chemistry in new zealand

NZIC

December Issue, Vol. 54 No. 7
Incorporating the 1990/91 Year Book

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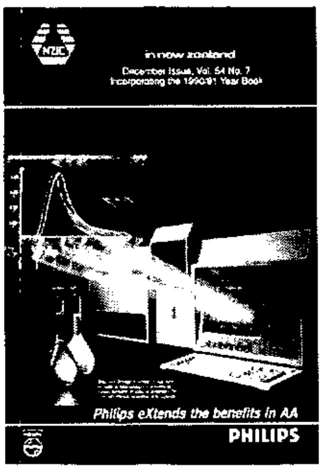

FRONT COVER

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Further Issues of Chemistry in New Zealand

As negotiations for a joint publication with the Royal Australian Chemical Institute have not as yet reached any finality "Chemistry in New Zealand" will continue to appear as usual. Contributors should send copy to the editor to arrive several days before copy deadlines which for 1991 will be the last weeks of January, March and May and the second weeks of July, September and November.

The Editor

EDITORIAL - GREENHOUSE ISSUES

As New Zealand ends its 150th year of European settlement we as chemists can well reflect on the important part that we have played thus far in helping to give this land a very special place among the developed nations with its healthy well educated peole, clear skies and a comparatively unpolluted environment. Our agricultural industries are what they are because of in part the wise use that has been made of chemical knowledge. Now however, we must consider the vital role that we must play in ensuring that many future generations of New Zealanders can continue to enjoy a lifestyle which is in all respects desirable.

There is little dissent that, as has been the case in all other countries for centuries, human occupation of the land has been exploitive. Natural resources are always used indiscriminately by man to serve the needs of a growing population until naturally abundant supplies of whatever have been virtually consumed. Our inherent cleverness then allows us to use what remains more efficiently, to get by without it or to obtain what we continue to need from somewhere or someone else. In this country we have dug up and sold most of our readily accessible precious metal minerals (and used our cleverness to determine where the rest is probably buried), we have dammed all the worthwhile river sites for energy production, made a wide range of useful marine species virtually extinct, replaced the bulk of the indigenous plant life with exotic species more amenable to managed exploitation and used an ever increasing area of cleared land for roads and housing. Along the way we have accidentally destroyed or made very rare many plant and land animal species and altered some of the landscape for ever. We have accidentally introduced unwanted plants and animals that have found the country as favourable to live in as we have and then been forced to use a variety of physical and chemical control measures to prevent their spread.

After 150 years we are left with a situation where the collective financial rewards of managed photosynthesis (farming, forestry, horticulture), showing off our scenery (tourism) exploiting our remaining natural resources (fishing, mining) and a variety of small by world scale manufacturing activities are insufficient to pay for our ever growing desire for such imported essentials as fossil fuel, vehicles, machinery, aircraft, chemicals, drugs, fabrics, travel and the like. We need these to maintain the high standard of living we have come to expect.

We are fortunately one of a group of countries which enjoy good health and affluence. As such we have the luxury of being able to join the debate on the niceties of the likely affects on our world of an increasing atmospheric carbon dioxide content. The people of New Zealand are committing themselves to a reduction in the emission of greenhouse discharges of 20-30% by the turn of the century. Almost all of these emissions are from the oxidation or discharge of fossil carbon compounds involved in supplying our energy needs.

To achieve any reduction at all technologists (chemists & engineers) will have to find ways of achieving more while using less fossil energy, using fossil energy more efficiently or avoiding the use of fossil energy but still satisfying our absolute financial need to earn our living from managed photosynthesis, tourism and manufacturing. It is salutary to note that our present greenhouse discharges represent only 0.1% of the global problem. Can we afford to lead the way in innovative technology or will we follow the example of others?

The environment has captured the imagination of many people. It has surpassed social, political and even religious belief in the minds of many. The reality is that only the continuous innovative use of basic chemical and physical truths will allow us as a nation to succeed economically and at the same time prevent further irreparable damage to our country and our planet. We Chemists as a group have a responsibility to ensure that New Zealanders as a whole are technically enlightened so that all can play their part intelligently and with common purpose.

Signed
Ron Hall

LETTER FROM THE PRESIDENT

Dear Member

Very significant moves are being made now to the structure of the Royal Society of New Zealand, prior to a Government review in 1991 of its statutory role and functions. NZIC is one of the largest affiliated scientific "societies" and has been involved at Council level to discussions aimed at producing a reformed Royal Society with new structures adapted to the future needs of science and technology in New Zealand. The discussions lead to a very useful meeting of Member Body President and representatives in Wellington on 29 October, with agreement on a new basic structure of the Royal Society that included a Council representing a federation (or confederation) of scientific societies.

The new Council will replace the current Member Bodies' Committee within the Royal Society but will now have a more equal partnership with the Fellowship of the Royal Society in overall scientific affairs. It should be able to act for the affiliated societies in a similar way as the Council for FASTS (Federation of Australian Scientific and Technological Societies) effectively does in Australia. Broad objectives for the new Council are:

1. To provide an independent voice on relevant issues to both Government and the people of New Zealand on behalf of the scientific community.

2. To engage in science policy development and lobbying.

3. To give a rapid response on technical and scientific matters where advice is sought.

A Council was formed at the Member Body Presidents' meeting to guide the scientific societies group within the new Royal Society through its first year. Two representatives were placed on the Council from each of the following groupings of affiliated societies - Land Science, Information and Mathematics, Environmental Sciences, Life Sciences, Physical Sciences, and Technological Sciences. I am one of the representatives for Physical Sciences, a group that includes NZIC, Institute of Physics, and the Geological Society.

