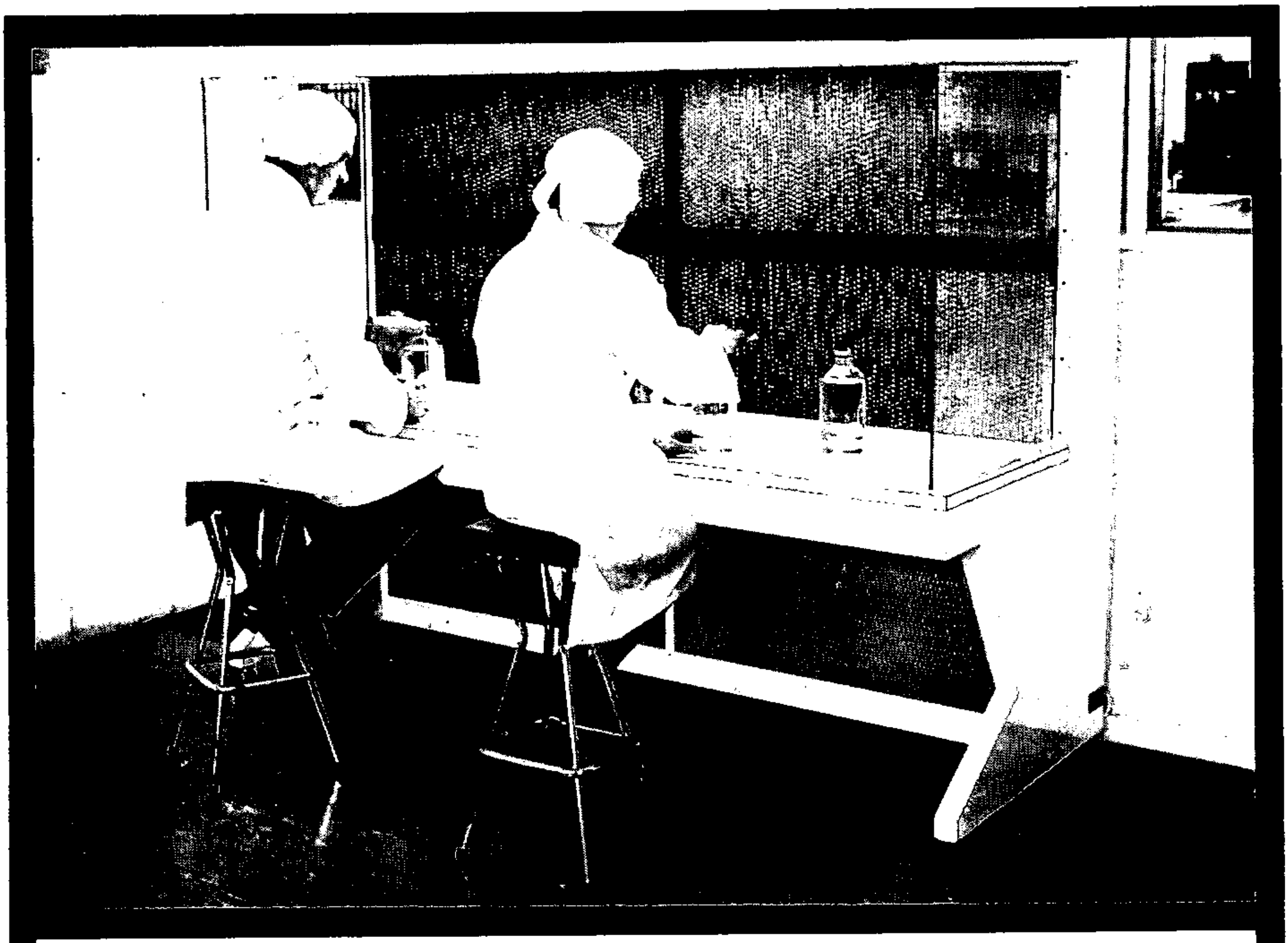

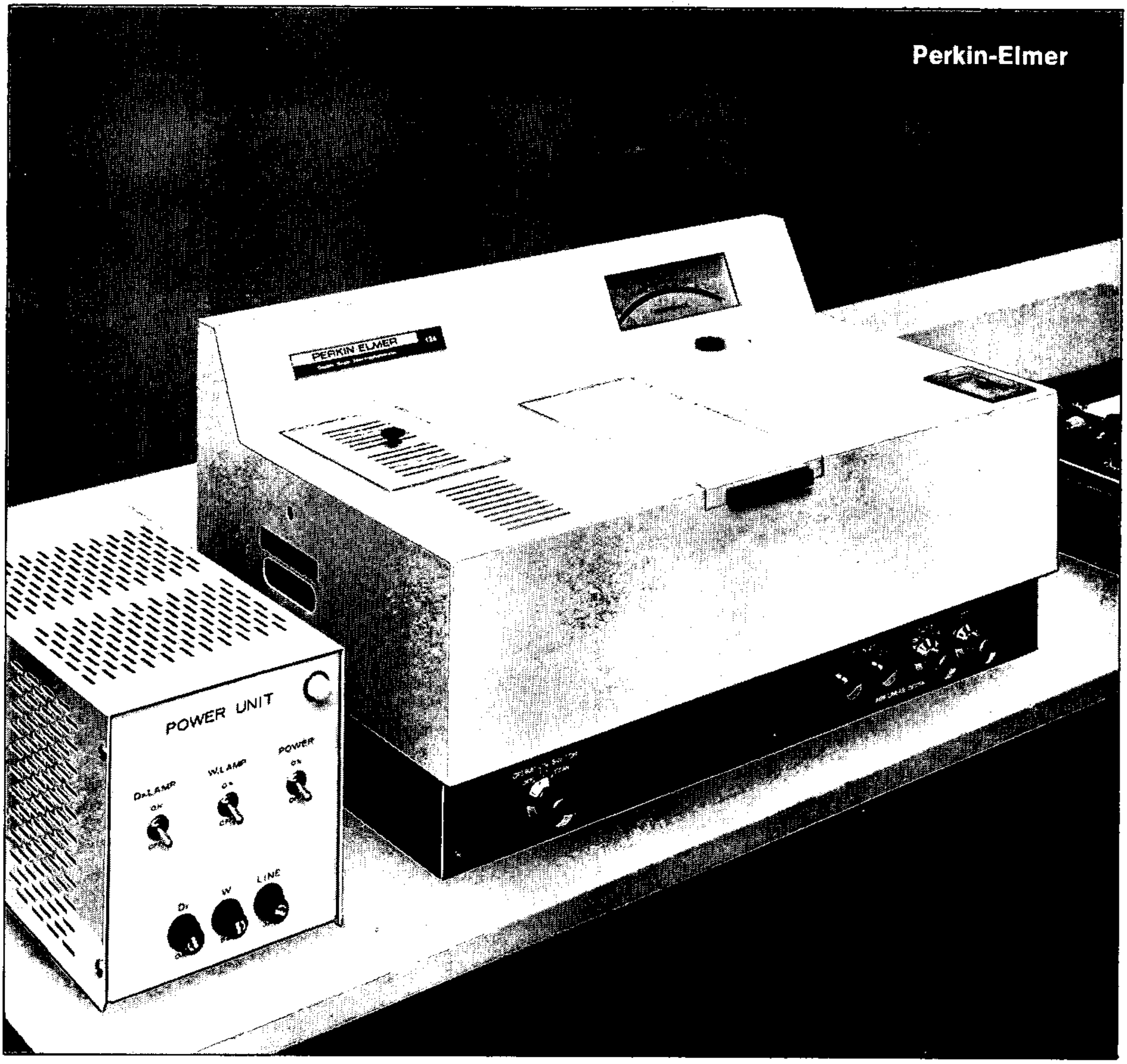
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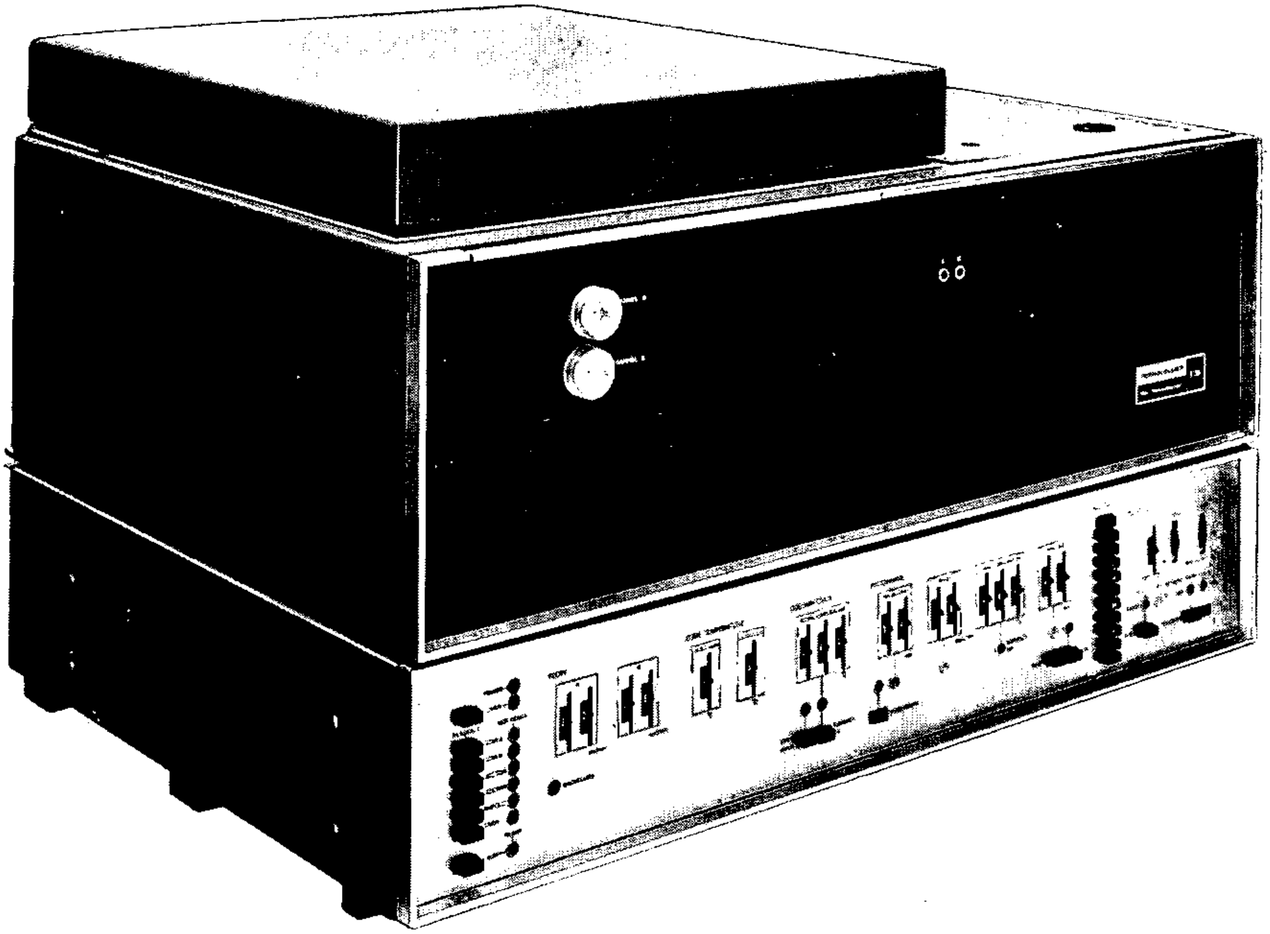


Comment

The Chemist in an Emergency

The Parnell Civil Defence Emergency received a greater publicity than has been known hitherto for chemical spillages in New Zealand. However, this particular spillage is only one of many incidents in which dangerous chemicals have been involved.

With the present day emphasis on pollution, toxicity, fire and explosion hazards, chemicals are receiving an unpleasant notoriety with the inevitable implication that the chemists who manufacture and handle them are not quite respectable.

It is true that the chemist may be held responsible for many of the chemicals in existence which nature has not thought fit to produce on this planet. Many of the chemicals, used for a good purpose, are at the same time hazardous and unsavoury when used irresponsibly or released into the environment.

The chemist would be the first to acknowledge that his "brain children" are his responsibility and that they may turn into "monsters" if he does not fully understand and know how to control them.

However, from experience, it appears that difficulties usually arise when chemicals are inadequately packaged, badly handled or transported and misused on delivery. All such factors have been known to result in incidents followed by doubts as to chemical structure, best method to 'neutralise' and dispose of the substance and treat any victims actually or psychologically affected by the chemical or its reaction products.

It is unlikely that anyone would argue against the logic that chemical organisations should be consulted on a national basis when the need arises to obtain information on chemical naming and recommended packaging. In addition the same organisations should be fully aware of the trade names in current use, and labelling instructions, particularly those relevant to actions to be taken in the event of a spillage.

In the U.S.A. this type of responsibility is undertaken, in part, by the Manufacturing Chemists Association. In the United Kingdom the potential hazards of chemicals transported by road and involved in an accident have been considered and action taken by the Chemical Industries Association by making available a Transport Emergency Card Scheme. The system has been adopted from that developed by the European Council of Chemical Manufacturers' Federations. More recently, a new system 'HAZCHEM' for the classification of hazardous chemicals has been considered by the Greater London Council Scientific Branch.

Usually, in New Zealand, the chemist is consulted only after the emergency has occurred. He may not be given the chemical name of the material and certainly won't have had a say in the overseas packaging. Worst of all he has no authority to resist lay or ill-informed opinions. He can only recommend a suitable course of action.

With an ever-increasing variety of chemicals entering the country it is time for our chemists to be consulted about such imports so that they may be positively identified. The identification would not then depend on a trade name which may be chemically useless or erroneous.

In addition, specifications, valid in New Zealand, should be laid down for the packaging of chemicals.

The New Zealand Institute of Chemistry has already made itself responsible for issuing advice on safety within the laboratory but has not, so far, extended its advice to imported chemicals and the industrial handling of chemicals.

Recommendations to avoid or alleviate a civil emergency arising from chemical spillage have been published in the "Report of the Commission of Inquiry into the Parnell Civil Defence Emergency" June 1973. Submissions were made to the Commission to establish a national dangerous goods advisory centre.

Surely it is time that the Institute, and each member, be active in facing this responsibility.

A. K. Kennet,

Publicity Officer,
Auckland Branch NZIC.

Winning Student Paper given at NZIC Conference 1973

Studies on the Mechanism of Action of an Experimental Anti-Tumour Drug

by W. R. Wilson

For many years attempts have been made to develop drugs of value in treating the various diseases that we collectively term cancer. The realisation of this aim requires the development of drugs which will be toxic to tumour cells while having minimal effect on the cells of the host.

Unfortunately no completely general biochemical difference between tumour and normal cells has yet been identified, although our understanding of the nature of cancer has advanced significantly in the last few years. At present the most useful distinction between cancer cells and their normal counterparts is the difference in growth kinetics of these two types of cell. Normal cell populations usually have only a proportion of cells in the process of growth and division, with the remainder in a dormant state (G_0 cells). When the demand for a particular type of cell increases, as occurs for example during wound healing, G_0 cells are able to enter into the cell division cycle and assist in the repopulation of the tissue. In contrast tumour cells appear to be relatively insensitive to the control processes which restrict the growth rate of normal cell populations. Thus a high proportion of tumour cells are in the process of growth and division.

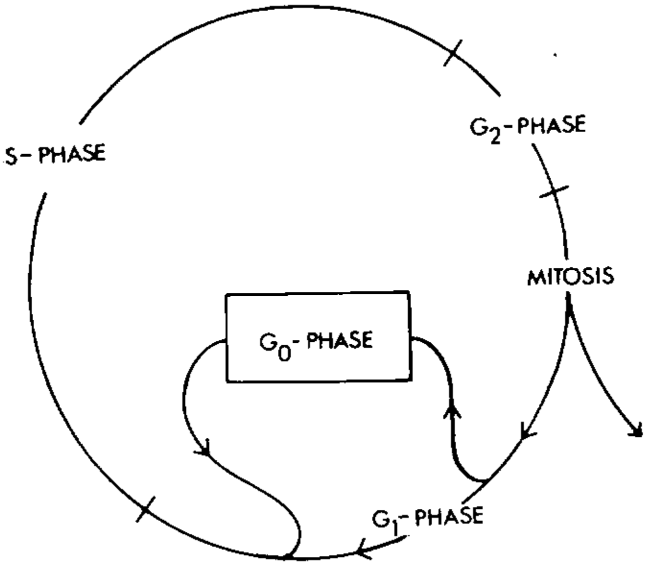


Figure 1. The L1210 cell division cycle.

Department of Cell Biology, University of Auckland.

The above considerations can be illustrated by reference to a schematic diagram of the cell division cycle (fig. 1). In the life of a cell between one division and the next the contents of the cell are duplicated. This is evidenced as a continuous increase in cell volume. However, replication of DNA occurs only during a discrete period (S-phase) of the cycle. Consequently four periods in the cell cycle can be distinguished, with G_1 and G_2 phases being defined as the periods of preparation for S-phase and mitosis respectively. The non-dividing G_0 cells can be considered to be reversibly inhibited from progressing through G_1 phase (fig. 1). The altered growth kinetics of tumour cells appears to result from their relative insensitivity to controls which normally maintain a large reserve of G_0 cells.

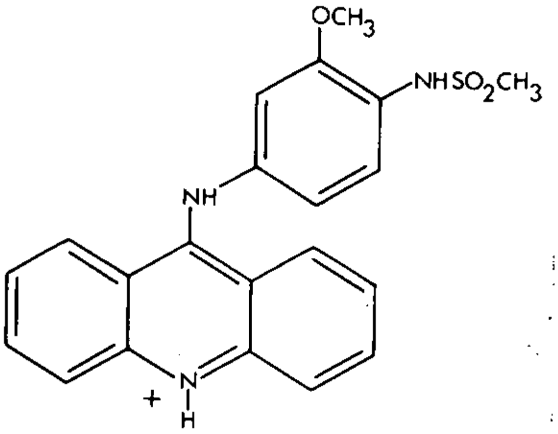
Because of the continuous passage of tumour cells through the cell cycle drugs which cause the death of cells at some stage in this cycle show selective toxicity for tumour tissue. Despite the small margin between tumour and host toxicity many drugs known to inhibit progression of cells through the cell cycle, particularly inhibitors of DNA synthesis or mitosis, are of value in the treatment of human cancer. Unfortunately none of the drugs are ideal. It is thus of importance to continue the search for more useful anti-tumour agents.

Recently in Auckland Dr. B. F. Cain and his associates have been responsible for the development of an interesting new series of anti-tumour drugs (Atwell *et al*, 1972, and B. F. Cain, personal communication). Several of these compounds are at present under investigation in the laboratories of the National Cancer Institute in the United States. Hopes are held that some of these drugs will prove clinically useful. The drugs were developed by testing putative anti-tumour agents in mice bearing a transplantable leukaemia known as L1210 murine leukaemia, and under certain conditions total cures of leukaemic mice can be achieved with several of these compounds.