By the time you have read this letter further meetings will have taken place to finalise the name of the Council and its functions. You will be kept informed of developmets but major functions of the Council are likely to include Public Awareness of Scence and Technology, advocacy on behalf of membership, government Science and Technology Policy, Science Education, and International matters. Some of the functions will be carried out jointly with the academy (Fellows) sector of the Royal Society.

I wish you all well for Christmas and the New Year. I look forward to visiting each Branch during 1991.

Regards
Harry Percival
President

WOMEN IN CHEMICAL SCIENCES SPECIALIST SESSION

Over forty women attended the Women in Chemical Sciences Specialist Session at the recent 1990 NZIC/NZBS/NZSPP Conference. This first scheduled gathering of women at an Institute Conference began with lunch, provided by Shell Holding NZ Ltd, which gave participants the opportunity to meet and talk before the formal sessions began.

The keynote address was given by Dr Irene Irvine, CSIRO Institute of Industrial Technologies, Melbourne who was brought to New Zealand by the NZIC Overseas Visitors' Fund supported by the Wellington, Hamilton, Auckland and Christchurch Branches, together with the Ministry of Agriculture and Fisheries' Equal Employment Opportunities Programme. Irene was a founding member of the Women in Chemistry Network (WINC) of the Victorian Branch of the Royal Australian Chemical Institute, she was able to share experiences of the establishment of the Network and of activities undertaken since to support members and to make them more visible in chemistry. These activities have included the establishment of a prestigious annual lecture by a woman chemist, the Joan Radford Lecture, encouragement and support for women to apply for awards and scholarships, submission of the names of women for elected positions on Boards and Councils, and (with male colleagues) mentoring of young women chemists.

Irene also briefly traced the contribution of women to chemistry since earliest times.

The Women in Chemistry Network has consistently lobbied for the survey of the position of women in chemistry in Australia, along the lines of that recently conducted in Britain. Irene was able to report that a Task Force has been set up within the Royal Australian Chemical Institute to investigate the means by which a similar survey may be conducted in Australia.

Following the address, participants broke up into small discussion groups where they considered the position of women in chemical sciences in New Zealand before reporting back in a final session. The opportunity to share experiences with people with similar interests and problems, to meet in a small group and to meet socially were considered extremely valuable. Perhaps the most pressing problem shared concerned the difficulties of caring for a young family while still trying to carry out research. Concern was expressed about the lack of knowledge of the position of women in the chemical sciences in New Zealand, for example, even the number of women in the Institute of Chemistry is not known. It was recommended that:

1. A Women in Chemical Sciences meeting should be a regular feature of future conferences; and

2. A survey of the position of women in chemistry, along the lines of the British survey and the proposed Australian survey, should be carried out by the New Zealand Institute of Chemistry.

BRITISH SURVEY RESULTS

From "Education, Employment and Attitudes of Men and Women Members", 1989, The Royal Society of Chemistry, London, UK

Results from analyses show that, among other things:

- members reported that careers advice at school on chemistry had been inadequate;
- career progression and promotion opportunities appeared to vary between men and women;
- both men and women had encountered instances of sex discrimination against, and sexual harassment of, women;
- a substantial proportion of women who took career breaks felt that, on return to work, responsibility or status in their jobs had changed for the worse;
- majority of both men and women would like refresher or retraining courses to be provided for people returning to work after a career break;
- a substantial proportion of women would like the Society to provide services or activities targeted at women chemists;
- an imbalance was identified between facilities wanted, and facilities provided, in certain areas, such as child care at work.

The following actions have been agreed:

- the Society should survey its Students Members to monitor the quality of careers advice in chemistry;
- where there are indications of discrimination, the Society should investigate further and take such supportive action as is practicable;
- the Society should encourage the provision of refresher courses and returner programmes;
the Society should consider whether there are additional professional services it might provide for women members;
- the Society should consider carrying out further surveys among its women members to update information on 'women at the workplace' and 'women in career breaks';
- the Society should invite the Women Chemist's Working Party to draw up proposed terms of reference for a Women Chemist's Committee to carry out the recommendations of the Working Party.

Janet Burns, Education Department, Massey University.

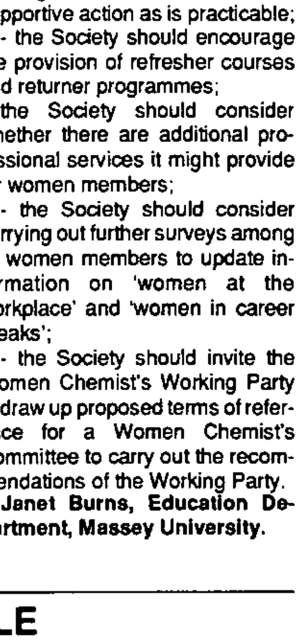
PEOPLE

WELLINGTON BRANCH CHAIRPERSON 1990/91

Elizabeth Douch was born in Wellington where she attended Tawa College before entering Victoria University from where she graduated BSc(hons) in chemistry in 1981.

Between 1983 and 1984 she worked with Dr Stuart Smedley at Victoria University on a contract from the Building Research Association to investigate the corrosion of metals embedded in preservative-treated timber.

In 1985 she attended Hutt Valley Outpost Teachers' College and was appointed as an assistant teacher of chemistry and mathematics at Wellington Girls' college, a position she still holds.



Elizabeth has been a member of the Institute since 1986. She has served as a committee member and treasurer for the Wellington Branch.

LETTER FROM AUSTRALIA

In September, while Melburnians were distracted by the Australian Football League playoffs, I was spending a few days in Port Moresby as guest of the Papua New Guinea Institute of Chemistry. Geographically the people of PNG are our nearest neighbours, and although there is regular contact between The Royal Australian Chemical Institute and the PNG Institute, there is potential for even stronger ties.

A number of people hold dual PNGIC/RACI membership, and they and others come to RACI conferences from time to time. In the other direction, PNG students take part in our Chemistry Quiz, after some "customising" of the questions, I think. The PNGIC Congress usually has a few people from down south, sometimes from companies who do business in PNG and sometimes courtesy of local industry sponsors as was my visit.

The Sixth Congress, which I attended, was held over a weekend at the University of Papua New Guinea, and about sixty people attended. The thirty of so papers fell mainly into two categories, having to do with plant products and with environmental analyses respectively. Chemists in PNG play important roles in national development, and this was reflected in papers about nutritional value of vegetables, composition of seed oils and maturing coconuts and structures of local polysaccharides.

An interesting paper in this category described the investigation of plant leaves which were used in preserving the meat which was left over from feasts involving the traditional mumu, the hot-stone oven. The chemist isolated the volatile oils, recorded their improved spectra, and sought the help of an Australian colleague in getting gas chromatopography/mass spectroscopy to work on the problem. While awaiting this result he checked the anti-bacterial properties of the oils against a range of organisms which were likely to cause meat spoilage, and found that none of his extracts had much effect. Reflecting that he had been rather too keen to tackle the chemistry of the problem, he got down to some trials with storage of cooked meat and found that the crushed leaves imparted a nice flavour but didn't have any effect on shelf-life. A lesson learned, no doubt, but the field-work must have been rewarding.

Trace metal analysis was the other major theme of the conference, with contributions from instrument suppliers, analytical companies, the two universities and the mining industry. In one case a mining company had surveyed three analytical groups to see whether different laboratories could come up with the same results. It gave me some pleasure to see that some people from our own university had shown up very well.

Many of PNG's gold and copper mines are in the highlands where annual rainfalls can reach 9000mm. "It's pretty steady", say the people from Porgera, "and we never record more than 100mm a day". Their government is taking a lot of interest in sediments and heavy metals, especially in the Fly/Strickland River system, so baseline studies are much in demand. Presentations in this section of the meeting were mostly accompanied by photographs, including some spectacular ones of last year's landslip near the OK Tedi mine. While these two themes dominated the conference, there were a few papers on such things as chemical education, chemiluminescence of blood plasma, and tricarbonyl chromium compounds.

The presenters at the congress reflected the changes taking place as PNG national slowly take over the professional life of their country. Expatriates now work on (renewable) three-year contracts, and a condition of employment is that nationals be trained to take over these jobs at the earliest possible stage. In chemistry, the number of B.Sc. graduates is small, with many of the best science students studying medicine after their foundation year. With a population of 4 million, PNG has about 800 students taking year 12 at its four National High Schools (year 11 & 12 only) and another 50 in international schools; about 500 are Science majors, and 250 proceed to higher education. The University of Papua New Guinea in Port Moresby gets about 100 of these, the others studying at the PNG University of Technology in Lae, and together these institutions produce 10-20 chemistry majors a year.

Local graduates are in demand in industry, with mining and analytical companies providing attractive alternatives to graduate school. For the few who stay on there are M.Sc. and PhD. programs but not many scholarships, although there are teaching fellowships which help to keep body and soul together until they can be enrolled in overseas doctoral programs, commonly Australian and British. While this practice stunts the growth of PNG graduate schools, it provides valuable breadth for the students who study outside their own country.

Natural product chemistry is a "natural" for a developing country, and I was one of many Australian organic chemists to cut their research teeth on bags or twigs of leaves which were thought to contain interesting substances. There is however a more public use of PNG native plants and it is one the government would like to see disappear - the chewing of buai (betel nut). Formerly a social drug consumed under well-understood social restrictions in the old lowland society, its use has spread to the highlands and also jumped socially-erected boundaries. The nut, from a slender palm tree, Areca catechu, contains various phenolics and the alkaloid arecoline (a reduced nicotinic acid derivative) in the form of its salts. While some people chew betel alone or with a spicy herbal accompaniment, most users in Port Moresby mix it with lime which frees the alkaloid and ensures more rapid absorption. It also produces a brilliant vermillion red colour which decorates the city as chewers unload their mouthfuls of spent betel. Government publicity concerning the prevalence of mouth cancer in betel chewers seems to have no effect, especially on those who value buai as a tonic. Sale of buai is still permitted (about 25c each nut) and it's quite common to see up to one hundred nuts set out on a cloth on the sidewalk and attended by a patient retailer.

Quarantine regulations prevented me bringing some buai home, but we probably have enough "tonics" in Australian society without importing more.

Kind regards

Ian D. Rae

MISSING PERSONS

Nearly 50 years ago, about 30 N.Z. chemists went to Australia to make explosives. Prof. Ian Rae of Monash University (our occasional Australian Correspondent) is researching the history of this episode, with the assistance in New Zealand of Lester Stoyner.

Some 20 have been identified, spoken to or written to, but a number who we believe were part of this was effort remain untraced. If any reader can supply an address or information about them, please write to Lester Stoyner (164A Beach Road, Auckland 1310) or the Editor.

The name of the "missing" are:

N.O. BATHURST - May have been in Palmerston North

Noel BYTHELL - Said to have entered the church and gone to South Africa

William CHAPPELL - May have stayed in Australia

Ron CONVENTRY

S.C. DENTHAM

Alex LEES

H.B. OAKLEY - May have come from the UK

J.D. RAESIDE - Possible in British Colombia

John F. MARTIN - could be in Australia or USA. worked in Pyrotechnics, Adelaide.

SAXTON - May not have been a chemist, but was in an administrative position.

ANALYTICAL CHEMISTRY COURSES AT ATI

The Department of Applied Science is again offering the Royal Society of Chemistry's Certificate course in Analytical Chemistry in 1991. This part-time course is available to NZCS or BSc graduates interested in extending and updating their analytical chemistry skills. Chemists without formal qualifications but with experience in analytical chemistry are also invited to apply.