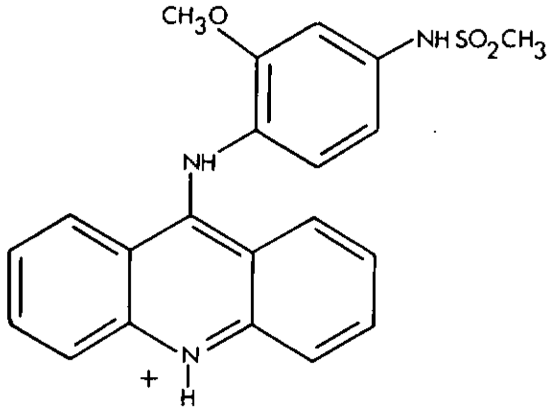
These new drugs are modified acridine compounds. The acridinyl nucleus was chosen because of its ability to bind to DNA with high affinity. Although this interaction has been shown to cause inhibition of DNA and RNA synthesis in many biological systems, previously few acridines have shown any anti-tumour activity.

In order to assess the validity of the initial premise behind the development of these drugs, that is that they bind to DNA and interfere with its function in such a way as to kill the cell, the effects of the new drugs were evaluated in several systems. The experiments described here concern two members of the new series: 4'-(9-acridinylamino)-methanesulphon-*m*-anisidine and the corresponding *o*-anisidine. These compounds have been chosen for study because in spite of their structural similarity (fig. 2) they display a marked difference in antileukaemic activity. *m*-AMSA is a potent inhibitor of a wide variety of tumours, including L1210, while *o*-AMSA has no measurable effect on tumour growth. Comparison of these drugs is thus of value since effects shown by both drugs can be inferred to be incidental to the mechanism of cell killing by *m*-AMSA while effects peculiar to the latter species may be related to this mechanism. Further, comparison of the two drugs may provide an indication of the ways in which structural parameters influence drug activity in this series. Both approaches are of obvious importance to the improvement of drug design.

The suggestion that DNA may be the site of action of these drugs prompted a study of the interaction of AMSA compounds with DNA. All members of the acridine series which were tested, including both the AMSA compounds, showed such an interaction. This was readily demonstrated by the alteration of the visible absorption spectrum of the drugs upon addition of the nucleic acid. A typical result is indicated to fig. 3.



o-AMSA



m-AMSA

Figure 2. Structures of the AMSA drugs. For systematic names, see text.

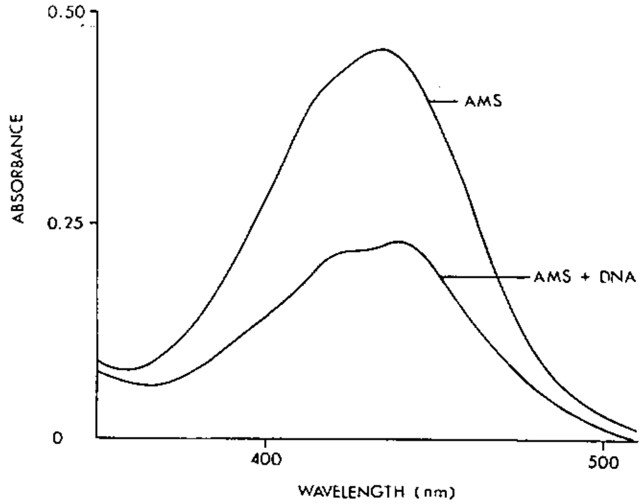


Figure 3. Visible absorption of 4'- (9-acridinylamino)-methane-sulphonanilide (3.5 x 100^{-n}M) in 0.01M Hepes buffer pH 7.0, and at the same concentration in the presence of calf thymus DNA (150 μg/ml).

The existence of an interaction between AMSA compounds and DNA indicated the importance of investigating the effects of these compounds on nucleic acid metabolism and the cell cycle. The measurement of such effects *in vivo* represents a considerable technical difficulty. Fortunately a useful experimental system for analysing effects on the cell cycle has recently been developed in our laboratory. This technique uses velocity sedimentation of cells under unit gravitational force, a technique which has previously been used to separate different classes of cells from complex mixtures of cell types (Miller and Phillips, 1969). The rate of sedimentation(s) is a function of cell density and volume and is given by:

$$S = \frac{2}{9} \frac{(P-Po)}{\eta} gr^2$$

where g is the acceleration due to gravity, P and Po are the cell and medium densities respectively, η the coefficient of the viscosity of the medium, and r the radius of the cell. Since cell density is almost constant during the cell cycle, growth and division of the cell can be followed by changes in sedimentation rate.

When cells in the division cycle are exposed to radioactive thymidine, a precursor for DNA synthesis, cells in S-phase can be identified by their ability to incorporate this label into DNA. For L1210 cells the average duration of S-phase is about six hours while the total cell cycle time is 12.5 hours. (B. C. Baguley, personal communication).

To determine whether m-AMSA inhibited DNA synthesis in L1210 cells [2-^{14}C]-thymidine was injected into leukaemic mice at various times after treatment with the acridine drug. A progressive decrease in ^{14}C radioactivity was detected in the S-phase pouulation (fig. 4), which indicated that inhibition of DNA synthesis was occurring.

In the same experiments the effects of *m*-AMSA on the passage of S-phase cells through the cell cycle was determined by labelling these cells with [5-Me-^{3}H] -thymidine before injection of the drug. Tritium-labelled cells continued to grow after *m*-AMSA treatment indicating that RNA and protein synthesis were not inhibited by the drug. However these labelled cells had not divided after six hours (fig. 4b) whereas in the absence of *m*-AMSA most of the S-phase cells had divided to form small G_1 phase cells by this time (fig. 4a). Even twelve hours after the exposure of S-phase cells to the drug, cell division could not be detected and abnormally large cells were produced (fig. 4c). A similar experiment indicated that by 18 hours most of the tritium-labelled cells had disappeared from the peritoneum.

The simplest hypothesis relating these observations is that *m*-AMSA inhibits DNA synthesis, presumably by binding to DNA, and thereby prevents cells from completing a normal division cycle. This leads to their death. That these events are in fact related to this anti-tumour action of *m*-AMSA is indicated by the inability of *o*-AMSA to induce any of these changes. The continued growth of cells prevented from completing S-phase suggests that *m*-AMSA does not inhibit RNA or protein synthesis. Continuation of RNA synthesis by L1210 cells after injection of *m*-AMSA has been demonstrated directly in other experiments.

Since both *o*- and *m*-AMSA were shown to bind to DNA *in vitro*, while only the latter inhibited DNA synthesis *in vivo*, a quantitative study of this binding was undertaken in an attempt to discern the basis for this difference.

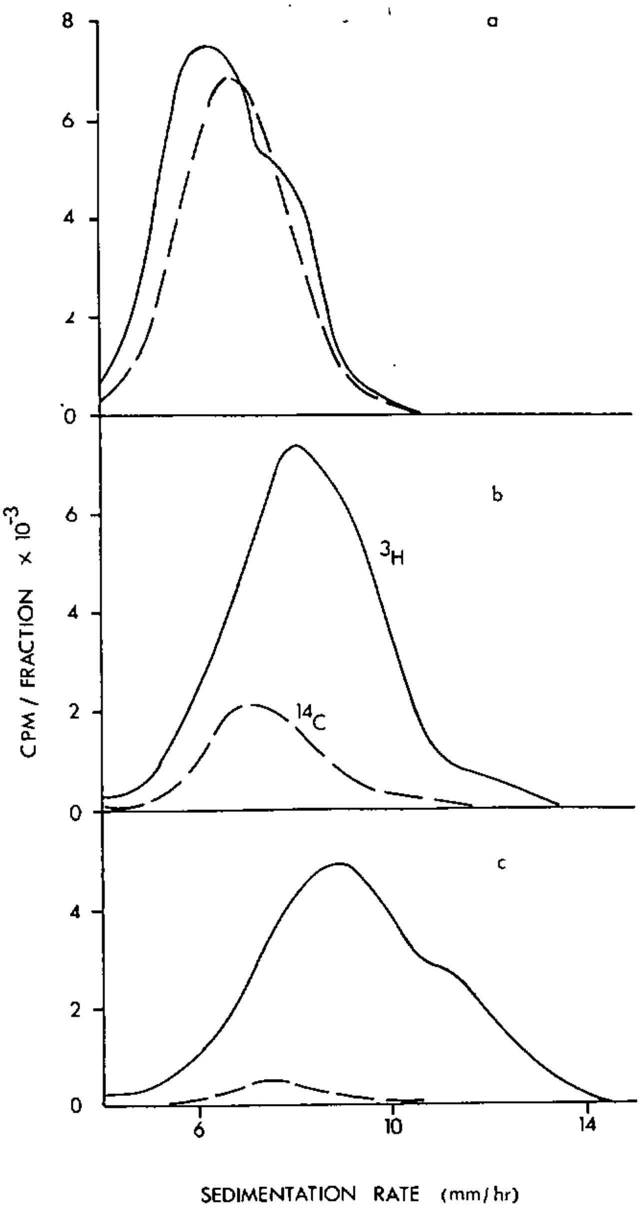


Figure 4. In each experiment mice were injected intraperitoneally (i.p.) with [5-Me-^{3}H] -thymidine (2 μCi, 26 Ci/mmole). The control group (a) were injected i.p. six hours later with [2-^{14}C] -thymidine (1 μCi, 62 mCi/mmole) and killed 15 minutes later. A second group of mice (b) were treated similarly but received a sub-cutaneous (s.c.) injection of *m*-AMSA (20 mg/kg) ten minutes after the injection of [5-Me-^{3}H) -thymidine. The third group (c) were treated as for (b) but the second dose of radioactive thymidine was administered twelve hours after the first.

Leukaemic cells were removed from the mice 15 minutes after injection of (2-^{14}C) -thymidine and were allowed to sediment through a 7-25% calf serum gradient at 4° for three hours. Fractions (12 ml) were collected by pumping out the contents of the sedimentation chamber, and acid insoluble radioactivity in each fraction was measured.

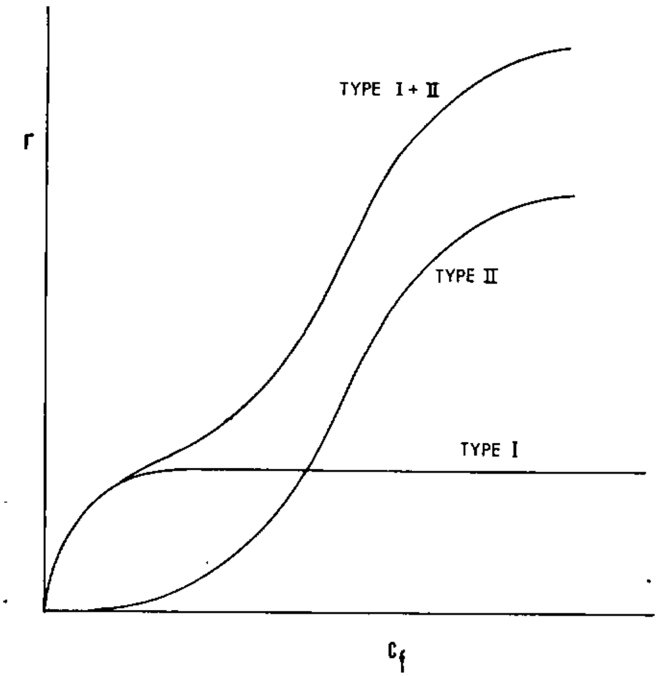


Figure 5. Theoretical DNA-binding curves for acridines. Symbols are defined in the text. Redrawn from Blake and Peacocke (1968).

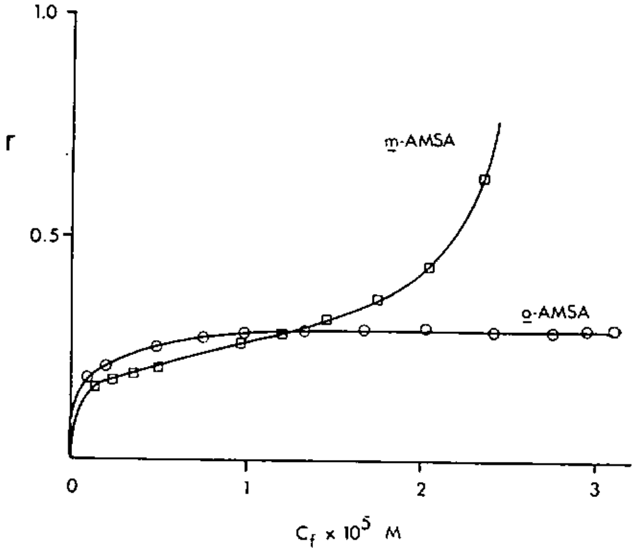


Figure 6. Experimental DNA-binding curves for *o*- and *m*-AMSA. Data was obtained from the absorbance of 430 nm of AMSA solutions (3.5 x 10^{-5}M) as a function of the concentration of calf thymus DNA.

The existence of a physical binding of acridines such as 9-aminoacridine and phenanthridinium salts such as ethidium to DNA has long been known, and both types of compounds bear resemblances to the AMSA drugs. This binding is known to occur by two modes (Blake and Peacocke, 1968). Firstly, at low drug concentration a number of high affinity binding sites in the DNA are occupied. These sites, known as type I, become saturated when about one mole of drug is bound for every four or five moles of DNA phosphate. At higher drug concentrations a second class of binding site become occupied, these being the type II sites. This weak binding is indicated to be primarily an electrostatic interaction by its sensitivity to ionic strength, as well as by other criteria. Although the nature of the type II complex has not yet been adequately defined, it is generally considered that the acridine molecules stack on the outside of the DNA helix with the cationic acridinyl nitrogen bonded to the anionic DNA phosphate.

The molecular nature of the type I complex has attracted more interest and is still generating controversy. Lerman proposed in 1963 that the acridine was inserted between two adjacent base pairs in the DNA; that is intercalative binding was the basis of the type I interaction (Lerman, 1963). Considerable evidence has indicated his model to be correct in general principle although revision of details has been necessary (Pritchard *et al*, 1966).

The difference in the extinction coefficient of the free and DNA-bound AMSA drugs at wavelengths near the visible absorption maximum allows quantitative determination of binding parameters by measuring the concentrations of free and DNA-bound drug as a function of DNA concentration. The theoretical binding curves predicted for a compound displaying type I and II interactions with DNA are shown in fig. 5. The type I curve is that given by the equation for the interaction of a ligand with a homogeneous class of sites on a macromolecule such as DNA:

$$r/c_f = kn - kr$$

where r is the molar ratio of drug to DNA phosphate in the complex, n is the number of binding sites per DNA, k is the intrinsic association constant at these sites, and c_f is the free ligand concentration. The type II curve is that expected for a co-operative interaction at low affinity sites, and is observed with many acridines.

The experimental binding curves for the AMSA compounds at low ionic strength are indicated in fig. 6. While *m*-AMSA displays a similar binding curve to acridines which display both type I and type II interaction, no type II interaction can be detected with *o*-AMSA. When the data indicated in fig. 6 is presented as a Scatchard plot the binding parameters for the type I interaction can be obtained. For both AMSA compounds this procedure indicates the presence of about one type I site per four DNA phosphates, and an intrinsic association constant or 2.5 x 10^6 m^{-1} for these sites. These values are similar to those for acridines such as proflavine whose type I binding has been thoroughly characterised. It is thus probable that both *o*- and *m*-AMSA bind to DNA by intercalation.

The difference in type II binding by the active and inactive antileukaemic agent is of interest since attempts to correlate DNA binding and physiological effects of acridines have concentrated on type I binding. These approaches have met with little success. It is tempting to infer from the present study that the antileukaemic activity of the AMSA compounds depends upon type II interaction.

However, such a conclusion cannot be drawn from the above data since the interaction with purified DNA *in vitro* may be quite different from the interaction occurring in the cell. In particular, the DNA in the nucleus is organised quite differently from that in the above experiments, being tightly compacted, and associated with basic histones and acidic nuclear proteins. Nevertheless the difference in type II binding of the two AMSA drugs suggests that these experiments may be significant.

Differences between *o*- and *m*-AMSA other than DNA binding have been detected. Thus distribution in the mouse after injection at the sub-cutaneous site, as well as the extent of association of radioactive drug with L1210 cells in culture, is different for the two ASMA compounds. The active antileukaemic agent thus appears to penetrate membranes more rapidly than its inactive homologue. In addition *m*-AMSA is degraded to 9-aminoacridine in alkali much more rapidly than is *o*-AMSA. If this reaction is a model for metabolism of AMSA compounds to an active antileukaemic agent this difference could also explain the inactivity of *o*-AMSA. Thus the reason for the inactivity of *o*-AMSA is not clear.

At present it appears that *m*-AMSA exerts its antileukaemic effect through inhibition of DNA synthesis, and consequent interference with the cell division cycle. Many aspects of this process are still to be explained, such as the molecular interactions causing this inhibition, and the phenomena which lead to the death of the large cells which are formed. It is interesting to note that an adequate description of the way in which cell killing is achieved is not yet available for any antileukaemic drug. Thus studies with *m*-AMSA and related compounds may provide new insights into a still largely unexplored field, as well as aiding in the development of more useful agents.

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TO PROPECTIVE IMMIGRANTS WHO WRITE TO OUR EMPLOYMENT OFFICER

The following remarks have been prepared by our honorary employment officer, Mr. C. L. H. Stonyer, as a guide to what can and cannot be done to help chemists who want to come to New Zealand.

The vast majority of enquiries concerning employment in New Zealand are from chemists and near-chemists in the United Kingdom, with a few from Canada and the United States, and despite a clear statement in information given to prospective immigrants at New Zealand House that it is almost impossible to arrange employment in New Zealand by correspondence, they nearly all want to know how to do this. To all these I would say:

Please do not write and ask us how to get a job in New Zealand with an employer sponsoring your trip here, because if an employer cannot find the staff he wants in New Zealand, he will advertise or make enquiries in the U.K. possibly even through New Zealand House, and is usually interested only in those he finds in this way. We do not know how many employers obtain staff in this way, nor is our Institute advised if they are interested in getting staff from overseas.

Most employers, especially those interested in industrial chemists and biochemists, advertise in New Zealand; and judging from the small number of advertisements this year there is not a great unfulfilled demand for staff at the moment. This is probably because Government is trying to avoid staff increases in state-controlled laboratories (even to the extent of not replacing those who leave or retire) and hence new graduates, chemists in industry looking for new jobs, teachers looking for other jobs, and overseas chemists who have arrived are all actively canvassing prospective employers. Under these circumstances many employers do not find it necessary to advertise. While this does not mean that there is no turnover of jobs, it does mean that it is difficult to advise people about the extent of the demand for chemists.

If you have a good degree (several O levels and a supervisory job are not enough) and have useful experience in an industry which exists in New Zealand, then you have a reasonable chance of obtaining employment as a chemist within a few months if you decide to come here unassisted.

Even if you do not immediately get work as a chemist, the newspapers are full of advertisements for comparatively unskilled workers, so at least in the main cities you will not starve!

The situation regarding University employment is slightly different, because a reasonable proportion of their staff is appointed from overseas. This is done by advertisements placed in scientific journals, in *The Times Higher Educational Supplement* and through the Association of Universities of the Commonwealth. Prospective applicants also often write direct to the Vice Chancellors of the seven universities.

One class of enquirer is typified by the family man of around 35-45 years of age, with a well-paid, responsible position in charge of an important laboratory or function in industry, who wants to know how he can get a sponsor in New Zealand to offer him a similar job here.

If you are in this category, your only hope is to watch for the advertisements our employers place in your country, and answer them.

Another rather difficult type of case is exemplified by the person with perhaps an L.R.I.C. who has become valuable to a particular employer, probably in charge of a number of staff, but who now wants to get into a new country. Until more employers here have discovered the value of our Certificate of Science (obtained by about five years part time study after leaving secondary school, and requiring practical experience of a suitable nature) then prospects for this type of person obtaining a similar position here are poor.

The present function of our honorary employment officer is limited. The sum of the efforts that he can at present make on behalf of prospective immigrants is limited to advising on general employment conditions. The Institute does not at present function as an employment agency, and apart from looking at local newspaper advertisements and discussing the situation with local employers from time to time, the Employment Officer does not know of specific vacancies.

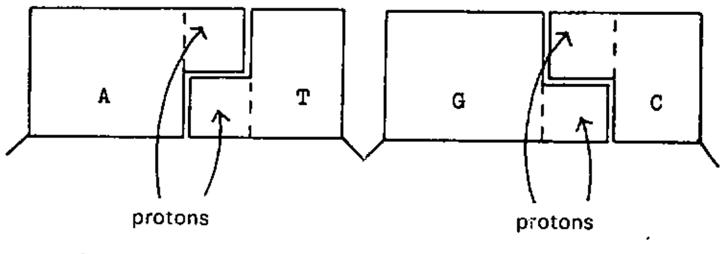
The Watson-Crick-Lowdin Theory of Mutations in DNA*

by J. N. Mulvihill

Introduction

It is now well-established that the genetic information characteristic of any species is carried by the chromosomes of the cell nucleus. These are built up from giant helical molecules known as deoxyribose nucleic acid or DNA. According to Watson and Crick's stereomodel, which is based on the results of X-ray diffraction studies,[1,2] the DNA helix is in fact a double helix, consisting of two sugar-phosphate chains linked by hydrogen bonds through pairs of nucleotide bases.

Figure (1) shows the three-dimensional double helix in diagrammatic form. It can be seen that pairing of the nucleotide bases across the two opposing sugar-phosphate strands is determined first of all by steric factors: the strand-to strand distance is such that, without any distortion, the helix can accommodate only a "short" pyrimidine base, thymine or cytosine, hydrogen bonded to a "long" purine base, adenine or guanine. Pairing of a purine to a pyrimidine is further restricted by the hydrogen bonds. Under normal conditions, adenine is linked only to thymine and guanine only to cytosine, since this is the only pairing pattern allowed by the positions of the protons available for hydrogen bonding. The pairing may be represented schematically by block diagrams:



A = adenine
T = thymine

G = guanine
C = cytosine

In these, projections are used to indicate the proton positions.

The genetic message is thought to be conveyed in the sequence of bases along a single DNA strand, for instance a sequence of the type ACTGGA. Replication of DNA is designed to preserve this sequence. As illustrated in the lower part of figure (1), the hydrogen bonds of the double helix are broken, the two strands become at least partially separate and each acts as a template for the formation of its own complement. The result is two daughter helices each with base sequences identical to those of the original.

Errors in the base sequence are known as mutations. It was first suggested by Watson and Crick[3] that these errors might arise through the occur-

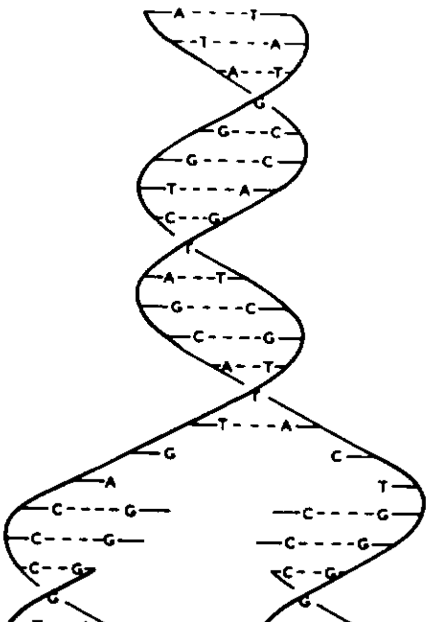
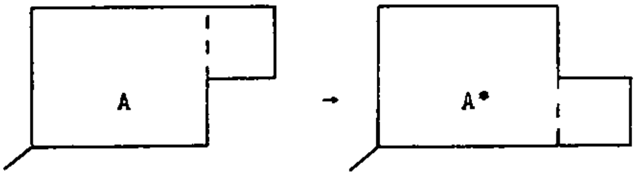


Figure (1)
Watson-Crick stereomodel of DNA in diagrammatic form. Pairing of the nucleotide bases across the two strands, indicated by the dotted lines, is shown to be specific: adenine (A) to thymine (T) and guanine (G) to cytosine (C). The lower part of the diagram illustrates replication according to the so-called Y model.

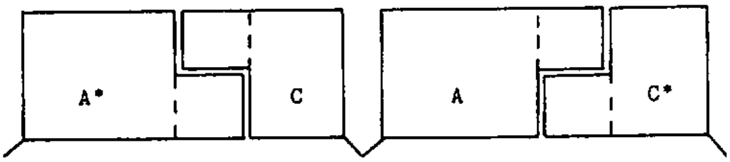
Chemistry Department, University of Canterbury

* *This paper won the Institute's Chemical Essay Prize, 1973.*

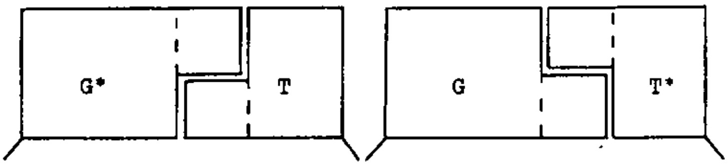
rence of isometric forms of the nucleotide bases. All four bases are capable of existing in at least two different tautomeric forms, interconverted by shifting a proton from one electron pair to another. For example, a tautomeric shift in adenine may be represented by the diagram:



This schematic representation shows directly that the pairing pattern of the less common tautomer A* will differ from that of the normal tautomer A. A* will pair with C and C* with A:



Similarly, in the case of guanine and thymine, G* will pair with T and T* with G:



Suppose now that by some mechanism a base pair A-T of the DNA helix is replaced by the tautomeric pair A*-T*. At the first replication, A* will pair with C and T* with G:

$$\begin{tikzcd} & A\text{-}T \arrow[d] & \\ & A^*\text{-}T^* \arrow[dl] \arrow[dr] & \\ A^*\text{-}C & \text{replication} & G\text{-}T^* \end{tikzcd}$$

These two bases C and G, introduced from the environment, will follow the normal pairing pattern. Hence a second replication will lead to replacement of the original base pair A-T by the new pair G-C:

$$\begin{tikzcd} & A^*\text{-}C \arrow[dl] \arrow[dr] & & & G\text{-}T^* \arrow[dl] \arrow[dr] & \\ A^*\text{-}C & & G\text{-}C & \text{second replication} \quad G\text{-}C & & G\text{-}T^* \end{tikzcd}$$

The double tautomeric shift: A-T → A*-T*.

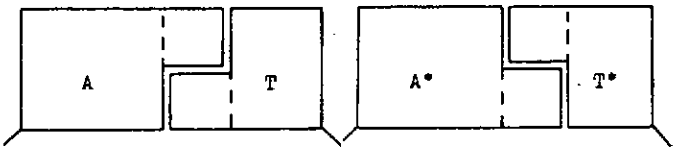
thus gives rise to the mutation or base pair transition: A-T → G-C.

The problem is: what mechanism will account for the occurrence of a tautomeric base pair in the double helix of DNA? It appears that there are two ways in which a pair of normal bases A and T (or G and C) may be replaced by a pair of tautomers A* and T* (or G* and C*). Firstly, during DNA replication, two tautomeric bases A* and T* from the environment may be incorporated, one into each of the two daughter helices:

$$\begin{tikzcd} & A\text{-}T \arrow[dl] \arrow[dr] & \\ A\text{-}T^* & \text{replication} & A^*\text{-}T \end{tikzcd}$$

This is termed as incorporation error. Secondly, according to quantum mechanics, the proton of a hydrogen bond shows wave-particle dualism. It may be regarded as a "wave packet", for which there is a small but finite probability of tunnelling through the potential energy barrier to proton transfer from one electron pair of the hydrogen bond to the other. This process will be more favourable if overall electrical neutrality is preserved. We therefore expect two protons in adjacent hydrogen bonds to tunnel almost simultaneously in opposite directions, producing a pair of tautomeric bases. In schematic notation we may write:

A-T → A*-T*



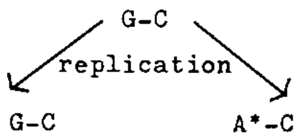
Incorporation Errors

This review will be concerned mainly with the possible importance of the quantum mechanical tunnel effect in the occurrence of spontaneous and induced errors in the genetic code. However, a good deal of study has been carried out with regard to the importance of incorporation errors. Lowdin and his co-workers[3,4] at Uppsala have proposed a mechanism of DNA replication in which incorporation of a single tautomeric base from the environment is very much less likely to take place than incorporation of a pair of tautomeric bases. For instance, consider the replication schemes (1) and (2) below:

Scheme (1)

$$\begin{tikzcd} & G\text{-}C \arrow[dl] \arrow[dr] & \\ G\text{-}T^* & \text{replication} & A^*\text{-}C \end{tikzcd}$$

Scheme (2)

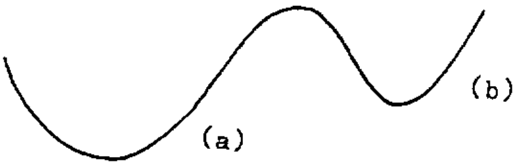


Lowdin's mechanism predicts that scheme (1), where a single tautomeric base A* is introduced, will be energetically much less favourable than scheme (2), where the pair of tautomers A* and T* is introduced.

Provided it is assumed that the nucleotide bases in the environment of a replicating DNA helix are in at least approximate tautomeric equilibrium, the probability of a "double" incorporation error as illustrated in scheme (2) will depend on the product of the equilibrium constants for formation of the two less stable tautomers, in this case A* and T*. Tautomeric equilibrium constants have been measured for a number of pyrimidine bases[5,6]. As yet, there is no accurate data available for purine bases, but it is thought that the product KK' for a pair of tautomers A* and T* or G* and C* should lie in the range 10^{-8} to 10^{-10}. This is in reasonable agreement with the present estimate from biological experiments[7] for the probability per generation of the spontaneous change of a base pair, taken to be of the order of 10^{-8} to 10^{-11}.

Quantum Theory of the Hydrogen Bond

A more detailed study of the quantum mechanics of proton tunnelling between base pairs of DNA must be based on the quantum theory of the hydrogen bond. A proton taking part in a hydrogen bond is attracted by two lone pairs of electrons. The attractive force of each lone pair may be represented as a single potential energy well. Hence the combined effect of the two electron pairs is a "double well potential", in other words two minima (a) and (b) separated by a potential energy barrier:



According to quantum theory, a proton is a "wave-packet" which, unlike a classical particle, may leak or tunnel through the potential barrier from well (a) to well (b). This corresponds to a transition or quantum jump from one permitted state to another.

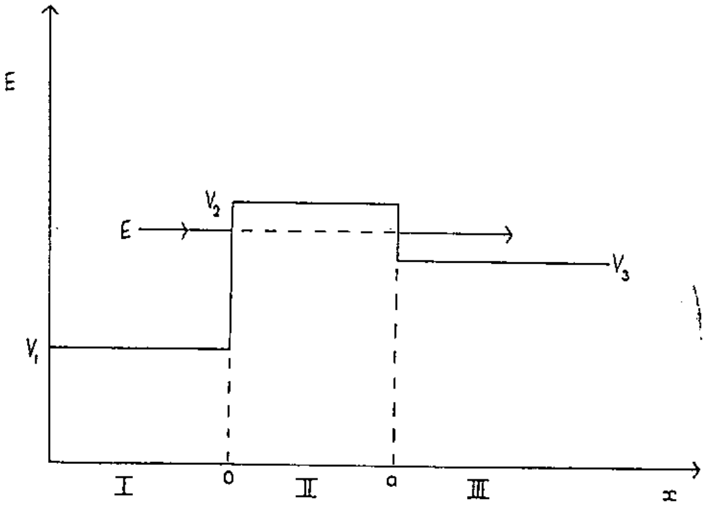


Figure (2)

Penetration of a rectangular potential barrier by a single incident wave approaching from the left in region I.

The essential features of the tunnel effect may be defined in terms of a one-dimensional potential barrier. In this case, the problem reduces to solution of the one-dimensional Schroedinger equation:

$$\frac{-h^2}{8\pi^2 m}\,\frac{\partial^2\Psi}{\partial x^2} + V\Psi = E\Psi \qquad (1),$$

where E is the total energy of the system in the state described by the wave function Ψ and V is its potential energy, which is a function of x. Introducing the notations:

$$p(x) = \sqrt{2m[E-V(x)]},$$

$$k(x) = \frac{2\pi p(x)}{h} = \frac{2\pi}{h}\sqrt{2m[E-V(x)]},$$

equation (1) may be rewritten in the form:

$$\frac{\partial^2\Psi}{\partial x^2} = -k^2\Psi \qquad (2).$$

We will consider initially a rectangular potential barrier of the type shown in figure (2). The general solution of equation (2) is then given by:

$$\Psi = Ae^{ikx} + Be^{-ikx},$$

where the first term represents a right-travelling wave of intensity $|A|^2$ and the second term a left-travelling wave of intensity $|B|^2$. In the particular case where $V_3 < E < V_2$, the general solution in the three regions takes the form:

$$\text{Region 1}: \Psi = A_1e^{ik_1x} + B_1e^{-ik_1x},$$

$$k_1 = \frac{2\pi}{h}\sqrt{2m(E-V_1)};$$

$$\text{Region II}: \Psi = A_2e^{|k_2|x} + B_2e^{-|k_2|x},$$

$$k_2 = \frac{2\pi}{h}\sqrt{2m(V_2-E)};$$

Region III: $\Psi = A_3e^{ik_3x} + B_3e^{-ik_3x}$,

$$k_3 = \frac{2\pi}{h}\sqrt{2m(E-V_3)}.$$

These three expressions will correspond to the same solution only if the wave function and its fisrt derivative are continuous at the boundaries $x = 0$ and $x = a$. At $x = 0$ we obtain the formulae:

$$\begin{aligned} A_1 + B_1 &= A_2 + B_2 \\ A_1 - B_1 &= -i\frac{|k_2|}{k_1}(A_2-B_2) \end{aligned} \qquad (3).$$

Similarly, using the notation:

$$K \doteq a|k_2| = \frac{2\pi a}{h}\sqrt{2m(V_2-E)},$$

at $x = a$ we obtain:

$$\begin{aligned} A_3e^{ik_3a} + B_3e^{-ik_3a} &= A_2e^K + B_2e^{-K} \\ A_3e^{ik_3a} - B_3e^{-ik_3a} &= -i\frac{|k_2|}{k_3}(A_2e^K - B_2e^{-K}) \end{aligned} \qquad (4).$$

If there is a single incident wave approaching the barrier in region I, so that $A_1 \neq 0$, but no incident wave in region III, so that $B_3 = 0$, then the incident wave of intensity $|A_1|^2$ will be partially reflected at the boundaries of the barrier but also partially transmitted into region III as a right-going wave of intensity $|A_3|^2$. The ratio:

$$g = \frac{|A_3|^2}{|A_1|^2}$$

is known as the "transmission coefficient" of the barrier. Setting $B_3 = 0$ in the connection formulae (4) and eliminating B_1, A_2 and B_2 in formulae (3) and (4) gives the relation:

$$\frac{A_1}{A_3}e^{-ik_3a} = \frac{1}{4}(1 + \frac{k_3}{k_1})(e^K + e^{-K}) + \frac{i}{4}(\frac{|k_2|}{k_1} - \frac{k_3}{|k_2|})(e^K - e^{-K}).$$

Hence:

$$\frac{|A_1^2|}{|A_3|^2} = \frac{1}{4}(1 + \frac{k_3}{k_1})^2 + \frac{1}{4}\frac{(k_1^2 + |k_2|^2)(k_3^2 + |k_2|^2)}{k_1^2|k_2|^2}\sinh^2K.$$

The inverse of the transmission coefficient may therefore be defined as:

$$g^{-1} = \frac{1}{4}(1 + \frac{k_3}{k_1})^2 + \frac{1}{4}\frac{(k_1^2 + |k_2|^2)(k_3^2 + |k_2|^2)}{k_1^2|k_2|^2}\sinh^2K.$$

Since $\sinh K = \frac{1}{2}(e^K - e^{-K})$, to a first approximation the transmission coefficient decreases as e^{-2K}:

$$g \simeq e^{-2K},$$

where: $K = \frac{2\pi a}{h}\sqrt{2m(V_2-E)}$.

From this simplified expression for the transmission coefficient, it can be seen that the tunnel effect will decrease exponentially with both the width of the potential barrier from $x = 0$ to $x = a$ and the square root of the energy distance to the top, given by the factor $\sqrt{(V_2-E)}$.

The present treatment may be extended to a double well potential of more arbitrary shape by using the JWKB approximation, a method named after its originators Jeffreys,[9] Wentzel,[10] Kramers[11] and Brillouin.[12,13] This review, which aims at no more than a brief outline of the quantum theory of the hydrogen bond, will not discuss the application of the JWKB scheme in any detail. The problem has been considered at length by Lowdin[3] and also by Johnston.[8]

We may take, for example, the generalised double well potential illustrated in figure (3). It can be shown in terms of the JWKB method that the transmission coefficient, as in the case of a rectangular potential barrier, is approximately given by the expression: $g \simeq e^{-2K}$.

However, the quantity K must now be defined by the integral:

$$K = \frac{2\pi}{h}\int_{x_1}^{x_3}\sqrt{2m[V(x)-E]}\,dx,$$

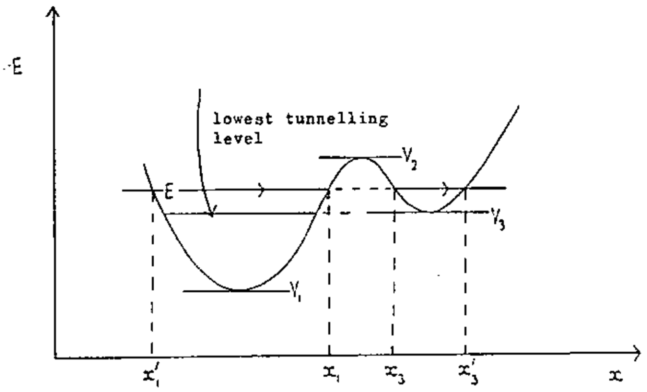


Figure (3)

Penetration of a potential barrier of arbitrary shape by a single incident particle or "wave" packet approaching from the left.

rather than by the product:

$$K = \frac{2\pi a}{h}\sqrt{2m[V_2-E]}.$$

The transmission coefficient is a measure of the probability that a single particle or "wave packet" incident at the potential barrier will tunnel through the barrier from region I into region III, or vice versa. Imagine now that the particle in the left hand energy well is a simple harmonic oscillator of frequency ν_1. This particle will strike the barrier ν_1 times per second. Hence we may define a "forward tunnelling rate":

$$c_1 = \nu_1 g \text{ sec}^{-1},$$

which is the probability per second of tunnelling to the right. Similarly, for a simple harmonic oscillator of frequency ν_3 in the right hand energy well, the probability per second of tunnelling to the left is given by the "reverse tunnelling rate":

$$c_3 = \nu_3 g \text{ sec}^{-1}.$$

We also define a quantity $\tau_{1,3}$, known as the tunnelling time of the double well potential:

$$\tau_{1,3} = \frac{1}{c_1 + c_3} \text{ sec.}$$

It is generally convenient to distinguish between fast and slow tunnelling according to the magnitude of the tunnelling time. In the case of the hydrogen bonds between base pairs of DNA, we will be concerned with slow tunnelling, where the tunnelling time is long in comparison with the time required for a particle in either potential well to reach thermal equilibrium with its environment.