The course runs for four twelve week terms, Thursday 2.30pm - 8.30pm for three terms and Thursday 4.30pm - 8.30pm for the fourth term. Topics fall into two main areas, Advanced Analytical Techniques and Applied Analytical Methods, the latter involving visits to industrial laboratories. In addition, a project is performed, normally at the student's place of work.

The course is moderated by, and the certificate issued by the Royal Society of Chemistry in the UK.

In late 1991, ATI also hopes to introduce distance learning routes to. UK qualifications (both RSC Certificate and BTEC) using the British Analytical Chemistry by Open Learning texts which would be suitable for students outside the Auckland area. As a preliminary step we would be pleased to receive requests for additional information from interested chemists.

For further information concerning the above analytical chemistry courses, pleast contact:

Dr A. C. Herd, Department of Applied Science, Auckland Institued of Technology, Private Bag, Auckland. Phone (09) 778-573 Fax (09) 371-588.

NZIC WELLINGTON BRANCH NEWS

LAND RESOURCES DIVISION DSIR

Dr Cyril Childs has returned from Ehime University, Matsuyama where he spent ten months under the Japan Society for the Promotion of Science programme studying ferrihydrate in soils. Dr Benny Thing is to visit the Japanese National Institute of Environmental Studies at Sukuba in January under the auspices of the Japan/NZ Scientific and Technical agreement.

VUW

Dr Sarah Russell has left the Department for postdoctoral work at the University of Laramie.

Professor Leiv K Wyndes (University of Troms), Vice-President of the Norwegian Chemical Society recently visited the Department and DSIR Chemistry and spoke on his work with small ring organics.

ENVIRONMENTAL AWARENESS - THE INDUSTRIAL CHALLENGE OF THE 1990'S

Clare Feeney is a Water Quality Scientist with the Auckland Regional Council's Water Board.

She has held that position for nearly 10 years, for most of that time being involved with processing water right applications to discharge wastes, particularly to ground disposal systems.

In recent months, Clare has moved into the area of Public Education, as part of the Water Board's programme of involving the population of the Auckland region in the management of their natural environment.

Industrial pollution is preventable - and it doesn't have to be a huge expense to the company according to Auckland Regional Water Board.

A department of the Auckland Regional Council, the Water Board has the responsibility for, among other things, the monitoring, maintenance and , where necessary, the enhancement of water quality in stream, underground and coastal waters. The Auckland Region has a land area of 5,000km^2 extending roughly from Pukekohe to Te Hana, north of Wellsford, and out to Great Barrier in the East. The total area is 16,000 km^2 when the sea areas are included.

Industry is just one of the many different activities contributing to pollution problems in Auckland's urban streams and harbours. But like all the other activities, for example farming, urban subdivision, residential, recreation and so on, the Water Board is asking industry to clean up its act.

Four areas of attention will reward those industries with serious intentions of cutting down water pollution from their site:-

- work practices and attitudes.
- spill control
- site design and drainage
- waste minimisation

Industrial chemists can usefully be involved in improving all of these.

Attitudes and Practices

Untidy yards, misuse of stormwater systems and being caught unprepared for a spill of raw material product or wasted are the most common reasons why industries cause pollution.

Outdoor working areas are typically messy - they are often covered in materials spilled from decanting, loading or unloading, overflowing waste storage vessels, leaking containers, dripping taps or spigots, or washdown of drums or machinery. When it rains, the runoff carries these contaminants through the stormwater grate and out to the nearest stream or beach. Bad housekeeping practices such as these result from lack of awareness - and cause unintentional pollution.

Many people - including those working in industry - don't know that under most city streets run two sets of drains - sanitary sewers and stormwater pipes. Water Board staff frequently find that when they point out to someone that hosing a spill of material down the stormwater grate in the yard has just turned a stream bright red, for example, the usual response is one of genuine amazement.

Stormwater pipes are only meant to discharge rainwater off outdoor surfaces (like roofs, roads and yards) into streams and harbours. There is not treatment for any wastes that get into the stormwater system. Changing attitudes and behaviour by increased awareness can make a significant difference in polluted areas.

If industrial staff keep as clean as possible all surfaces that rain lands on, to ensure that only uncontaminated rainfall is discharged through stormwater systems, they can significantly reduce the chronic water pollution caused by continual, low lever contamination of stormwater in industrial areas. This involves no capital outlay by the firm, the only costs being staff time.

Spills

Spill control for pollution also requires informed attitudes. Accidents will always happen, even on the best managed and designed sites, so spill contingency planning is a must.

Even on small sites, industrial staff need the training and equipment to contain the spill and block access to stormwater grates. The spilled material can then be collected for reuse of safe disposal, without harming the environment.

Some spills may need to be neutralised. The industrial chemist or chemical engineer must ensure that staff are adequately trained to do this themselves, or know who to contact to supervise them.

Surprisingly, food products can be a serious water quality hazard. Site personnel trained in chemistry or engineering are aware of the occupational health hazards of chemicals - but they often don't realise the biological damage that can result from food products being spilled into streams or harbours.

Biodegradability is one reason why these apparently innocuous products cause environmental damage. The oxygen demand of whole milk is 100,000 g/m^3 - 3-4000 times greater than that of raw sewage. Whey, milk's industrial byproduct, from butter manufacture, still has a Biochemical Oxygen Demand (BOD) of around 40,000 g/m^3. Many of Auckland's streams and estuarine headwaters may contain only 5-10 grams of oxygen per cubic metre, with very small flows and little tidal flushing. It is easy to see how a spill of even a small quantity of food product can suffocate aquatic life, and in fact food spills have caused Auckland's biggest fish kills.

So, just because it is biodegradable, a spill still can't be hosed down a stormwater grate. This should only be done for substances which pose a serious and immediate threat to human health.