Approximate Numerical Value for Tunnelling Parameters

Experimentally, the lengths of hydrogen bonds in the DNA helix are found to vary from 2.5Å to 3.0Å. To obtain some approximate numerical values for tunnelling rates and tunnelling times, it is sufficient to take the value 3.0Å and assume that this distance is equally divided by the two minima of the double well potential. This gives a curve of the type shown in Figure (4).

To a first approximation, the potential barrier may be taken to be roughly parabolic. The tunnelling length a_o, which is the width at the base of the barrier, ranges from 0.8Å to lower values depending on the degree of asymmetry between the two energy wells. In Table I data is summarised for tunnelling lengths of 0.8Å, 0.6Å and 0.4Å.[3] This table gives the tunnelling rate c_1 and its reciprocal, the tunnelling time τ_1, for proton transfer through the potential barrier from the left hand to the right hand well. "Back-tunnelling" from right to left has been neglected. It can be seen even from these approximate calculations that the tunnelling time τ_1 is highly sensitive to changes either in the tunnelling distance a_o at the base of the potential barrier or in the energy distance to the top, which is given by the difference V_2-V_3. For instance, at an energy difference V_2-V_3 of 8.0 eV., the tunnelling time τ_1 varies from $10^{-4.5 \text{ sec}}$ to 156 min as the tunnelling length a_o increases by as little as 0.4Å. At a fixed tunnelling length of 0.8Å, the effect of barrier height is particularly striking. Here, as the height or energy differences V_2-V_3 increases from 1.0 eV. to 4.0 eV., the value of τ_1 changes from $\frac{1}{10}$ sec to approximately three thousand million years.

From this brief survey of the quantum mechanics of proton tunnelling, we may conclude that the tunnelling rate, which gives a measure of the probability that spontaneous transmission will take place, is extremely sensitive to the shape of the double well potential which describes the hydrogen bond. This sensitivity is readily explained in terms of the simplified expression derived earlier for the transmission coefficient:

$$g \simeq e^{-2K}.$$

Since K increases with the width of the potential barrier and with the square root of the energy distance to the top, g decreases exponentially with both these two parameters. As a result, any quantum mechanical calculation of the potential energy surface will need to be highly accurate to give even an approximate estimate of the probability of spontaneous proton transfer.

Table I[3]

Approximate tunnelling rates and tunnelling times for a Parabolic barrier over the ranges a_o = 0.4 to 0.8Å and V_2-V_3 = 0.0 to 4.0 eV.

V_2-V_3 (eV.)	a_o = 0.8Å		a_o = 0.6Å		a_o = 0.4Å	
	c_{-1}	$\tau_1 = \frac{1}{c_1}$	c_1	$\tau_1 = \frac{1}{c_1}$	$c_{\cdot 1}$	$\tau_1 = \frac{c_1}{1}$
0.0	10^{13}sec.$^{-1}$	10^{-13}sec.	10^{13}sec.$^{-1}$	10^{-13}sec.	10^{13}sec.$^{-1}$	10^{-13}sec.
1.0	10sec.$^{-1}$	$\frac{1}{10}$sec.	10^{4}sec.$^{-1}$	10^{-4}sec.	10^{7}sec.$^{-1}$	10^{-7}sec.
2.0	10^{-4}sec.$^{-1}$	156min.	$10^{0.3}$sec.$^{-1}$	$10^{0.3}$sec.	$10^{4.5}$sec.$^{-1}$	$10^{-4.5}$sec.
4.0	10^{-11}sec.$^{-1}$	3x10^{9}yrs.	10^{-5}sec^{-1}	1.16dys.	10sec.$^{-1}$	$\frac{1}{10}$sec.

Table II[3]

Boltzmann factors at a temperature of 310°K, i.e. approximately body temperature, for energy differences V_3-V_1 ranging from 0.0 to 3.0 eV.

V_3-V_1 (eV.)	$B = e^{-(V_3-V_1)/kT}(T = 310°K)$
0.0	1
0.2	$10^{-3.3}$
0.5	$10^{-8.1}$
1.0	$10^{-16.3}$
2.0	$10^{-32.5}$
3.0	$10^{-48.8}$

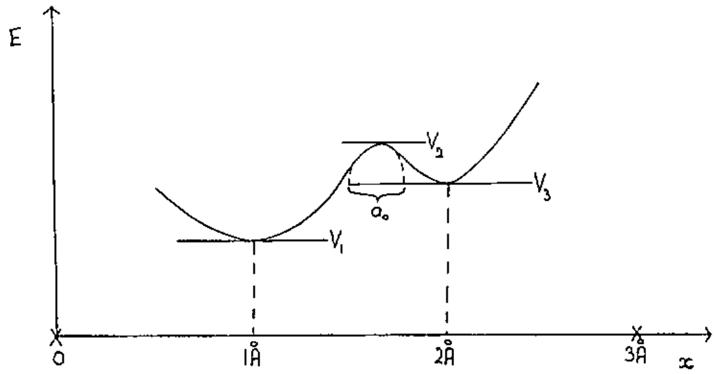


Figure (4)

Approximate double well potential experienced by a proton in a hydrogen bond. The points x indicate N or O positions 3Å apart, this distance being equally divided by the two minima at V_1 and V_3. A parabolic approximation to the potential barrier gives the dotted curve of base width a_o.

The tunnelling probability is also strongly influenced by the Boltzmann factor for the lowest tunnelling level in the deeper energy well. Referring back to the generalised double well potential given in figure (3), it can be seen that in this case the lowest tunnelling level will correspond to the first energy level in the left hand well which has an energy greater than or equal to the minimum energy in the right hand well. Hence the Boltzmann factor will depend on the energy difference V_3-V_1 between the two minima. At a particular temperature T°K,

$$B = e^{-(V_3-V_1)/kT} \qquad (5).$$

Equation (5) gives the fraction of the proton population in the deeper potential well which has sufficient energy at thermal equilibrium to tunnel through to the shallower well. Since this "tunnelling fraction" of the population decreases exponentially with the energy difference V_3-V_1, proton tunnelling will be important only when the energy difference between the two minima of the double well potential is not too large. We might take, for example, a difference of 0.5 eV. From table II[3], this corresponds at a temperature of 310°K to a Boltzmann factor of the order of 10^{-8}. Therefore, under conditions of slow tunnelling, if the proton population is initially at thermal equilibrium in the deeper potential well, the probability of spontaneous transmission through the barrier into the shallower well will be reduced by a factor of 10^8.

Proton Tunnelling in the Hydrogen Bonds of DNA

Lowdin and his co-workers were the first to apply quantum mechanical calculations to the problems of proton tunnelling in the hydrogen bonds of DNA. In 1963, from the results of simple Huckel calculations, Lowdin[15] concluded that the difference in π electron density was smallest across the central hydrogen bond of the guanine-cytosine pair and that proton transfer would therefore be most likely to occur at this point. More detailed studies have since taken into account all three hydrogen bonds of the guanine-cytosine system. Rein and Harris[16,17] used a semiempirical self-consistent-field method considering explicitly the twelve lone pair electrons involved in the three hydrogen bonds and also the twenty-four π electrons associated with the aromatic rings. Electronic potential energies were determined for a total of seventy-four different proton configurations. These correspond, in terms of the structure given in figure (5), to a simultaneous tautomeric rearrangement in the central N_1:H_1 - - - N_1 bond and in the upper O: - - - H_2:N bond of the base pair.

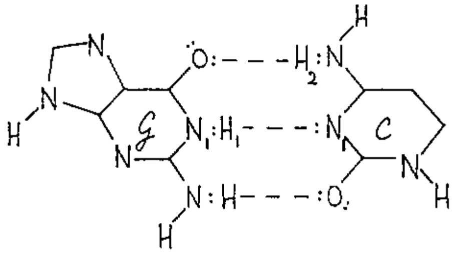


Figure (5)

Hydrogen bonding in the normal tautomeric form of the guanine-cytosine pair.

Figure (6) shows the energy contour diagram plotted from the results of Rein and Harris's calculations. There are four minima, denoted I, II, III and IV, which correspond to four different metastable tautomers: the "normal' tautomeric form I lies in the deepest energy well; in tautomer II proton H_2 has been transferred from cytosine to guanine; in tautomer III proton H_1 has been transferred from guanine to cytosine; and in the fourth tautomeric form IV double proton transfer has occurred, giving the tautomeric pair G*-C*. To investigate the probabilities of proton tunnelling between the different tautomers, energy profiles were constructed along the paths A, B, C, D and E. In each case, the profile was used to determine values for the forward and reverse tunnelling rates and also for the Boltzmann factor of the lowest tunnelling level in the deeper potential well. The results indicate that direct formation of the tautomeric pair IV from the "normal" base pair I along path E is energetically unfavourable. Instead, it appears that interconversion proceeds via tautomer II. The calculated tunnelling probability is highest in the upper O: - - - H_2:N bond, which suggests that proton transfer will be most likely to occur first at this point, to give the ionic form II. Reverse proton transfer in the central N_1:H_1 - - - N_1 bond would then lead almost immedi-

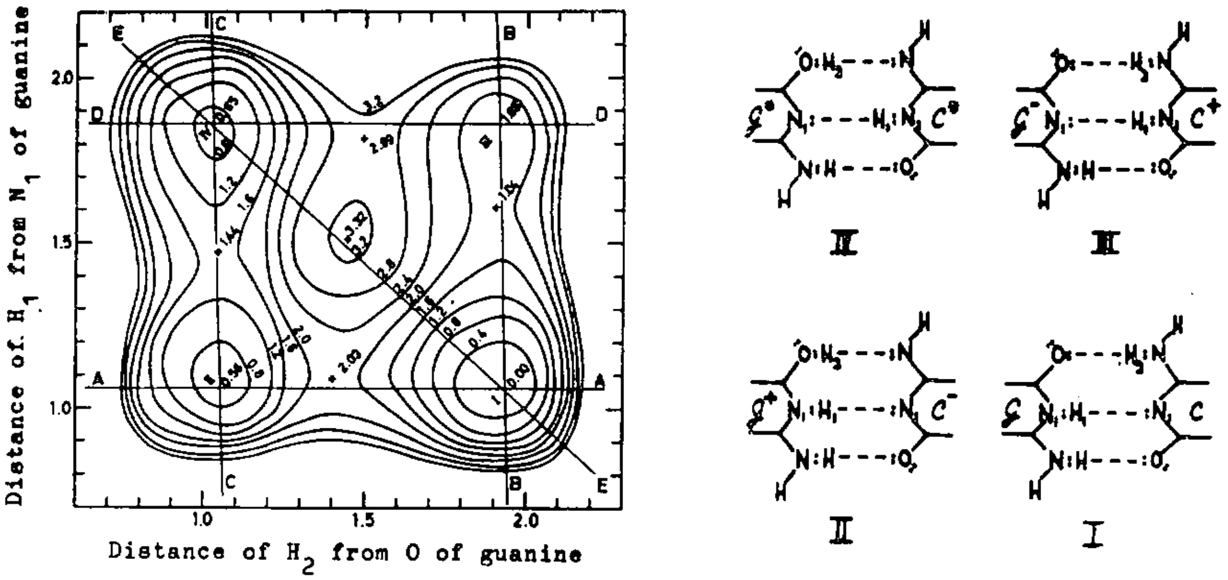


Figure (6)

Energy contour diagram for tautomeric rearrangement in the guanine-cytosine base-pair, as obtained from molecular orbital calculations by Rein and Harris. (17) The figures beside the contour lines are electronic potential energies in electron volts, relative to an energy zero at the minimum point of the deepest potential well. There are four minima, denoted I to IV, which correspond to the structures I to IV below the diagram.

ately to the neutral form IV. It is estimated that tautomeric equilibrium between forms I, II and IV is established extremely rapidly, within a period of about 10^{-5} sec.

From these results, Rein and Harris have concluded that the time required for tautomeric rearrangement in the guanine-cytosine base pair is short in comparison with the time interval between successive DNA replications. They have also obtained an approximate picture of the equilibrium tautomeric distribution. Using the calculated total energies of the four tautomers, it was possible to estimate the relative proportions of these different metastable forms at thermal equilibrium. At 310°K, the equilibrium populations of the "normal" guanine-cytosine pair, from I, and the tautomeric pair, form IV, are found to be in the ratio $1:10^{-9.1}$. This suggests that the probability of occurrence of a tautomeric pair G*-C* in the base sequence of the DNA helix should be of the order of 10^{-9}. In an attempt to assess the accuracy of these calculations, Rein and Harris[20] compared their results with data given by Pitha[21] for the infrared absorption spectrum of a hydrogen-bonded guanine-cytosine complex in chloroform solution. Proton energy levels and transition probabilities were calculated from the energy contour diagram given in figure (6). It was found that the two transitions of highest probability should give absorption in the region of 0.5 eV., whereas the observed absorption peak, assigned to a hydrogen-bonded N-H stretch, lies at 0.436 eV. Hence the calculated result agrees with the experimental data to within about 0.1 eV.

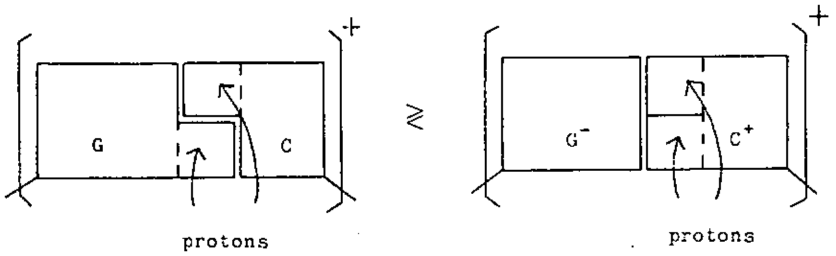
With regard to the adenine-thymine base pair, Lunell and Sperber[18] have used the technique developed by Rein and Harris to carry out a series of similar calculations. The results were plotted as before on an energy contour diagram. From this diagram, at a temperature of 310°K, the equilibrium populations of the "normal" base pair A-T and the tautomeric pair A*-T* are calculated to be in the ratio $1:10^{-11.1}$. Assuming that tautomeric equilibrium is established rapidly, this gives a value of about 10^{-11} for the probability of occurrence of a tautomeric A*-T* base pair.

Induced Errors in the Genetic Code

We have considered so far only the probability of occurrence of spontaneous errors in the genetic code. However, the genetic code is known to be influenced by irradiation, by electron or proton bombardment and by certain chemicals known as mutagens or carcinogens. It appears that the effect is usually produced by addition or removal of a single charge to one of the bases in a pair. Under these conditions, proton transfer towards the more negatively charged base gives transitions of the type:

$$(G\text{-}C)^+ \rightleftharpoons (G^-\text{-}C^+)^+,$$
or
$$(G\text{-}C)^- \rightleftharpoons (G^-\text{-}C^+)^-.$$

If these transitions are written schematically, using projections to indicate the positions of the protons taking part in hydrogen bonding, then it becomes clear that the "ions" formed, in these two examples G^- and C^+, cannot pair with any of the normal bases. Take for instance the equilibrium:



After protein transfer, the "anion" G⁻ no longer has a proton available for hydrogen bonding at the upper electron pair, while in the "cation" C⁺ the upper lone pair is blocked by an additional proton which is not present in the neutral base. Hence if these "ions" persist during DNA replication, they could lead to gaps or "deletions" in the base sequence on the complementary strands of the two daughter helices.

Rein and Harris[19] have carried out molecular orbital calculations for the cation and anion of the guanine-cytosine pair using the same technique as was previously applied to the neutral base pair. Their results indicate a marked difference in the equilibrium tautomeric distributions of the ions as compared to that of the neutral form. Most significant is an increase in the relative concentration of tautomer III, the tautomeric form which, as shown is figure (6), is obtained by transfer of proton H_1 along the central N_1:H_1 - - - N_1 bond from guanine to cytosine. At 310°K, the calculated equilibrium populations of the "normal" tautomer I and the "abnormal" tautomer III are in the ratio $1:10^{-4.9}$ for the cation and in the ratio$10^{-3.6}:1$ for the anion. Thus tautomer III of the anion is actually predicted to be the more stable form.

Tunnelling rates between forms I and III were evaluated and the corresponding tunnelling times, of the order of 10^{-11} sec in the cation and 10^{-9} sec in the anion, appear to be sufficiently short for tautomeric equilibrium to be established within the lifetimes of the ionic species. This equilibrium is in both cases thought to involve a significant proportion of tautomer III. The present results therefore suggest that production of either the cation or the anion, initially as tautomer I, will lead, through the transition:

$$\text{(I)} \quad (G\text{-}C)^{+} \rightleftharpoons (G^{-}\text{-}C^{+})^{+} \quad \text{(III)},$$

or

$$\text{(I)} \quad (G\text{-}C)^{-} \rightleftharpoons (G^{-}\text{-}C^{+})^{-} \quad \text{(III)},$$

to formation of appreciable concentrations of tautomer III. Then, if these ionic tautomeric forms are present at the site of DNA replication, they could well give rise to deletion errors in the genetic code.

Conclusions

This review has presented some aspects of what has become known as the Watson-Crick-Löwdin theory of mutations in DNA. According to the Löwdin theory, spontaneous mutations may arise through one of two processes: by incorporation errors during DNA replication, or, as a result of the quantum mechanical tunnel effect, by spontaneous proton transfer in the hydrogen bonds between base pairs of the double helix. The major problem is that the order of magnitude of both these effects is as yet uncertain.

With regard to proton tunnelling, the tunnelling parameters are found to be highly sensitive to the shape of the potential energy surface which describes the hydrogen bond. We require, therefore, a very accurate knowledge of the electronic structures of the nucleotide base pairs. Assuming an error of ±0.1 eV. in each of the total energies quoted by Rein and Harris for the four tautomeric forms of the guanine-cytosine pair, the corresponding uncertainty in the predicted probability of occurrence of the tautomeric pair G*-C* is of the order of $\pm 10^{-2}$. Thus it appears that the theoretical results derived from quantum mechanics are at present accurate to within no more than one or two orders of magnitude.