Any material spilled in an industrial yard must by contained and removed - and, importantly site managers must find out how and why it occurred, to prevent similar accidents in the future.

Site Design and Drainage

Structural alterations may be necessary to reduce pollution from some sites, incurring some expenditure for measurements such as roofing, bunding or drainage alterations.

Roofing of work areas which cannot reasonably be kept clean and bunding of key storage areas both cut down the movement of contaminants into stormwater pipes.

Similarly, all contaminated flows (e.g. from internal floor drains, process activities or sanitary fixtures) must by connected to the sanitary sewer, with any necessary Trade Wastes approvals from the relevant drainage authority.

Steps such as these often enable relatively inexpensive retrofits or site upgrading for smaller operations, particularly in older premises or in new spec-built premises not especially designed for the operation. Bigger, newer operations tend to be better designed from the start because of more effective planning controls now in place.

Waste Minimisation

The greatest challenge for the industrial chemist or chemical engineer, is, however, to cut down the wastage throughout the industrial process.

Spills represent wastage, of sometimes very expensive product - but industrial wastes can represent unnecessary wastage, too.

Good product, raw material and waste disposal charges all cost money. Minimising industrial waste streams can save money - and benefit the environment too.

The Water Board's pollution abatement inspectors are increasingly encouraging industries to examine their entire process, by asking themselves:

- does my process really need to generate waste?
- can I re-use my wastes?
- can I recover usable product from my wastes?
- would a change in process cut down my waste steam?
- would alternative materials make my waste less harmful?
- does anybody else want to use my wastes?

Reuse on site is possible for wastes such as washdown water, electroplating fluids, timber treatment compounds or solvents. The Water Board suggested this to a firm which was discharging contaminated wastewater into underground water which flowed directly into the Manukau Harbour. The firm came up with a system to return the wastewater into their process. The payback period was only 18 months, after which the company expects to save thousands of dollars in the long term - dollars which formerly went down the drain and had to be spent buying new chemical raw materials.

Recovery of expensive product from waste streams can be possible where the total waste flow cannot easily be reused. Separation can be worthwhile for some expensive materials, rather than paying for both waste disposal charges and new product.

Reduced waste volumes can be achieved by cutting down water usage throughout all industrial processes. If this makes the waste too concentrated for safe or economic disposal into the sanitary sewer, this may make it easier to recover useful constituents from it. Lower waste volumes also make it easier to handle waste storage or peak flow problems.

Recycling is available for some wastes that cannot be reused on site. Glass, paper, oil, aluminium, tin cans and some plastics can all be recycled. The ARC has a Recycle Hotline (09) 366-2070 to inform people of their nearest recycling station.

Rethinking the process may reveal that there are other practices or products that could be used to either cut down the waste stream of make it less harmful. A simple substitution of materials could do the trick. If they are more expensive, the costs saved in waste charges may compensate for the expenses.

Pollution Prevention Pays

Pollution prevention can save firms money otherwise lost in product loss, downtime for injury or clean up and waste disposal charges. It can save further costs incurred when Water Board staff need to revisit problem sites. The Water Board charges to recover costs of staff time, travel and analytical costs. In the event of a prosecution for water pollution, further costs are incurred by legal and court costs and fines from pollution convictions. The costs of being publicly identified as a polluter are harder to measure - but can be significant.

On the positive side, financial benefits from pollution prevention may even outweigh costs saved by avoiding expenses. Many major international firms now consider there are significant financial gains to be made from pollution prevention - including improved health, safety and staff morale, and corporate image. The PR benefits of environmental friendliness give firms a competitive edge in today's marketplace.

Education

The key to improved environmental awareness is education, to encourage industries to discover for themselves the benefits of being proactive in meeting consumer demands and regulatory requirements for environmental protection. This has supported the Water Board's increasingly proactive role in pollution prevention as part of the drive for sustainable environmental management.

To meet industry's information needs, the Water Board is in the process of putting together a folder about industrial pollution prevention. Topics covered include waste minimisation, spill control, good housekeeping and site design to reduce the environmental impact of small and large industries.

Copies of the folder will be available in early 1991, and can be obtained be phoning Clare Feeney at the Water Board on (09) 366-2135 or writing to the Water Board, Auckland Regional Council, Private Bag, Auckland.

The folder will also publicise the Water Board's Pollution Hotline (phone (09) 773-107), a 24-hour emergency response service for water pollution events. Industries which have a spill can phone the Water Board for advice about preventing or remedying water pollution.

The Challenge

Innovative and creative thinking by industrial chemists and engineers is called for to enable industry to meet the demands of the green consumer - and the more powerful and consistent green electorate - for sustainable impacts on the planet's resources.

The new environmental awareness has major potential for industry to discover new cost efficiencies. The environmental benefits will be welcomed by the Water Board and industry alike.

For further information please contact Clare Feeney, Water Quality Scientist, on (09) 366-2135.

THE FUNDING OF R & D AN AUSTRALIAN MODEL

J.R. May

Chief Executive Officer, Australian Mineral Industries Research Association Limited

The R & D Scene

Never before in the history of Australia has research and development enjoyed such a high public profile. Never a day goes by without there being an article in the press on some aspect of R & D. We have well watched TV programmes like 'Beyond 2000' and 'Quantum', one on a commercial channel and one on ABC, that have lifted the public profile of science immeasurably.

Some years ago the Prime Minister set up a Science and Technology Council to provide him with direct advice on science and technology matters. We now have a Chief Scientist who also reports to the Prime Minister on science matters. All this would have been unheard of in Australia 10 years ago.

What is behind all this activity? Why is science, technology and research now seen as so important? I think there are two factors.

a) Publicly funded R & D in Universities and Government Laboratories has become a significant expenditure item. As our economy has tightened so has expenditure been more closely scrutinised. We are being called to account for our spending!

b) Research is seen as a tool of Government economic planning. If we can increase our R & D spending and make it more focused and effective this will improve our economic performance or so the argument goes.