On the experimental side, it must be mentioned that genetic errors may be caused by a number of different types of base pair change. The Watson-Crick-Lowdin theory deals solely with transitions:

$$G\text{-}C \rightarrow A\text{-}T,$$

or in the reverse direction:

$$A\text{-}T \rightarrow G\text{-}C.$$

These changes, in which a purine is replaced by a purine and a pyrimidine by a pyrimidine, may well be due to the occurrence of a tautomeric pair G*-C* or A*-T* in the base sequence of the DNA helix. However, there are many point mutations which do not seem to correspond to a base pair transition. In the case of the T4 bacteriophage, Freese [22] has concluded from his experimental results that most spontaneous mutations are caused not by transitions but by what he has termed transversions. Transversions involve replacement of a purine by a pyrimidine which has an equivalent hydrogen-bonding system, or alternatively replacement of a pyrimidine by its equivalent purine. A second important class of non-transition mutations is thought to result from insertion or deletion of one or more bases in the squence of a single DNA strand. [23,24] Base pair changes of this type have recently been found to occur in proflavin-induced mutations. [25]

Biological evidence therefore indicates that in different organisms spontaneous and induced mutations arise through a number of different molecular mechanisms, the dominant mechanism depending on the particular organism.[14] In addition, every base pair change will not necessarily alter the phenotype properties of the organism. There are some DNA regions which are not utilised in protein synthesis, while many amino acid changes do not affect the enzymatic properties of a protein. Furthermore, the triplet code determining the order of amino acid linkage is degenerate. Freese[7] in 1962 put the probability per generation of a spontaneous point mutation or base pair change in the range 10^{-8} to 10^{-11}. This seems to be in acceptable agreement both with Rein and Harris's value of 10^{-9} for the guanine-cytosine pair and with Lunell and Sperber's value of 10^{-11} for the adenine-thymine pair. However, as in the case of the quantum mechanical results, there is an error margin of several orders of magnitude. Particularly since base pair transitions are only one of several types of base pair change, we may conclude that there is very little point as yet in attempting to relate experimental frequencies of occurrence of point mutations to the calculated probabilities of occurrence of the tautomeric pairs A^*-T^* and G^*-C^*.

To sum up, current evidence from quantum mechanics, despite the limited accuracy of the results, does favour the idea of proton tunnelling as one cause of spontaneous and induced errors in the genetic code. The concept is simple and temptingly plausible. But until more accurate calculations are possible and until a great deal more information is available from genetics experiments in biological systems, we are faced with a hypothesis which cannot be subjected to any rigorous test.

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IUPAC Information

XXIV IUPAC CONGRESS
HAMBURG: 2-8 SEPTEMBER 1973

Every two years an International Congress of Pure and Applied Chemistry is now organised under the auspices of IUPAC. The first meeting in this series was held in Brussels as long ago as 1894. These Congresses comprise one or more branches of chemistry represented by the Divisions of the Union. The scope of each Congress is decided with a view to achieving, by simple rotation, the coverage of all branches of pure and applied chemistry.

The XXIV Congress took place in Hamburg during the period 2-8 September 1973. A scientific programme was arranged which ensured a great assembly of chemists, many of them highly eminent, from all parts of the world.

At the XXIII Congress (Boston, 1971) the main invited lectures were published, within three months, by offset (lithographic) printing directly from manuscripts supplied at the meeting. The success of that experiment has ensured that it will be repeated for the Hamburg Congress. Some eleven plenary and section lectures will be published from each of the following sections:

Section 1—High Polymers
Section 2—Chemistry of Organic Natural Products
Section 3—Solid-state Chemistry
Section 4—Compounds of Nonmetals
Section 5—Applied Electrochemistry
Section 6—Radiochemistry
Section 7—Symposium on Information and Communication in Chemistry

The seven volumes will be available from the IUPAC publisher, Messrs. Butterworth (London), by mid-December 1973.

IUPAC COMMISSION II 1:

ATOMIC WEIGHTS

At the XXVII IUPAC Conference, held in Munich 21-31 August 1973, the following changes in recommended values for atomic weights were aproved:

Nickel from 58.71 to 58.70

Rhenium from 186.2 to 186.207.

These changes, together with important new annotations and listings, will be in the Commission's full Report to be published in **Pure Appl. Chem.** This Report will also contain the full Table of Atomic Weights, 1973.

FROM COUNCIL

The Place of the Technician in a Professional Body

This paper from Council to all Institute members is based on a working paper prepared for the meeting of Presidents of National Chemical Societies, Rome, September 1973. The purpose of that paper is to promote discussion and lead to the expression of other countries' views and experiences on a subject which is at present under debate within the NZIC.

Because of the numerous points of view and possible clouding of the basic issues, Council considers that this paper should be made available to all members of the Institute. The logical procedure of firmly establishing aims and criteria before proceeding to consideration of means of satisfying them is emphasised and illustrated.

There are a number of aspects to be considered:

What is a technician

What is the present situation of the New Zealand Institute of Chemistry?

What are the present functions of the N.Z. Institute of Chemistry?

Why consider technician membership?

What criteria should be adopted in considering enlarging the membership of the N.Z. Institute?

What is a Technician?

He is most easily defined in the negative—he is a scientific worker who performs a function complementary to the professionals who comprise our present membership. It is realised that there is no clear-cut nor sharp distinction that can be made in definitions; matters of degree as opposed to principle are involved. However it is only in a very small proportion of cases that the Institute Membership has had difficulty in making a recommendation. Professional corporate members of the Institute generally have:

(a) A University degree or its equivalent (attested to by a University).

(b) A minimum of 4 years suitable practice of the profession (attested to by the Institute).

In guidelines adopted by the NZIC, the following are examples of the ways in which professionalism can be demonstrated.

(1) Evidence of integration of academic knowledge with one's professional duties.

(2) Creativity in one's duties e.g. by the combination of existing academic ideas in new ways to meet particular problems.

(3) The ability to change to new fields of work and new types of problems as distinct from being highly skilled from long experience in one limited field only.

(4) Responsibility in the management of other scientists particularly of professional scientists.

(5) Ability to exercise judgment, particularly on the unexpected.

(6) Evidence of adequate quality of professional reports and papers.

A technician is one, then, who performs the complementary functions. He is specially trained, but trained differently in a different institution with a different outlook. For example, a good, experienced technician can set up and perform experiments more efficiently and more rapidly—this is his special expertise. If he develops to such an extent that he becomes equivalent in knowledge, training and experience, there is adequate provision and flexibility in the rules for recognition of his professionalism, and subsequent admission to corporate membership.

The N.Z. Institute of Chemistry

The NZIC comprises six branches, distributed geographically. The Council is composed of six branch delegates, a president, two vice-presidents and general secretary. The Council is thus a place to reach agreement between branches. It is in recognition of the need for representation of widely-dispersed membership that Council has all the power e.g. in setting subscriptions, changing rules, setting and operating standards of admission.

As a professional body, NZIC carries out the following:—

1. Maintains professional standards of admission.
2. Produces salary and manpower surveys.
3. Comments on syllabi for technician training.

4. Gives advice on employment in New Zealand.
5. Publicity.
6. Alterations to rules—these are carried out from time to time to give greater flexibility for the admission of members having unusual combinations of knowledge, training and experience, without any lowering of standards.

In serving its members as a learned society, NZIC, collectively and through its branches, also performs the usual range of activities:

1. Monthly branch meetings.
2. Annual New Zealand conferences.
3. Organisation of national specialist groups:
   Electrochemistry
   Biochemistry
   Geochemistry
   Organic chemistry
   Analytical chemistry
   Thermodynamics
4. Award of Essay and Research Prizes.
5. Organisation of overseas visitors.

The membership of the Institute comprises extremes—from chemists in large government research organisations to chemists working to a large extent in isolation from their fellows (employees in small groups, or even as the only chemist in an industrial firm). The former, in having their own system of status and rewards, are much more concerned with the learned society activities, while the latter are much more concerned with matters of professional status, in having to continually maintain their position relative to other types of employee.

Why Consider Technician Membership?

A system of tertiary education, comparatively new to New Zealand, and growing rapidly, is the system of work-based education carried out at Technical Institutes. After a minimum of 3 to 5 years (depending on the stage of secondary education reached before employment was commenced) students can qualify with the New Zealand Certificate in Science (N.Z.C.S.) for which chemistry is a popular option. The training comprises approximately four days per week in approved scientific employment, and one day per week of formal tuition in a Technical Institute. The academic standard is indicated by the granting by N.Z. Universities of exemption of up to $\frac{3}{4}$ of one year of a degree course to successful Certificate holders who wish to transfer to University courses.

Because of the rapid growth in numbers at present and projected, of N.Z.C.S. holders, the NZIC is considering under what circumstances and conditions technicians might be admitted, and to what form of membership.

To do this, the NZIC is facing up to the fundamental questions:-

"What is its Primary Role?"

Consideration of this question requires establishing criteria and objectives by which any alterations to structure and functions should be judged. The major issue is whether the Institute is primarily a professional body with rigorous standards of admission, which, as part of its subsidiary services to its members, also promotes learned society functions, or whether it is primarily a learned society with correspondingly lesser regard for admission standards, a correspondingly lower reputation in the outside world and of correspondingly lesser interest and value to the industrial chemists who comprise one third of the present membership.

Criteria by which to judge Functions and Structure

The Institute is attempting to reduce needless complexity and misunderstanding by first reaching agreement on the objectives of the Institute and criteria by which alternative forms of membership and structure must be judged. (This is on the principle that no sensible debate on the merits of alternative means of transport—rail, ship, plane etc. —is impossible if the destination is not agreed on beforehand!).

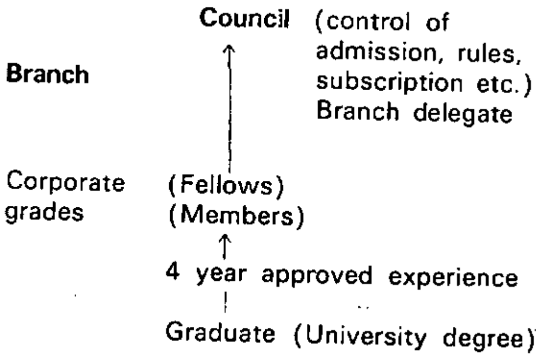
The following are criteria which have been suggested:

1. To maintain and protect the rights and status of the present members within the Institute.
2. To maintain and protect the democratic rights of corporate members.
3. To offer status and privileges to career technicians, to the mutual advantage of both the technician and the professional membership.
4. To recognise the complementary roles of technician and professional.

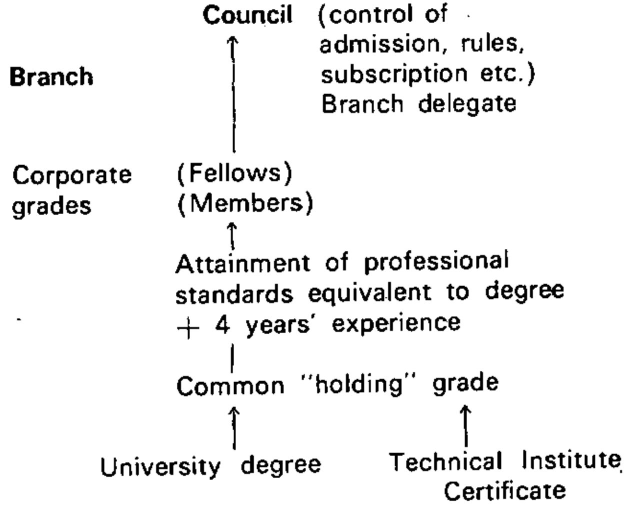
Examples of Application of Criteria

Examples are given to show explicity how the above criteria are expected to be applied. The first can be seen to be a negative example. This will illustrate the value of criteria, before showing their application to the more constructive examples.

The present structure is:-



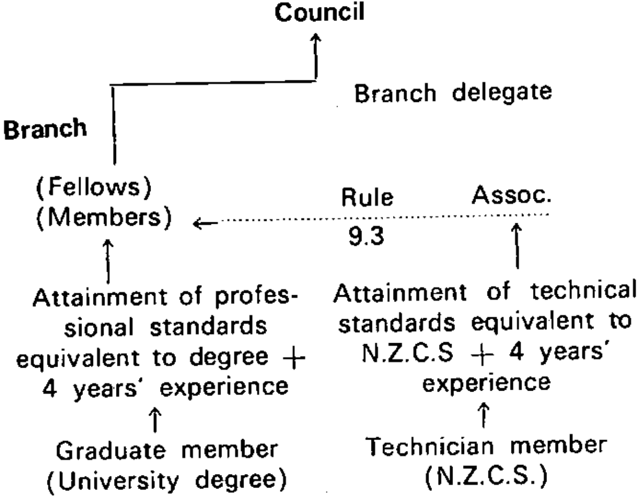
Example 1



If the criteria suggested, are applied it can be seen:-

1. The rights and status of the present membership are down-graded to the extent that a common "holding" grade suggests equivalence of academic standard.
2. The second criterion is satisfied in that the control of the Institute affairs remain in the hands of the corporate members.
3. No status is offered to the technicians. For those who do not become professional practitioners of chemistry, the "holding" grade would be permanent. Corresponding dissatisfaction would be expected. Being automatic on attaining the Technical Institute qualification, it confers nothing of value on the technician over and above that which he already has.
4. The common grade conflicts with the fourth criterion. The common grade implies that Universities and technical institutes do **not** have complementary functions, that their graduates do **not** have complementary roles, and perhaps worst of all carries the connotation that a technician does not have an important contribution to make, and a career to pursue, in his own right.

Example 2



This structure can also be submitted to the tests of the criteria:

1. The rights and status of the present membership are unaltered. Note that Rule 9.3 already exists, and is specifically for recognition of the development of knowledge, training and experience to a professional level.
2. The second criterion is met.
3. Status is offered to the technicians. In a parallel and complementary way to the **professional grades,** the Institute attests to and recognises the attainment of an acceptable **technical standard** of knowledge, training and experience. It is thus a distinction of progress beyond the Certificate attainment. It is envisaged that Associates would be permitted public use of the qualification: "Assoc. N.Z.I.C."
4. The fourth criterion is met.

The parallel structure recognises the complementary and different origins and functions of the two groups which are both essential to the chemical world. As noted above, no new machinery is required to recognise transfer across from technician to professional in valid cases.

Conclusion

Council has agreed on the criteria set out in this paper, and on the way in which they have been applied to the particular examples considered.

The next step is thorough discussion by Branches so that delegates can report back to Council.

MEMORANDUM FOR ALL MEMBERS OF N.Z.I.C.

At a meeting of Council on 10 May 1973 it was unanimously resolved that Rule 5 be amended to read as follows:

"There shall be three classes of members; Fellows, Members and Graduate Members."

The effect of this is as follows—

All Associates became Members, and their designation ANZIC became MNZIC, as from that date.

Addressograph plates will be changed as soon as possible.

The State Services Commission, University Registrars, and Directors of Research Associations have been informed.

Council regrets the delay in generally notifying the membership of this decision by notification in the first available journal.

NEW ZEALAND INSTITUTE OF CHEMISTRY INC.

Forty-third Annual Report

For the year ending 31st July, 1973

Officers

President:	Professor R. E. Corbett
First Vice-President:	Dr. P. K. Foster
Second Vice-President:	Mr C. L. Davey
Immediate Past President:	Mr. K. E. Seal
Editors:	Miss Joan Mattingley/ Mr. C. L. H. Stonyer
Hon. Librarian:	Mr. S. G. Brooker
Registrar:	Mr. D. J. Hogan
General Secretary:	Professor W. E. Harvey/ Mr. D. J. Hogan

Delegates

Auckland:	Professor G. A. Wright
Hamilton:	Dr. J. W. B. Watkinson
Manawatu:	Dr. I. D. Watson
Wellington:	Mr. C. L. H. Stonyer
Canterbury:	Dr. A. G. Williamson
Otago:	Professor G. B. Petersen

Membership

During the past year membership of the Institute has changed as follows:

New Fellows	3
Members elected to Fellowship	8
New Members	48
Graduate members becoming Members	28
New Graduate Members	43
Resignations	7
Deaths	9
Struck Off	27
Re-instated	3

Consolidated membership figures for the last four years are as follows:

	1970	1971	1972	1973
Auckland	229	256	284	302
Waikato	58	67	76	85
Manawatu	108	113	126	138
Wellington	233.	252	275	273
Canterbury	152	157	161	169
Otago	94	89	91	94
Overseas	124	123	123	128
	998	1059	1136	1189

Honorary Fellowship

Mr. T. H. McCombs was elected Honorary Fellow. Mr. McCombs retired as Principal of Cashmere High School and brought further honour to a distinguished career when he was appointed N.Z. High Commissioner in London.

Obituary

We record with regret the deaths of the following members: J. E. Allan, Pai Wah Chang, H. H. Edwards, M. Fieldes, G. S. Holmes, B. R. Law, T. J. McKee, F. Morgan, R. V. Perryman, Sir Theodore Rigg, L. Wilkinson. Sir Theodore Rigg was an Honorary Fellow.

Vice-Presidents

Mr. J. E. Allan was First Vice-President at the time of his sudden death. Dr. P. K. Foster, Second Vice-President, was appointed by Council to replace Mr. Allan and the Waikato Branch at Council's request nominated Dr. C. L. Davey as Second Vice-President.

Prizes

The I.C.I. Prize for 1972 was awarded to Professor L. F. Phillips, Chemistry Department, University of Canterbury.

There were no entries for the Chemical Essay Prize.

The Morcom Green-Edwards Prize has been discontinued by A. C. Hattrick Ltd. who took over the firm.

Conference

The 1972 conference was held in Wellington at Victoria University and was attended by a record 255 delegates. The programme consisted largely of review sessions where an invited chairman selected speakers to review the chosen topic. The Guest Speaker was Professor J. O'M. Bockris from Adelaide University. All research papers were programmed for the one afternoon and this seemed to work well.

The Institute Prize for the best student paper was awarded to Mr. M. J. Boland of Massey University.

Publications

Mr. C. L. H. Stonyer continued as Editor until Miss Mattingley's return from an overseas trip. The size of the journal has been changed to A4 bringing it into line with present trends. The change has occasioned delays in publication which are regretted but the normal publication date should be resumed with the August issue. The attractiveness of the new format has brought many favourable comments. Increased advertising revenue is one benefit expected from the change. However, after many years of holding costs inflation is inevitably catching up and it is clear that there will be increased nett cost for the journal, although it is still a relatively small nett cost per number. The two editors and Mr. D. G. Howard, the Advertising Manager, deserve the Institute's thanks for their many hours of effort in producing the journal.

A List of Members was not published but work has begun on compiling the next revision. School bulletins were not produced this year but plans are in hand for the next series.

The Institute continued to act as a distribution centre for "R.I.C. Monographs for Teachers" and "Education in Chemistry", "Chemistry" and other publications of sister organisations.

In view of an apparent demand for a publication on laboratory safety Council decided to import 1,000 copies of the Imperial College Publication "Safety in the Laboratory and in the Handling of Chemicals". This well reviewed publication is available through the Registrar at the low price of 40 cents per copy. We regret to record that the demand has been very light and a large stock of these booklets is still on hand.

Overseas Visitors

Professor J. O'M. Bockris, the Conference Guest Lecturer, visited a number of branches in August. Following an R.A.C.I. conference in Australia Professor R. Belcher of Birmingham University and Professor P. W. West of Louisiana State University made short lecture tours largely as a result of the initiative of Professor A. D. Campbell. These visits required very little financial support from the Institute. A series of very stimulating and well attended meetings resulted.

Royal Society

Contact with the Royal Society continues mainly through the Member Bodies Committee. It appears that this committee is seeking to play a more active part in Royal Society affairs, a position which the Institute strongly supports. It is a pleasure to record that Dr. A. J. Ellis and Dr. W. A. McGillivray have been elected to the R.S.N.Z. Council.

Salaries

No salary survey was conducted this year. Council has written to the State Services Commission regarding what it considers to be an imbalance between the salaries for N.Z.C.S. holders and graduate recruits to the State Services.

Manpower Survey

The Manpower Survey is providing a complex task and this report is not yet available. It is hoped that this will be completed during the coming year.

Technician Training

A Council sub-committee has prepared a revision of the N.Z.C.S. Chemistry III, IV and V syllabuses and a suggested prescription for a terminating intermediate (three years) certificate. These have been forwarded to the Technicians Certification Authority which has set up a review committee under Professor A. L. Odell. This committee has accepted the N.Z.I.C. suggestions as a starting point for revision.

Testing Laboratory Registration Council

Representations were made to the Minister of Science regarding the constitution of the Testing Laboratories Registration Council. The Minister replied that due regard would be given to the Institute's views when the Council was selected and it is pleasing to note that a Fellow of the Institute, Mr. R. H. Hopgood was appointed to the Council representing the Manufacturers' Federation. In addition Professor A. D. Campbell has been appointed Chairman of the Chemical Sectional Committee of the Council. N.Z.I.C. is very well represented on this committee.

Public Relations

In an attempt to further improve the Institute's public relations a small sub-commitee under Professor G. A. Wright has been given authority and finance to retain the services of a firm of public relations consultants to publicise matters of concern to the Institute. The first example was the news release about Council's actions in the Levich affair. Further such releases will follow.

Rules

The Membership Committee has produced and Council has adopted a Commentary with Rules regarding Grades of Membership and election to the several categories. This will be published in the journal and should provide a clear guide for the future in these matters.

A major change to the Rules was the amendment to Rule 5 to provide for the abolition of the grade of Associate and its replacement by the grade of Member.

Discussion is continuing on the place of technician members in the Institute and a suitable designation and entrance standard for them. This matter should be resolved during the coming year.

It has been proposed that the Fellowship Rule be changed so as to permit nomination to Fellowship by branches and by other Fellows.

Standards Association of N.Z.

Mr. W. A. Joiner who had represented the Institute on S.A.N.Z. Council for a very long time indicated that he did not wish to be renominated. In his place the Minister appointed on Council's recommendation, Dr. P. K. Foster.

Conference of Institutes of Chemistry

Council has accepted an invitation to attend an international conference of Presidents of Institutes of Chemistry in Rome in November this year and will be represented by the President Designate, Dr. P. K. Foster. This will be the first occasion N.Z.I.C. has been represented at such a conference.

Biochemical Visitor

Agreement has been reached with the N.Z. Biochemical Society that it will accept financial responsibility for the annual Biochemical Visitor of the Biochemical Society and that N.Z.I.C. will meet the expenses of an annual Biochemistry visitor from Australia for the N.Z.I.C. Conference.

Finance

The balance sheet for the year ending shows a small excess of expenditure over income amounting to $34.84. It is clear that the Institute's present income level is not sufficient to maintain current activities and to keep pace with inflation. Consideration must now be given to an increase in subscriptions.

Permanent Secretariat

Branches have had for consideration a suggestion from Auckland that the time has come for the Institute to engage some form of permanent secretariat. A first estimate of cost is $3000 per year or approximately $3 per member. It is clear that some form of additional secretarial service will soon be needed. A decision on this must be made shortly.

Thanks

It is a pleasure once again to record the thanks of Council to the many individuals, committees, and groups who have assisted the Council throughout the year and without whom the Institute would cease to function as a viable organisation.

For the Council

R. E. CORBETT, President

D. J. HOGAN, Acting General Secretary

RIC MONOGRAPHS FOR TEACHERS

Available from the Registrar, Box 1926, Christchurch.

1.	*Principles of Electrolysis.* C. W. Davies	$0.38
2.	*Principles of Oxidation and Reduction.* A. G. Sharpe	$0.38
* 3.	*Principles of the Extraction of Metals.* D. J. G. Ives	$0.64
4.	*Principles of Metallic Corrosion.* J. P. Chilton	$0.64
5.	*Principles of Chemical Equilibrium.* P. G. Ashmore	Out of Print
6.	*Principles of Titrimetric Analysis.* E. E. Aynsley and A. B. Littlewood	$0.48
7.	*Principles of Catalysis.* G. C. Bond	$0.64
* 8.	*Principles of Atomic Orbitals.* N. N. Greenwood	$0.64
* 9.	*Principles of Reaction Kinetics.* P. G. Ashmore	$0.80
10.	*Industrial Chemistry Inorganic*—2nd Enlarged Edition	$2.60
11.	*Industrial Chemistry—Organic.* D. M. Samuel—2nd Edition	$3.00
12.	*Elements of Chemical Thermodynamics.* E. A. Guggenheim	$0.75
13.	*Principles of Osmotic Phenomena.* J. F. Thain	$0.86
*14.	*Principles of the Colloidal State.* G. D. Parfitt	$0.64
*15.	*Physico-Chemical Quantities and Units*—2nd Edition. M. L. McGlashan	$1.50
16.	*Chemical Processing in Industry.* M. D. Wynne	$0.85
17.	*An Introduction to Biochemistry.* E. G. Brown	$1.50
18.	*Principles of Crystal Chemistry.* E. Cartmell	$1.30
19.	*The Molecular Basis of Entrophy and Chemical Equilibrium*	$1.10
20.	*Silicon Chemistry and Applications.* C. A. Pearce	$2.00
21.	*Modern Analytical Methods.* D. Betteridge and H. E. Hallam	$4.00
22.	*Chemical Aspects of the Atomic Nucleus.* J. G. Cunninghame	$2.50
23.	*Principles of Photochemistry.* P. Suppan	$2.00
24.	*Safety in Chemical Laboratories*—Imperial College	$0.40

* Out of stock but can be ordered if sufficient demand.

Minutes of an Annual General Meeting of the N.Z. Institute of Chemistry (Inc.) held at the University of Canterbury, Ilam, on Thursday, 23rd August, 1973 at 4.30 p.m.

Present

Professor R. E. Corbett (President) in the chair and 65 Fellows and Members.

Apologies

Apologies were received from Professor M. P. Hartshorn, Dr. M. S. White, Messrs. P. J. Gallagher, R. H. Hopgood, A.D. Robb and G. M. Ryburn.

Minutes

The minutes of the last Annual General Meeting held at Victoria University of Wellington on 24 August 1972 were read and confirmed.

Presidential Remarks

Members stood in silence in memory of those members who had died during the year. The President particularly mentioned Mr. J. E. Allan who was First Vice-President at the time of his death and commented on the great loss sustained by Council and the Institute. He reported that Council had elected Dr. P. K. Foster to the vacancy as First Vice-President and had asked Waikato Branch to make a nomination for Second Vice-President. Waikato Branch had nominated Dr C. L. Davey and Council was pleased to accept this nomination.

The President announced the election of the following as Honorary Fellows: Dr. Elsa Kidson, Dr. F. B. Shorland, Messrs. F. W. Hullett, H. L. Longbottom, T. H. McCombs and L. S. Spackman.

In commenting on activities during the year the President particularly mentioned the new format of the journal; new syllabuses for N.Z. Certificate in Science which had been forwarded to the T.C.A. for consideration; the election of Drs. W. A. McGillivray and A. S. Ellis to the Council of the Royal Society of N.Z.; the change in title "Associate Member" to "Member" and on proposals, which were being referred for full branch discussion, for the inclusion of technician members in the Institute.

Annual Report

On the motion of the President the Annual Report as circulated was adopted.

Balance Sheet

The Registrar answered questions on the balance sheet and moved its adoption. This was seconded by Dr. I. K. Walker and carried.

Officers

The President announced that the officers for 1973 would be: President, Dr. P. K. Foster; First Vice-President, Dr. C. L. Davey; Second Vice-President, Mr. J. S. Pollard. Professor W. E. Harvey continues as General Secretary.

Institute Prizes

The President anounced the award of the 1973 I.C.I. Prize to Dr. J. C. Dacre presently of Tulane University, Louisianna and the Chemical Essay Prize to Miss J. Mulvihill of Canterbury University.

General

No matters were raised.

The President thanked Branch Committees and Council Members and officers for their support during the year.

A vote of thanks to the retiring President was carried by acclamation.

Extracts from Minutes of Council Meeting August 19, 1973

Conferences

1973. Dr. Williamson reported that registrations had reached a record 340.

1975. The decision of the previous meeting to allocate the 1975 conference to Waikato branch was an error. This decision was rescinded and the 1975 conference allocated to Manawatu branch.

Specialist Groups

The Organic Group raised the question of keeping group address lists up to date. It was agreed (1) that Groups be asked to supply the Editor and Registrar with the names of their Chairman and/or Secretary and a brief report on their activities in line for printing in the April Journal (i.e. by 10th March at the latest) and (2) that with their notification of election new members be sent a list of groups and their officers and an invitation to join one or more of the groups.

It was noted that Council wishes groups to prosper and to give all N.Z.I.C members who wish the opportunity to belong to a specialist group.

Recruitment of New Members

Ways of encouraging new graduates to join the Institute were discussed. It was suggested that all graduates should receive an invitation from the President accompanied by an application form showing current subs and information about membership rules. Manawatu Branch were asked to prepare a working paper for this for the next meeting. Meanwhile branches could aid in recruiting immediately by compiling lists of students completing degrees and sending them application forms.

Technician Certification Authority and Syllabuses

The Technician Syllabus Committee under Dr. C. L. Davey was asked to produce for the next meeting a case for a three year terminating certificate.

Journal Matters

The Editor expressed concern at long delays in distribution of the Journal apparently due to the Post Office. The Editor was asked to report on the feasibility of sending Conference issue by first-class mail. The Editor made an appeal for more news of the activities of the Groups.

Other Publications

The Registrar reported that sales of the Imperial College safety booklet were very slow and that the pollution booklet had reached page proof stage.

Rules

The Registrar was instructed to proceed immediately with a reprinting of the Rules including the commentary on membership and with the printing of new application forms for Members (to replace present form for Associates) and Fellows. Following comment from the Membership Committee on the design of the Fellowship form the committee was asked to re-draft this form.

Conference of Institutes of Chemistry

The President reported that approval had been received for Professor G. B. Petersen to attend the Conference as New Zealand's second delegate. Return fares London to Rome were approved for Professor Petersen.

Notice of Motion to Change Rules

Notice of Motion to change Rule 10 having been given it was resolved that Rule 10 be amended by adding to Clause 10.4 the following sentence:

"Fellows of the Institute and Branch Committees shall have the right to nominate Members for Fellowship. In so doing they shall provide supporting evidence as outlined in this clause."'

Grades of Membership

Reports from branches indicated general approval, at least at committee level, for some way to be found to incorporate technicians into the Institute structure. It was agreed among branches that transfer from "Technician Member" to Member should be done only via Rule 9.3. Council approved the four criteria given by the Membership Committee in "Chemistry in N.Z." August 1973 p. 127 and was of the opinion that any changes in the rules should leave the career status of both technicians and professional chemists unchanged. It was agreed that the paper prepared by Dr. Foster for the Rome Conference should be accepted as a Council paper, a scheme for parallel development of technician and professional members added and subjected to the scrutiny of the four criteria, and then published in the journal with the comment that Council strongly favours parallel development and the preservation of two distinct groups both of whom have their own career prospects. Branches were asked to have this paper discussed at a branch meeting.

The Registrar was instructed to notify all members, University Registrars, State Services Commission and Research Associations of the change in title of Associate to Member.

Director of Productivity Advisory Services

The Registrar was instructed to write to the Department of Trade and Industry asking that the Institute be listed in the Directory.

Officers for 1973

The President reported that only one nomination had been received for the position of Second Vice-President, that of Mr. J. S. Pollard who was accordingly elected to that position.

On 1 September Dr. P. K. Foster assumed the position of President and Dr. C. L. Davey became First Vice-President. Dr. W. E. Harvey continued as General Secretary.

Prizes

The 1973 I.C.I. Prize was awarded to Dr. J. C. Dacre, Tulane University, Louisianna and formerly of the Toxicology Research Unit, Medical School, Dunedin.

The Chemical Essay Prize was awarded to Miss J. Mulvihill, Chemistry Department, University of Canterbury, for an essay entitled: "The Watson-Crick-Lowdin Theory of Mutations in D.N.A."

The prize for the best student paper at the 1973 Conference was awarded to Mr. W. R. Wilson, Department of Cell Biology, Auckland University.

Public Relations

It was agreed that publicity releases should continue on a trial basis through Neilson McCarthy. It was suggested that each branch should appoint a press-liaison officer to assist in getting publicity for chosen topics.

Executive Secretary

All branches were in agreement in principle. A subcommittee of Drs. Foster and Wright assisted by the General Secretary and Registrar was appointed to go into ways and means to report to the next meeting.

Financial—Balance Sheet

The Registrar commented on the balance sheet and drew attention to the loss on the year's working and a projected increase in expenditure. It was agreed that the subscription would need to be raised but there was no agreement among branches as to the extent. It was agreed that the President would mention the need for an increased subscription at the A.G.M. and tell members that Council was thinking in terms of $13-$14. A decision could be made at the next Council meeting.

The Registrar was instructed to prepare a trial budget for the next meeting.

Honorary Fellowship

On the unanimous recommendation of the Membership Committee the following were elected as Honorary Fellows: Dr. Elsa Kidson, Dr. F. B. Shorland, Messrs. E. W. Hullett, H. L. Longbottom and L. S. Spackman.

Report of Commission of Enquiry into Parnell Civil Defence Emergency

Resolved Auckland/Canterbury that:

Council commends the Commision of Enquiry into the Parnell Civil Defence Emergency for its thorough investigation into the causes of the chemical spillage that occurred in Auckland in February 1973;

and that Council strongly urges Government to take prompt action on the following recommendations in the Commission's Report:

(Report of the Commission of Enquiry into the Parnell Civil Defence Emergency, Government Printer, Wellington, June 1973.)

(a) appointment of hazards officers to fire brigades, with responsibility for assembling information, identifying and dealing with dangerous chemicals (p. 89);
(b) establishment of a National Dangerous Goods Advisory Centre (p. 127);
(c) provision of Dangerous Goods Storage Centres to handle dangerous chemicals, other than inflammable or explosive materials which are satisfactorily provided for at present (p. 128);
(d) upgrading the training of health inspectors in the chemical field, so that they can recognise potentially dangerous chemicals and initiate the precautions that may be necessary (p. 128);
(e) adequate labelling of dangerous chemicals be made mandatory, and should include trade name, synonyms (not mentioned by the Commission), scientific name (and synonyms), nature of danger, and precautions; and that appropriate regulations be promulgated (Traffic Regulations, Agricultural Chemicals etc.) (p. 139, 140);

and that recommendations (d) and (e) are regarded by Council as having high priority;

and that regulations and precautions concerning dangerous chemicals in future have similar status to the regulations which already exist for explosives, inflammable materials, poisons, dangerous drugs, narcotics, etc.

SPECIALIST GROUPS

The Groups and their secretaries are as follows:

BIOCHEMISTRY, Dr. B. A. Tapper, Applied Biochemistry Division, D.S.I.R., Private Bag, Palmerston North.
GEOCHEMISTRY, Dr. R. Goguel, Chemistry Division, D.S.I.R., Private Bag, Petone.
ORGANIC CHEMISTRY, Dr. K. L. Richards, Chemistry Department, University of Canterbury, Christchurch.
ELECTROCHEMISTRY, Professor G. A. Wright, Chemistry Department, Auckland University, Private Bag, Auckland.
ANALYTICAL CHEMISTRY, The Registrar, P.O. Box 1926, Christchurch.
THERMODYNAMICS, Dr. D. V. Fenby, Chemistry Department, Otago University, P.O. Box 56, Dunedin.
CHROMATOGRAPHY, Dr. P. G. Robinson, Department of Paediatrics, Medical School, Auckland University, Private Bag, Auckland.

CHEMICAL ENGINEERS, Hon. Secretary, Chemical Engineers Group of the N.Z. Institution of Engineers, P.O. Box 12-241 Wellington.

If you wish to be on the mailing list of one or more of these groups you are invited to write to the secretaries.

PRESIDENT 1973-74

Dr. P. K. Foster is Director of Pottery and Ceramics Research Association, Gracefield. He completed his first degrees at Canterbury University College (as it was then), then took his Ph.D. at Imperial College, London. From 1957-63 he worked at the D.S.I.R. Corrosion and Metallurgy Section, then went to PACRA as Director.

He has served on the Wellington Branch Committee as member then chairman. He is a member of the Institute's Membership Committee, has produced a number of salary surveys and currently has organised the Manpower Survey. He is NZIC nominee on the Standards Council, and Chairman of the Committee revising the Masonry Section of the Building Code.

He is interested in research management. He is a keen yachtsman and recently passed the navigation exams.

Dr. P. K. Foster

First Vice-President 1973-74 Mr. C. L. Davey.

Second Vice-President 1973-74 Mr. John Pollard

RETIREMENTS

MR. L. R. SPACKMAN

Leonard Spackman was born in Inglewood, in 1902, educated at Napier Boys High School and Auckland University.

His initial experience in analytical chemistry were gained in thirteen years of employment with Mr. Alf Parker, handling both private and governmental analytical work.

He was present at the inaugural meeting of the NZIC, called by Professor Easterfield during the NZAAS Conference in Auckland, 1931, and was elected an Associate of the New Zealand Institute of Chemistry the same year. He became the secretary of the Auckland Branch, a position he held for 8 years. His responsibilities during this time included the organisation of the first combined NZIC and RIC conference in Hamilton.

In 1932 he set up private practice as an analyst in Auckland and became deeply involved in dairy chemistry, through his position as consultant and analyst to the Auckland Metropolitan Milk Board. Apart from general chemical problems, he has had broad experience in the fields of forensic, food, drugs and water chemistry, and bacteriology. At one stage he held the position of chemist to the Auckland City Council Waterworks department.

Mr. Spackman sold his practice to Dr. T. J. Sprott in 1966, and this business was reformed as T. J. Sprott & Associates.

Retirement was Mr. Spackman's objective shortly after handing over his business, but his reputation both local and international, has prevented this and he is still actively involved in all spheres of chemical analysis.

MR. E. W. HULLETT

A graduate of Canterbury University College, Mr. Hullett joined the staff of the Wheat Research Institute in 1934 after working at the Canterbury Museum and Lincoln College. In 1936 he was appointed chief chemist, and he remained in charge of the laboratory until his retirement, being appointed Director when the wheat breeding section of the Institute became part of Crop Research Division.

The activities of Mr. Hullett have covered a wide range. Before World War II he carried out original work on drying of wheat (which was applied many years later), and, in the course of developing a method for incorporating wheat germ into bread, began a fruitful line of biochemical research. During World War II he was seconded to the defence development section of the Department of Scientific and Industrial Research and was engaged in scientific work for the services. In the post-war years he was concerned with the development of the W.R.I.-Detacher and its application to the problems of raising the extraction rate in the face of the world wheat shortage, and then with methods of proof and maturity control and their application to problems of matching bakery processes to fully mechanised plant. In latter years he was particularly concerned with methods for retaining steam in ovens, and with improving testing methods to make better use of the increasing wheat harvest in New Zealand.

He has served as Canterbury Branch Chairman, and was President in 1960.