This changed view of R & D is not peculiar to Australia. As far as I can tell it pervades the views of Governments in most Western economies. It is not totally disconnected from similar changes to funding of education in our tertiary institutions but this is not an area I propose to explore tonight.

However, if we look at R & D in our Universities it is enlightening to see what has been happening over the past 30 years or so. Professor Don Aitken, Chairman of the Australian Research Council, has analysed this in a fascinating lecture given at Leeds Polytechnic earlier this year.

He points out that prior to the 1950s Universities in U.K. and Australia were not heavily involved in research. The first PhD graduated from an Australian University in 1950. I was about to enter University at that time! Most research was done in industry or Government research laboratories up until then.

Following the second world war national governments began funnelling substantial public funds into expanding our University sector. In Australia this has seen a ten fold increase in students and institutions.

At the same time, following initiatives in the U.S.A. which led to the setting up of the National Science Foundation, there was a strong push to involved Universities in fundamental scientific research. By 1985 all academic staff in Universities in Australia were said to doing research and were contractually obliged to do so. Funding from Government assumed staff would be involved in both teaching and research.

This growth came to an abrupt halt in Australia in the late 1970's. Deficit budgets, demographic changes and a slowing of the uptake of PhDs into the workplace has brought about a rethink by governments of its funding approach.

This new phase is a period of conflict and substantial change to research funding mechanisms. It is characterised by heavy Government intervention in determining both research priorities and who should get the available funds. It is not clear yet where it will lead but again this change is not peculiar to Australia.

As far as the role of research in economic policy is concerned, we have seen all sorts of Government initiatives - grant schemes, tax incentives, funding of key centres, etc. etc. to try and increase the amount of R & D especially within industry. The assumption seems to have been that if we can only get our R & D right it will lead to a marked improvement in our economy.

It seems to me much of the tinkering in this area is both shallow and simplistic in its understanding of the complex process we know as innovation. I do not intend to develop this theme tonight but I will come back to it from time to time.

So research and research funding is a high profile topic in our country at present. And I expect it is in most Western countries.

R & D STATISTICS

What do the statistics tell us about R & D spending?

Generally R & D spending is quoted as a percentage of a country's GDP. Great store is placed on these numbers and the OECD makes widely publicised comparisons between countries. Australia does not sit well in these comparisons. It spends about 1.2% GDP on R & D compared with the U.S.A. which spends 2.5%. Our policy makers are deeply concerned about this and have used the statistics to justify all sorts of policy initiatives.

But let us for a moment look behind these statistics. In the U.S. something like 0.7% of GDP is spent on defence research leaving only 1.8% of GDP being spent on civil R & D. Australia has relatively little defence research. Its economy is based heavily on its rural and mining sectors. These industries require a different profile of R & D to remain competitive to industries producing computers and pharmaceuticals. So when making comparisons it is important to understand the different profiles of the economies of the countries being compared.

But let us take this a step further. Research in an industry like pharmaceuticals is vital. It is its lifeblood to ensure its future. Without a continuing stream of new products emanating from its R & D a pharmaceutical company has a limited life.

If we add the exploration expenditure in Australia to our R & D expenditure we come up with a figure of about 1.6% of GDP. This is not all that different to civil R & D spending in U.S.A.!

Now I am not using this argument to say that all is well with research in Australia. Far from it! But I want to point out how dangerous simplistic comparisons of R & D spending can be. What a hazardous basis for formulating science policy!

CONCEPTS OF INPUTS AND OUTCOMES

I think there is an even greater problem to confront than uncertainties in statistical comparisons about R & D spending. We have to ask the question why do research in the first place? As Professor Aitken and others have pointed out, Australia has inherited a culture that equates research to pursuit of knowledge. In other words, research is an end in itself. It deserves public funding for its own sake.

I acknowledge that the continuation of effectiveness of this curiosity motivated process is of crucial concern to the future of our society. However, when dealing with research in the context of an industry such as mine or when Governments want to use research as a tool of economic policy, it is an insufficient definition of research or justification for it. Research must be linked to an end and this, for my industry, must be to bring about technological change to improve the competitive position of the industry.

Therefore in assessing R & D spending we must be concerned about outcomes. Measuring outcomes of research is much more difficult than measuring inputs. And yet most of the focus of the R & D funding debate is on imputs. Policies have been developed largely with a goal to increasing inputs not to improving outcomes.

How do we improve outcomes of our research?

My experience tells me this is very difficult. It really is the problem on which the R & D funding and management debate sould be focused. Over the next few minutes I will give you a brief overview of how AMIRA functions so you might have a glimpse of some of the issues involved in improving outcomes and how we have been addressing them in the mineral industry in Australia.

THE AMIRA MODEL

AMIRA was set up by the Australian mineral industry in 1959. There are three key elements to its concept.

a) We have no R & D facilities of our own. All work is contracted out. AMIRA has been able to focus on its special role leaving the management of the R & D infrastructure to others.

b) Each project is separately funded by a group of sponsoring companies who choose to put their money into the project. This forces the companies to accept responsibility for priority setting rather than leaving it to AMIRA. It also brings a level of commitment from the participating companies that aids the technology transfer process.

c) The running of AMIRA is funded by an administration charge on each project. This forces AMIRA to be totally client or market driven in its approach.

AMIRA plays a bridging role between its members or clients and the R & D contractors. It has two functions. The first is to develop new projects. This is a brokerage role which determines what R & D gets done. The second is to manage the funded projects to ensure delivery of appropriate outcomes that sponsoring companies can use. This determines how the R & D is done. This concept is shown in figure 1.

To give you a brief overview of our current business let me share with you some statistics.

a) Membership - 139

b) Council of 15 elected from these members establishes policy

c) Staffing - 8 research co-ordinators who set up and manage the portfolios of projects
   1 Company Secretary who manages financial aspects of the business
   10 Support staff

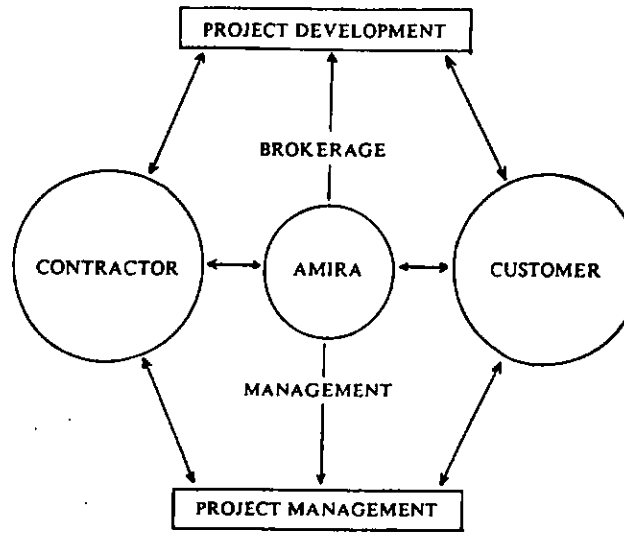


FIGURE 1
Diagram showing the role of AMIRA as a broker and manager. AMIRA is the bridge between the research community and the industry.

The AMIRA Model

d) Size of business
   * Currenty we have 89 projects valued at $28 million
   * Spent $9 million with our contractors last year
   * Will put nearly $13 million worth of new contracts in place in 1990/91 It will cost just over $2 million to run the business 1990/91
   * 10% of this will come from subscriptions
   * 50% of this will come from administration charges on projects
   * 40% of this will come from interest earned on money flowing through the Association

The crux of the business is the way we seek to develop new projects. Figure 2 shows the model we have developed to do this.

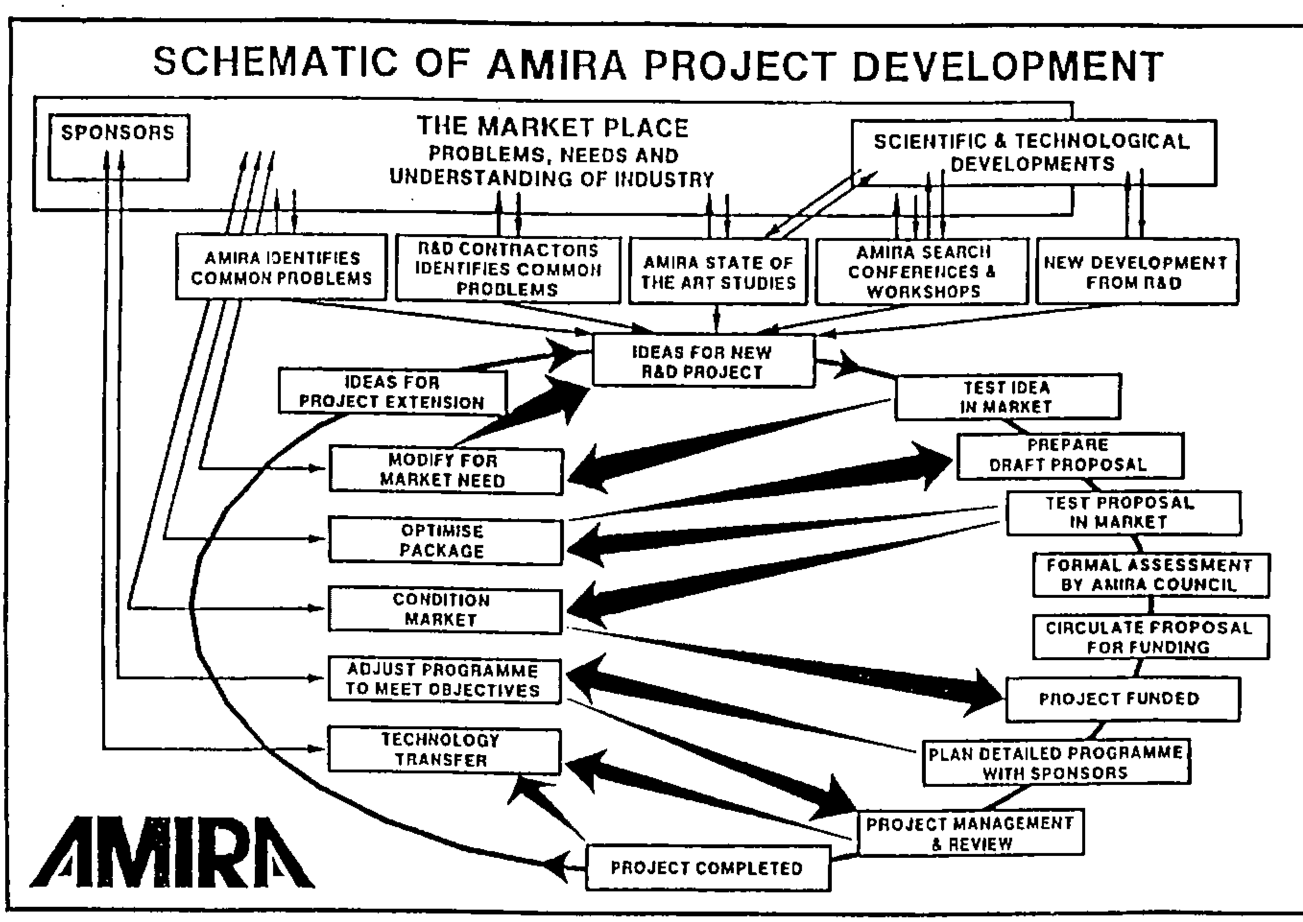


FIGURE 2

The ideas for new proposals come from a number of processes both formal and informal. An idea that will lead to a successfully funded new project must contain two elements:

* the scientific problem or issue that must be addressed
* the problem that the industry wants resolved to improve its performances

The two elements must be clearly defined and appropriately linked before a worthwhile research proposal can be prepared.