Typically, Mr. Hullett remains active in retirement. He lives in Auckland and is consultant to a number of firms associated with the baking industry.

THE REGISTRY (ELECTED 19 AUGUST 1973)

The following were elected as FELLOWS:

CORBAN, George Annis, B.Sc., *Hellaby Shortland Ltd., Auckland (Chief Chemist).*

FREITAG, Walter, M.Sc. (N.Z.) *B.P. (N.Z.) Ltd., Wellington (Chief Chemist).*

HURST, Frank, M.Sc. (N.Z.), *Chemistry Division D.S.I.R. Gracefield (Section Leader, Forensic).*

STONE, Harry MacEwan, M.Sc. (N.Z.), *Chemistry Division, D.S.I.R. Gracefield (Section Leader, Toxicology).*

WRIGHT, Graeme John, M.Sc., Ph.D. (Cantaur), *Chemistry Department, University of Canterbury (Reader).*

The following were elected as MEMBERS:

DORMER, Robyn Alethea, M.Sc. (Auck.), *Post Grad. School of O. & G., National Women's Hospital, Auckland (Ph.D. Student).*

GRANT, William Donaldson, B.Sc. (Hons.) (Cantaur) Ph.D. (N.S.W.), *Cawthron Institute, Nelson (Research Scientist).*

GREENWAY, Robert Michael, M.A. (Oxon), Ph.D. (McGill), *Department of Chemistry & Biochemistry, Massey University (Reader in Biochemistry).*

HARWOOD, Victor Douglas, B.Sc. (Hons.) Ph.D. (McGill), *Forest Research Institute, Rotorua (Scientist).*

HEENAN, Michael Perry, M.Sc., Ph.D. (Well), *Chemistry Division D.S.I.R. Gracefield (Scientist).*

LOVE, Alexander James, B.Sc. (Hons.) (Cantaur), *B.P. N.Z. Ltd., Petone (Analytical Chemist).*

LOVE, John Lancelot, M.Sc., Ph.D. (Cantaur), *Chemistry Division, D.S.I.R., Gracefield (Scientist).*

McDONALD, Duncan Finlayson, *N.Z. Forest Products Ltd., Tokoroa, (Senior Analytical Chemist).*

NIXON, Leon Nicholas, B.Sc. (Hons.), Ph.D. (Otago), *Applied Biochemistry Division D.S.I.R., Palmerston North (Scientist).*

PRICE, Harlech Craig, B.Sc., *Auckland Technical Institute (Tutor in Chemistry).*

SCHILD, Frederik Willem Johannes, B.Sc., *Reckett & Colman (N.Z.) Ltd., Auckland (Quality Control Chemist).*

ZABKIEWICZ, Jerzy Antoni, B.Sc. (Hons.), Ph.D. (Glasgow), *Forest Research Institute, Rotorua (Scientist).*

The following were elected as GRADUATE MEMBERS:

CHAPMAN, Ronald Henry, B.Sc., *National Radiation Laboratory, Christchurch (Scientist).*

DOWN, Graham John, B.Sc. (Hons.) (Cantaur), *Chemistry Division, D.S.I.R., Gracefield (Scientist).*

FITCHETT, Mrs. Catherine Ruth, M.Sc. (Auck.), *Chemistry Division D.S.I.R. Gracefield (Scientist).*

HOPE, Graeme d'Egville, B.Sc., *Soil Science Dept., Lincoln College, Canterbury (Technician).*

LASCELLES, David Rohde, B.Sc., *Dept. of Chemical Engineering, University of Canterbury (Student).*

MOYNAGH, Shaun Michael, B.Sc., *Shell Oil N.Z. Ltd., Christchurch (Industrial Chemicals Rep.).*

NG, Ah Chin, B.Sc. (Hons.) (Cantaur), *Chemistry Dept., Auckland University (Ph.D. Student).*

SOTEROS, George James, M.Sc. (Well.), *Chemistry Div. D.S.I.R. Gracefield (Scientist).*

WILSON, Raymond Donald, B.Sc., *Chemistry Dept. Auckland University (M.Sc. Student).*

YATES, Terence Edward, M.Sc. (Massey), *Water & Soil Division, M.O.W., Wellington (Scientist).*

It was agreed that when Graduate Members are notified of their election they should be informed of the requirement of four years professional experience before qualifying as a member and invited to seek assistance from the Institute if they were in doubt regarding the nature of their experience.

The following deaths were noted with regret:
M. Fieldes, B. R. Law, R. V. Perryman.

The following resignations were accepted:
R. A. Barnes, L. F. Downes, R. B. Glover, J. W. Kennedy, P. M. Shanks.

Remission of subscription was granted to the following members:
P. L. R. Charlton, H. W. Crozier, T. A. Thomson, Mrs. E. Thomson.

The following members were listed as in communicando and deleted from the list of members:
B.| M. Beckingham, J. R. Hunt, K. R. Laing, R. C. Stewart, E. P. Witcher.

The following were re-instated as members:
P. C. Betts, R. V. Winchester.

HONORARY FELLOW

MR. T. H. McCOMBS

The New Zealand High Commissioner in Great Britain, Mr. T. H. McCombs, has been made an Honorary Fellow of the New Zealand Institute of Chemistry.

Mr. McCombs is a chemist by training, holding a Master of Science degree in Chemistry. He made his career in education and politics, although he originally intended a research career.

Professor Corbett, the President, said Mr. McCombs had been made an Honorary Fellow in recognition of his contribution to education, and for his long service with the Institute. Mr. McCombs became a member of the Institute in its foundation year in 1931 and was made a Fellow in 1958.

He has been headmaster of Cashmere High School, Chancellor of the University of Canterbury, a prominent Labour politician and was Minister of Education during the 1957-60 Labour Government headed by the late Sir Walter Nash.

Institute Prizes for 1973

Chemical Essay Prize: Miss J. N. Mullvihill, University of Canterbury.

I.C.I. Prize: Dr. J. C. Dacre, Tulane University School of Medicine, New Orleans, U.S.A.

Student Paper given at Conference 1973: W. R. Wilson, Dept. of Cell Biology, Auckland University.

Medical Research Council Awards

Two women members of the Institute have been awarded the first Career Fellowships by the MRC. Dr. M. G. Metcalf, Medical Unit, Princess Margaret Hospital, Christchurch, graduated M.Sc. from Victoria University College in 1948. She gained her Ph.D. from the University of Otago last year. Her research interests are in the steroid field.

Dr. P. M. Wiggins, Department of Medicine, University of Auckland graduated M.Sc. from Canterbury College, and Ph.D. from University of London in 1952. Her interests are in the field of ions associated with membranes.

BRANCH NEWS

Auckland

Mr. I. Clements has produced a detailed membership list of Branch members. This has been circulated to these members.

The very successful short course entitled "Management for Chemists" organised and conducted by the Auckland Technical Institute in conjunction with this Branch, resulted in the following participants receiving their Certificate:

G. A. Corban
B. J. Cowell
I. J. Erceg
S. A. Jordan
G. Kime
N. Lodge
A. F. Peacock
O. H. Skarsholt
T. J. Millar
A. Svoboda
J. Thorp
D. Hing

Mr. E. W. Hullett, F.N.Z.I.C. and Mr. L. S. Spackman, F.N.Z.I.C. — two long serving and outstanding members of this branch have deservedly received Honorary Fellowships. The branch offers its congratulations and wishes them a long and active retirement.

Mr. L. S. Spackman and Mrs. B. Nickless gave a very informative and well timed address to the August Branch meeting on "Biogradability of Detergents". This meeting was a highlight on this year's technical calendar.

Dr. Ashley Wilson addressed a crowded luncheon meeting on the topic "Chemistry and Conservation". Obviously a very talented chemist, he outlined the duties of a technologist in the crusade to keep New Zealand clean. This meeting was a joint one with the Oil and Colour Chemists Association who are desirous of closer links with the Institute. Auckland's mayor Sir Dove-Meyer Robinson also addressed the luncheon.

The Branch was sumptuously entertained when they toured the new pharmaceutical plant of Warner Lambert Ltd. on September 25. Mr. B. G. Barrack and his staff had gone to considerable trouble to make this plant visit a memorable one. The Branch is indebted to the organisers of this tour.

Some senior members have been concerned about the entry of New Zealand Certificate holders into the Institute. The Branch committee has decided to make considerable time available at the Annual General Meeting for this topic to be discussed. This will probably be the last occasion for your views to be expressed before Council passes a resolution on this matter.

Dr. J. Aggett, Chemistry Dept. University of Auckland is spearheading the establishment of an Analytical Chemistry Group in Auckland under the auspices of the N.Z.I.C. The function of this group will be to promote and facilitate discussion and communication of techniques and their applications between users in the Auckland Area.

University of Auckland

Dr. G. A. Bowmaker took part in the Australian Spectroscopy Conference in Canberra in August.

Mr. Ian G. Mawston is now with J. Lucas N.Z. Ltd.

Dr. J. T. France of National Women's Hospital recently visited U.S.A. to attend conferences and visit research institutions in the field of steroidal biochemistry.

The Department of Education held a Secondary National course on Senior Chemistry at Lopdell House, Titirangi in September. The course was organised by Messrs. T. C. Ralfe and B. G. McFarlane, and was attended by 30 chemistry teachers and university staff.

Other

Dr. H. J. Percival, M.Sc. Ph.D. (Wellington), A.N.Z.I.C., will be taking up a staff appointment at the Otara Research Station of the New Zealand Fertiliser Manufacturers' Research Association early in November 1973 after post-doctoral work in the Department of Industrial Chemistry, University of Brussels

Prof. R. C. Cambie has been appointed Chairman of the 1974 N.Z.I.C. conference committee. He is collecting a vibrant group to make next year's conference a really outstanding one.

Canterbury

D. J. Higgins, formerly Works Superintendent, Kempthorne Prosser and Co., has been appointed Manager of the Chemical Fertiliser Division of that company.

University of Canterbury

Dr. W. Robinson has returned from study leave at Stanford.

Dr. M. Munroe will be away for a year on study leave. He will be working with Professor K. L. Rhinehart at the University of Illinois.

Professor Emil Slowinski from McAlister College, Minnesota will be associated with the Chemistry Department for about a year.

Christchurch Hospital

Dr. R. W. Carrell has been appointed associate professor in the Pathology Department.

The Protein Laboratory of the Department of Clinical Biochemistry has moved into the new Christchurch Clinical School building.

Wheat Research Institute

Dr. P. Meredith will be away on a study trip to Europe and North America until December.

Manawatu

Dr. G. G. Midwinter addressed the July meeting of the branch. Dr. Midwinter, who is a Reader in the Department of Chemistry, Biochemistry and Biophysics, Massey University, spoke on "The Structure of Proteins".

This year's Sixth and Seventh Form Lecture "Macromolecules in Physical Chemistry and Molecular Biology" was given by Professor G. N. Malcolm, Professor of Physical Chemistry at Massey University.

Dr. J. MacMillan, Chemistry Department, University of Bristol, addressed a special branch meeting on the "Biosynthesis of Gibberellin Plant Hormones in a single Gene Mutant of *Gibberella fujikuroi* and in a Cell-Free Enzyme System from a Higher Plant."

Dairy Research Institute

Work has been progressing on extensions to the Dairy Product Development Centre. Work has also started on the building of more offices for increasing numbers of staff.

K. R. Marshall has been awarded a Ph.D. from Massey University with his thesis, "Production of lactic acid by continuous culture of whey as a possible means of waste disposal".

Dr. A. E. Dennard has joined the Institute as a Research Officer in the Whey Products and Ultrafiltration Section. Dr. Dennard obtained his Ph.D. from Oxford University and has worked for A. D. Little and British Oxygen Company.

Two recent appointments to the Milkfat and Butter Section are Mr. B. J. G. Bewick, a Food Technologist who has been in South Africa for several years, and Mr. T. G. Bissell a Chemical Engineer who has been completing a Ph.D. at Canterbury University.

Mr. R. W. Russell, Butter Technologist, has resigned from the Institute to take up a position as Assistant Manager of the butter factory at Rangitaiki Plains Dairy Co.

D.S.I.R., Applied Biochemistry Division

Professor R. W. Sheard, Department of Land Resource Science, University of Guelph, is visiting for 9 months. His interests are in the sulphur nutrition of plants, and in the effects on root growth and function of small amounts of ethylene in the soil atmosphere as a result of flooding.

Massey University

Dr. G. G. Midwinter and Dr. G. G. Pritchard have been promoted to Readers in the Department of Chemistry, Biochemistry and Biophysics.

Mr. K. L. Mackie has left to take up a Canadian Commonwealth Scholarship. He will be studying in the field of wood technology, with emphasis on chemical processing, at the University of British Columbia.

Visitors to the Department of Chemistry, Biochemistry and Biophysics have included Professor J. L. Wain, F.R.S., Professor of Agricultural Chemistry at Wye College, University of London, Professor F. W. E. Gibson, Department of Biochemistry, John Curtin School for Medical Research, A.N.U. and Dr. J. MacMillan, Chemistry Department, University of Bristol.

Dr. R. Mann, Biochemistry Department Auckland University, spoke to the Manawatu Branch of the N.Z. Institute of Food Science and Technology on "Low-level environmental chemical health hazards — whose baby?"

Wellington

Victoria University of Wellington Chemistry Department

Professor W. E. Harvey returned from leave earlier this month.

Institute of Nuclear Sciences, D.S.I.R.

Amongst those attending the biennial Geochemistry Conference at Nelson in May were Dr. M. Kusakabe and Dr. B. W. Robinson who both spoke on stable isotope equilibria in hydrothermal solutions, Dr. J. D. Adams who presented his recent work on K/Ar dating, Dr. G. L. Lyon who recently visited the Antarctic volcanoes, Dr. P. Blattner whose recent work on oxygen isotope fractionations was discussed, and Dr. N. E. Whitehead who spoke on proton induced X-ray fluorescence as an analytical method. Dr. J. Richards from the Australian National University visited the Institute after the conference.

Mr. W. J. McCabe attended the seminar on chemicals in the environment held recently in Christchurch, and chaired the D.S.I.R. Pollution Research Conference at Wairekei in June. He spoke on his recent work using radioactive tracers.

Chemistry Division, D.S.I.R.

In July Mr. J. D. Pope, Editor of the New Zealand Law Journal, delivered a lecture entitled "The Law and the Scientist". The views expressed by Mr. Pope evoked wide ranging discussions from attending staff.

Dr. P. P. Williams, head of the Physical Chemistry section left in June to visit laboratories in the U.S.A., Canada, Sweden, Holland, Switzerland, West Germany, the U.K. and Australia. He will study advances in techniques and instrumentation relevant to his section and while in Stockholm will attend a conference on "Structure of Biological Molecules".

Mr. D. J. O'Brien, head of the Metallurgy section left in June on a three month trip to visit metallurgy establishments in the U.S.A., the U.K., France, Italy and Australia.

Dr. I. M. Morice recently spent four weeks in Tahiti and the Marquesas Islands in order to collect seeds of species of *Astelia*. The collection of these samples will enable Dr. Morice to complete a survey of the seed oils of this species.

Mrs. C. Fitchett, a student bursar who recently completed an M.Sc. at

Auckland University, is working in the Toxicology Section.

Mr. M. N. Hutchinson who recently submitted his M.Sc. thesis to Victoria University has joined the Geochemistry section.

Mr. A. J. Mason, a former teacher who has a B.Sc. in Applied Chemistry has joined the Chemical Engineering section.

Mr. R. Dalby who recently submitted his Ph.D. thesis to Otago University is a member of the Physical Chemistry section. He will be working with the NMR spectroscopy group.

Mr. R. B. Williamson is a new member of the Water Laboratory. He recently completed research for his Ph.D. in Electrochemistry under the supervision of Associate Professor G. A. Wright at Auckland University.

Soil Bureau, D.S.I.R.

Dr. R. B. Miller has been appointed Director of the Soil Bureau. Dr. Miller joined Soil Bureau in 1945 and was leader of the Scientific Administration Section prior to his appointment as Director. In September and October he will be in Rome assisting with the preparation of the FAO soil map of the world.

Other recent changes include the appointment of Dr. W. B. Healy, Mr. N. Wells, and Mr. A. J. Metson as Group Leaders, and Dr. R. J. Furkert as head of the Scientific Administration Section.

Dr. B. K. G. Theng, at present in Bonn on a Humboldt Fellowship, has been awarded the 1972 Adam Hilger Prize for publications of outstanding merit in science for his book "The Chemistry of Clay-organic Reactions".

Otago

Secondary School Lectures

The three secondary school lectures to 6th and 7th form students were well received. About one hundred and fifty attended the first lecture, with a slightly smaller attendance at the second and third lectures.

Chemistry Department, Otago University

Dr. B. H. Robinson has left on a 12 month leave to work on organometallic chemistry with Professor J. Lewis, F.R.S., at The University Chemical Laboratory, Cambridge.

The Open Days held jointly by the Chemistry Department and the Biochemistry Department were highly successful. Over one thousand secondary school pupils visited undergraduate teaching laboratories and research facilities.

Biochemistry News

The installation of two major instruments is of interest to biochemists. The first of these is a Beckmann 850 C Protein/Peptide Sequencer, for the automated Edman degradation cycles on proteins. The instrument was financed by grants from the University Grants Committee, Otago University, and the Medical Research Council. The second instrument is a JEOL 6AH Amino Acid Analyser for the fully automated injection analysis of protein hydrolysates, with detection down to 1 nana mole. Cost of this analyser: $22,000.

Professor G. B. Petersen, head of the Biochemistry Department, has left on a Commonwealth Bursary for one year's sabbatical leave at the Medical Research Council Laboratory of Molecular Biology, University Post Graduate Medical School, Cambridge.

Professor Petersen will be working with Dr. F. Sanger. During his absence from Dunedin Associate Professor M. G. Smith is acting head of the Biochemistry Department.

A recent visitor to the Biochemistry Department was Professor T. N. Waters, Department of Chemistry, University of Auckland. In addition to a series of lectures on the X-ray Crystallography of Proteins, he gave a seminar entitled "The Biological Role of Copper — A Chemist's Viewpoint" which was very well received.

Pharmacy News

Dr. B. R. Hajratwala of the Department of Pharmacy, Otago University, attended the recent ANZAS Meeting in Perth where he presented a paper on th applications of Laplace Transformations to pharmaco-kinetics.

Visitors

There have been several distinguished overseas chemists who have visited Dunedin recently. Included among these was Professor R. O. C. Norman of the University of York, who was an Erskine Professor at Canterbury University. Professor Norman lectured on the applications of E.S.R.

Dr. Macmillan of the Chemistry Department, Bristol University, delivered a lecture entitled "Tetracyclic Diterpene Chemistry" to a special meeting of the Otago Branch of the Institute on September 10th.

Successful Seminar on Trace Element Analysis

Dr. Howard Siegerman, Head of Electrochemistry Department, Princeton Applied Research Corporation, Princeton, New Jersey, delivered a lecture on May 25 at the Department of Chemistry, University of Auckland on recent advances in the techniques of determination of trace element concentrations. Applications to environmental studies were frequently mentioned with examples discussed in heavy metals where sensitivities of 10^{-8}M are easily achieved by the new technique of Differential Pulse Polarography. In situations where a reversible amalgam is possible at the mercury electrode, anodic stripping is useful in solution concentrations of 10^{-9}M.

Uses in the pharmaceutical industry were demonstrated with an interesting example of the ease by which penicillin and penicilloic acid may be separately analysed.

The relative simplicity and economy of the equipment required was a pleasant surprise to the delegates.

Dr. Siegerman had the opportunity to discuss particular analytical problems with delegates at an informal meeting at the University Club, where discussions continued on the complementary aspects of polarography to atomic absorption techniques, and work proceeding on automation of the analytical procedures.

The seminar was sponsored by ANAC Limited (Auckland Nuclear Accessory Company) and made successful by the co-operation of the University of Auckland.

TO THE EDITOR

The Editor,

Dr. Young's article in the July issue on interdisciplinary chemistry presented some interesting ideas which would be more convincing had he not started off with a totally false premise. The University of Waikato advertised last year not for "an inorganic chemist specialising in some aspect of organometallic chemistry" but for a lecturer in chemistry "with experience in transition metal or organometallic chemistry" and added "an interest in any of the major branches of spectroscopy" would be an advantage. Any modern chemist would know the advertisement was directed to about two thirds of all inorganic chemists and was looking for the sort of generalist that most universities seek in their early days. It is a fact of life in New Zealand, if not in more opulent university systems, that a new School of Science, like Waikato, starts off with a small staff whose interests have therefore to be broad, have to cover the major areas of their subject, and can only overlap at the expense of omissions elsewhere.

We are further distressed that this corrupted text was used to talk of "missed opportunities" at Waikato. As you will know Madam, science teaching at Waikato is broad, cross-disciplinary, and extremely flexible. Chemistry makes its full contribution to this approach, both by its emphasis on the interdisciplinary areas within chemistry (such as organometallic chemistry!) and by its extensive links in teaching and research with the other science subjects. Indeed, within the limits imposed by its small staff, Waikato already covers the more desirable of the areas discussed by Young in that small part of his article directed towards undergraduate programmes.

Dr. Young's sermon comes from a bastardised text and is addressed to the already-converted not only at Waikato but in New Zealand chemistry in general.

K. M. Mackay,
Reader in Chemistry,
School of Science,
University of Waikato.

The Editor,

As a young Graduate Member of the Institute I wish to support the members of Council in the stand that they have taken on behalf of us all, over the dreadful case of Professor Veniamin Levich. I feel very concerned about the plight of Professor Levich and I also wish to congratulate Professor G. A. Wright for bringing this state of affairs to the attention of chemists in this country.

I must confess however that I have never ever considered it appropriate to ask the Council to express the concern of New Zealand chemists at the wholesale use of Agents Orange and White in Vietnam. Neither have I lobbied them to denounce Professor Louis Feiser (of "Feiser and Feiser" fame) for inventing and developing napalm and the later "improved" (it sticks better) versions. Nor have I politely suggested that we express doubts, about the use of CS gas in Ulster. In fact I must confess to inaction on many occasions when chemistry and man's inequity to man have been components of the same evil cocktail.

You see, unless I knew that political problems—no matter how disturbing or heart-rending—were none of the Institute's business then I must confess to being a hypocrite. And no one likes to admit that they might be hyprocrites!

Stephen A. Short.
Cawthron Institute.

THE INSTITUTE'S LIBRARY

The Institute's library really began in 1949 when Dr. H. J. T. Ellingham, then secretary of the Royal Institute of Chemistry, arranged an exchange of official organs between the various chemical institutes of the British Commonwealth. Since then through various circumstances other exchanges have been entered into and at present we receive 36 publications in exchange for "Chemistry in New Zealand."

During the 24 years of the library's existence, a number of journals have been received for a period but have since dropped out, but the number is steadily growing, and is a tribute to the acceptability of our own journal. This is rather remarkable when it is considered that it contains few original papers; when the inevitable day comes for a change of policy in this matter, then we can expect the number of exchanges to increase considerably.

As will be seen from the list below many countries are represented, and for some the Institute's file is the only one in New Zealand.

The library continues to be housed at the Auckland Museum through the courtesy of the Director, Mr. E. G. Turbott, and the Librarian Mr. I. G. Thwaites who sees that the publications are properly catalogued and serviced. Journals are available on loan on application to the Librarian, Auckland Institute and Museum, Private Bag, Auckland. We are grateful to the authorities there for housing and servicing our library, and as a mark of our appreciation the Institute supplies the Museum library with a subscription to the "New Scientist."

The following list gives details of the publications at present received with an indication of the language in which they are written. Most non-English papers have English summaries.

Affinidad: Barcelona, monthly, Spanish.
Azerbaijan Chemical Journal: Baku, Monthly, Russian.
Buletinul Institutului Politehnic Gheorghe Gheorghiu-Dej: Bucharest, bi-monthly, Romanian.
Canadian Journal of Chemical Engineering: Ottawa, monthly, English.
Chalmers Tekniska Hogskolas: Goteburg, occasional, English.
Chemie in der Schule: Berlin, monthly, German.
Chemistry: Washington, monthly, English.
Chemistry in Britain: London, monthly, English.
Chemistry in Canada: Ottawa, monthly, English.
Collection of *Czechoslovak Chemical Communications:* Prague, monthly, English, German and Russian.
Croatica Chemica Acta: Zagreb, quarterly, English.
Education in Chemistry: London, monthly, English.
IUPAC Information Bulletin: London, quarterly, English.
Journal of the Franklin Institute: Philadelphia, monthly, English.
Journal of the Korean Chemical Society: Seoul, bi-monthly, Korean and English.
Journal of the South African Chemical Institute: Johannesburg, quarterly, English and Africaans.
Kagawa University: *Technical Bulletin of the Faculty of Agriculture:* Kagawa-Ken, twice yearly, Japanese.
Kemija u Industriji: Zagreb, monthly, Croatian.
Kimisk Tidskrift (Formerly *Svensk Kemisk Tidskrift):* Stockholm, monthly, Swedish.
Kyoto University: Bulletin of the Institute for Chemical Research: Kyoto, bi-monthly, English.
ibid: *Annual Report of the Research Reactor Institute:* Kyoto, English.
N.Z. Patent Office Journal: Wellington, monthly, English.
Polish Technical and Economic Abstracts: Warsaw, quarterly, English.
Proceedings of the Royal Australian Chemical Institute: Melbourne, monthly, English.
Progress in Chemistry and Chemical Industry: Seoul, quarterly, Korean.
Pure and Applied Chemistry (IUPAC): London, quarterly, English.

Revista Portuguesa de Farmacia: Lisbon, quarterly, Portuguese.

Revue Roumaine de Chimie (Formerly *Studii si cercetari de Chimii):* Bucharest, monthly, English or French.

Roczniki Chemie (Annals of the Polish Chemical Society): Warsaw, monthly, Polish and English.

South African Chemical Processing (Formerly *South African Industrial Chemist):* Johannesburg, monthly, English and Africaans.

Uspekhi Chimii (Progress in Chemistry—Reviews): Moscow, monthly, Russian.

Zhurnal Prikladnoi Chimii (Journal of Applied Chemistry): Leningrad, monthly, Russian.

S. G. Brooker,
Hon. Librarian.

INVITATIONS

The Clean Air Society of Australia and New Zealand

(New Zealand Branch)

The Society is offering a scholarship of up to $800.00 to be taken up in 1974 for an overseas study tour or project to extend qualifications and/or experience in the field of air pollution investigation and control, or for undertaking an appropriate project in this field in New Zealand. In all cases it is essential that proposals are appropriate to the New Zealand scene.

Application, in letter form, giving full details of the applicant, including qualifications and experience, and his proposal with reasons why he considers this to be of benefit to New Zealand, are to be forwarded to the Secretary-Treasurer, Clean Air Society of Australia and New Zealand (New Zealand Branch), P.O. Box 2225, Auckland before 20 November 1973.

Congress on Essential Oils

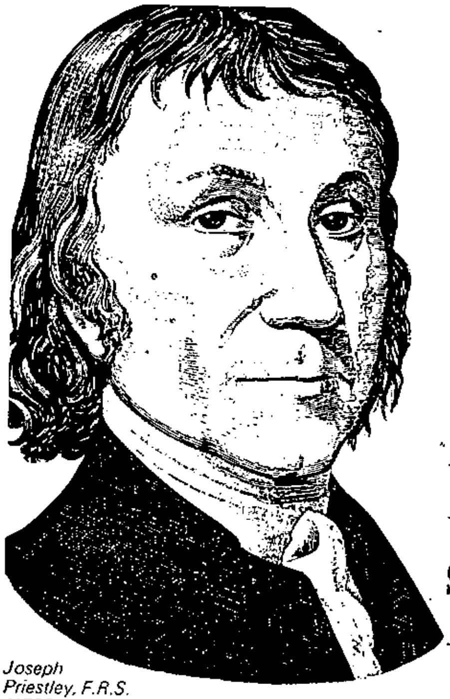
The VIth International Congress of Essential Oils will be held in San Francisco, California, U.S.A., from 8-12 September 1974. Papers from intending delegates are invited from the following technical areas:

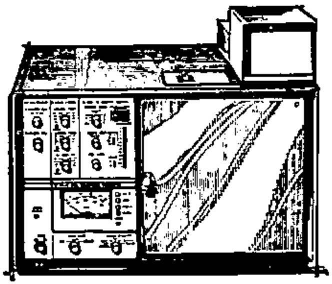
A. Agricultural/Botanical Section — includes Plant Introduction, Soil and Fertilization effects, Crop Management, Weed and Pest Control, Taxonomy, Morphology, Cytology and Biosynthesis of Essential Oils.

B. Chemistry/Technology Section — includes composition of essential oils and chemistry of their components, and Synthesis and Substitutes for Essential Oils.

C. Section on Utilization of Essential Oil Isolates and Aroma Chemicals.

Further Information available from Dr. T. D. R. Manning, Chemistry Div., D.S.I.R.





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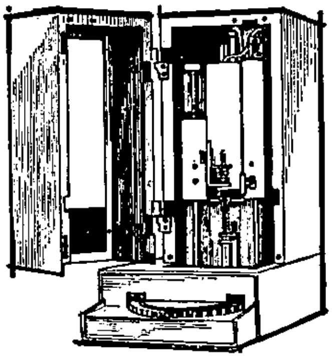

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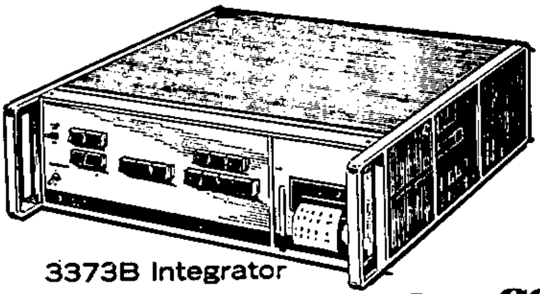

3373B Integrator

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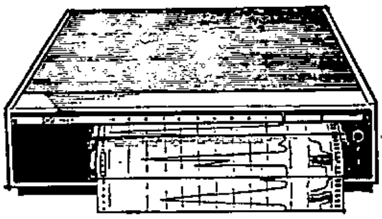
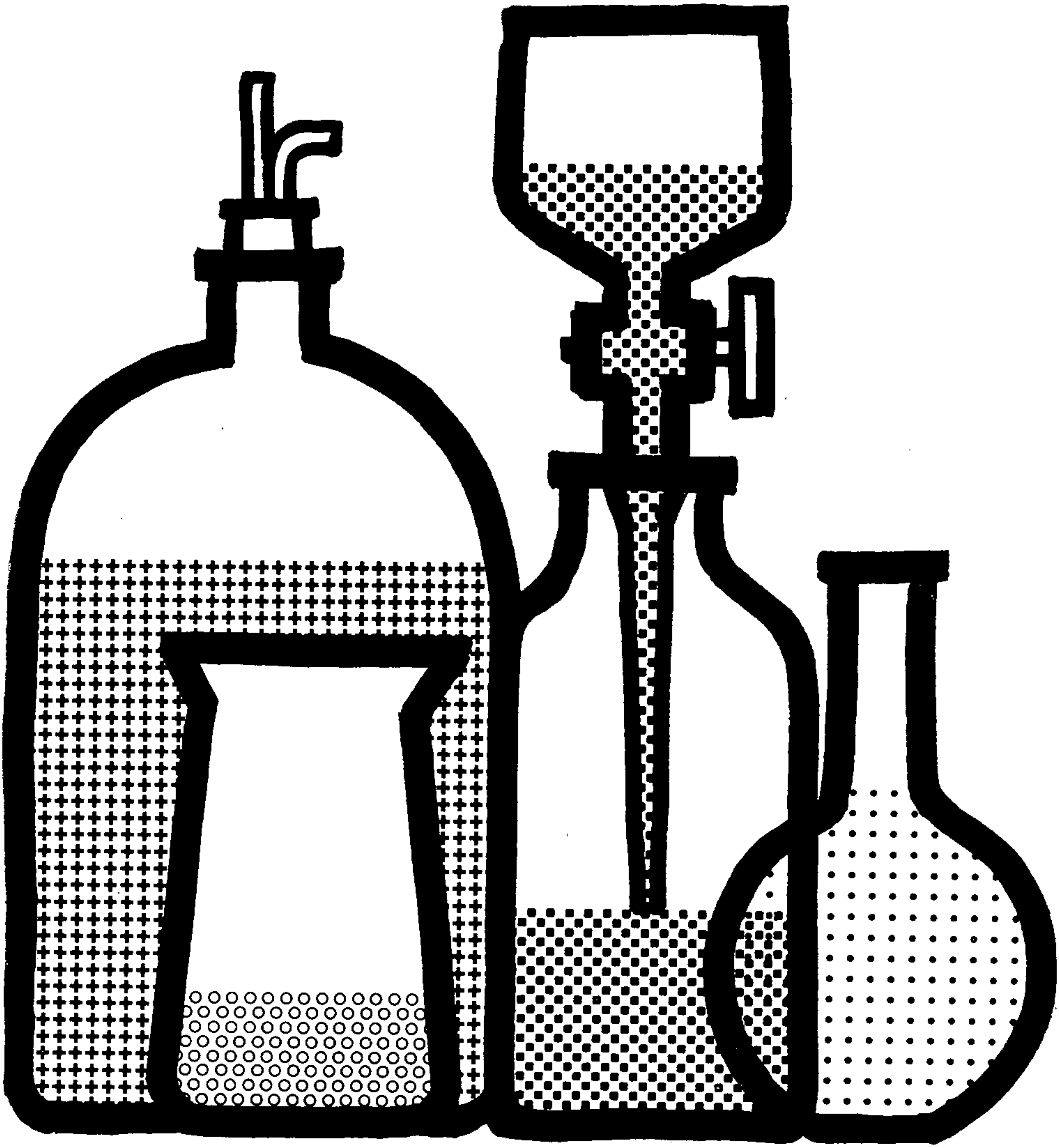
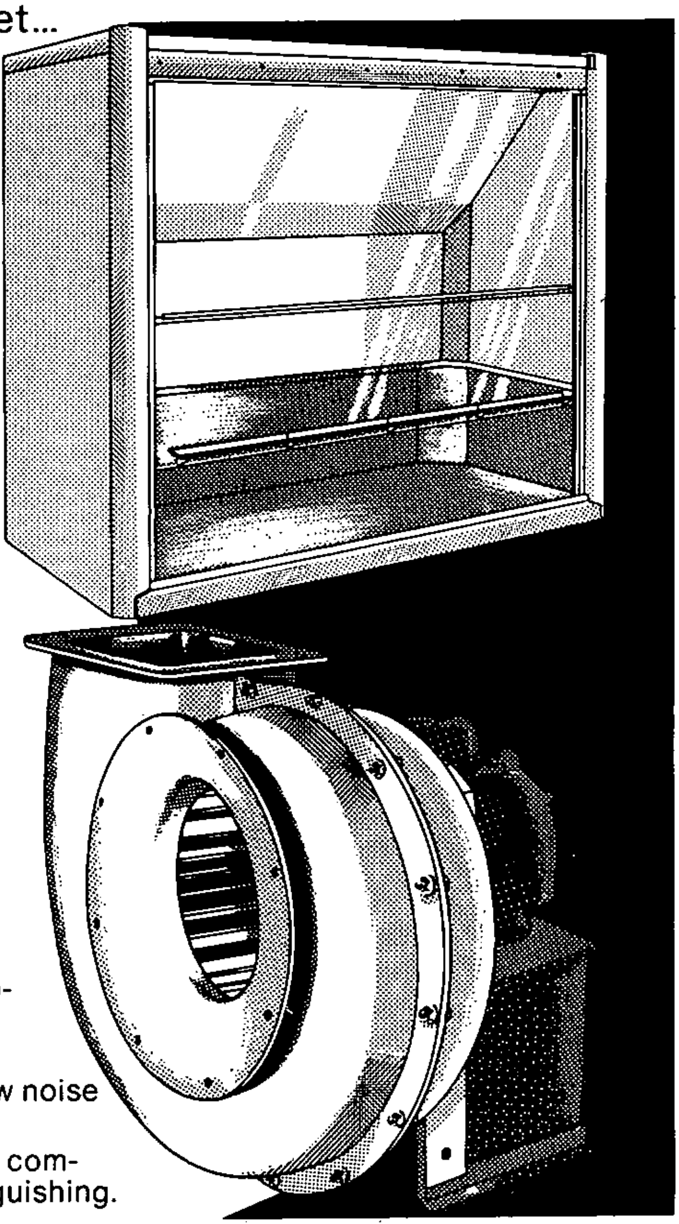


7123B Strip Chart Recorder





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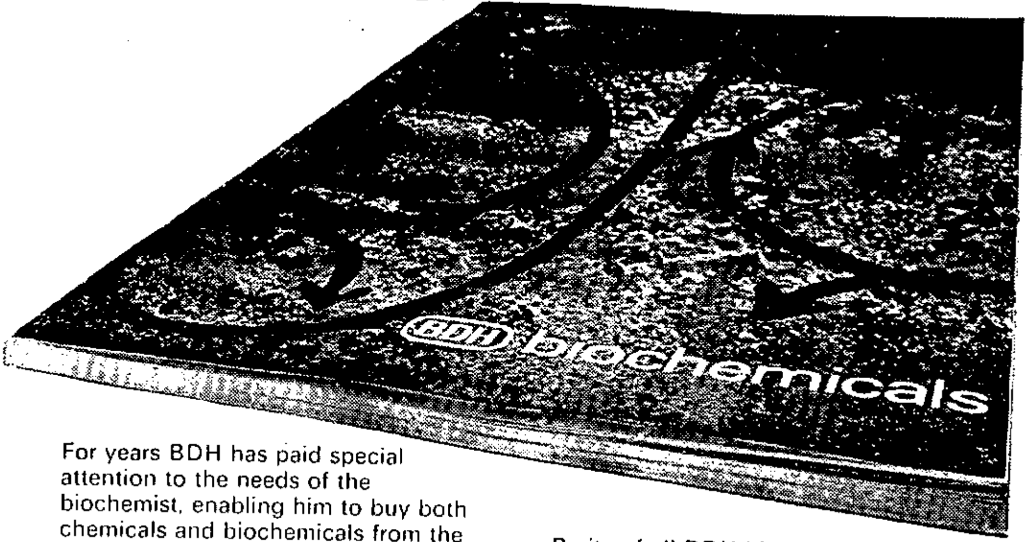

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