In the model the ideas are taken through an iterative process with the market place to develop a packaged proposal that will get funding support. This process is based on a clear understanding of what is required to ensure technological change in a company which can then lead to improved performance.

If the project development phase is successful and generates funding support the projects are then managed by a careful process of reporting and review to ensure appropriate outcomes for the sponsoring companies.

This is a complicated and sophisticated process which takes much time and effort. It is designed to maximise the chances of identifying projects which will be supported. This, in turn, increases the likelihood of getting outcomes from the R & D that can and will be used by sponsors.

See how fundamentally different this process is from that which follows from levy based systems of funding. With a levy system you can never be sure you have your priorities right for the industry. Furthermore, because the decision making process about priorities is removed from operating personnel, there is limited commitment to the resulting research. Ensuring companies use the outcomes is very difficult.

If the purpose of a research funding scheme is to increase R & D spending, then a levy is most effective. However, if the purpose is to improve an industry's competitiveness or a country's economic performance, a levy is an inappropriate funding approach.

Note how the objectives of R & D policy determine the choice of funding mechanism.

THE FUTURE

Let me close by making a few remarks about the future. I am sure the research funding debate in Australia will continue a pace for some time to come. It has the potential to be very divisive. In fact, some policy decisions could see the dismantling of part of our R & D infrastructure as we know it.

Much of the tension stems from concern about the balance between fundamental, curiosity motivated research and targeted research driven by economic need. The balance is changing and probably needs to change even more. Yet there needs to be a balance.

Furthermore, not all researchers are equally creative. How do we pick those who have the potential for making real paradigm shifts. Who should pick these people for special funding? As our education system in Australia is currently functioning, some people are expressing concern as to whether we will produce enough of these creative people to service our future R & D needs. With funds for education unlikely to increase significantly in the near future, how are we going to ensure an adequate flow of skilled people into our science and technology R & D infrastructure?

All these questions remain unanswered but are at the very centre of the debate over R & D funding. In addition there remains for me several other unanswered questions. These relate to management. Do we have managers of our R & D infrastructure who have the skills to guide us through this time of massive change? Are we devoting enough effort to developing and training them? We are beginning to focus on this issue in Australia but it may be question of too little too late.

Another unanswered question relates to management within our companies. Is it really aware of the strategic importance of technology to its business? Does it have its time frames set appropriately? Is it creating appropriate environments to encourage technological development and change?

Overall I feel optimistic. I do see encouraging signs of change. I hope they continue to grow because we desperately need to develop a culture that encourages science and technology as an avenue to strategic business success.

As far as my own organisation is concerned, it has been undergoing a period of sustained growth. This seems set to continue. The principles on which AMIRA is based are seen as fundamentally important to improving the effectiveness of R & D. They are being copied in Australia by other industry groups such as the Information Industry. In the minerals area they have been copied in U.K. and now are being copied in Canada. This clearly demonstrates the realisation that we need to be much more concerned about outcomes in our R & D. Funding of R & D is not simply about how to get more dollars into R & D. It is a much more complex issue than that and I hope here I have been able to stimulate you to think more broadly across a subject that is likely to continue to be of critical importance for both our countries.

NZIC 1991 CONFERENCE

The 60th Anniversary Conference of the New Zealand Institute of Chemistry and the New Zealand Biochemical Society will be held at the University of Canterbury from Monday, 26 August 1991 to Wednesday, 28 August, 1991.

Plenary Speakers who accepted invitations to date are: Professor Kim Janda (Scripps Institute, La Jolla), Professor Frank P. Larkins (University of Melbourne), Professor Clark Still (Columbia University), and Professor Bob Ramage (University of Edinburgh).

The conference will follow a format of sumposia to focus attention on various aspects of chemistry and biochemistry. Symposia themes will include:

History of the N.Z.I.C.	Denis J. Hogan
Education	A. Geogg Groves, Ellesmere College, andDavid E. Lewthwaite, Christchurch Polytechnic
Spectroscopy	Leon F. Phillips, University of Canterbury
Biochemistry	Maurice Barnes, Lincoln University
Biochemical Toxicology	Christine C. Winterbourn, ChCh HospitalDiagnostic and Forensic
Biochemistry	Ross Boswell, Christchurch Clinical School
Molecular Medicine	Steve Brennan, Christchurch Hospital
Modelling	James M. Coxon, University of Canterbury
Natural Products	Graeme B. Russell, Biotechnology Division, DSIR
Synthesis	Brian R. Davis, University of Auckland
Reaction Mechanisms	Michael P. Hartshorn, University of Canterbury
Industrial Chemistry	A. John McKinnon, W.R.O.N.Z.
Primary Produce Chemistry/ Chemistry of Food and Drink	Graeme M. Keeley, Canterbury Frozen Meat
Environmental/Analytical	Keith A. Hunter, University of Otago
Inorganic	Derek W. Smith, University of Waikato

There will also be opportunity for presentation of papers and posters not covered by the symposium topics. Accommodation will be available in University Halls and motels.

The Conference Executive is Jim Coxon (Chairperson), Robert Maclagan (Secretary) and Jan Gregor (Treasurer). Further information is available from the Conference secretary: Dr R.G.A.R. Maclagan, Department of Chemistry, University of Canterbury, Christchurch. (e-mail CHEM171@CANTERBURY.AC.NZ;FAX(64-3)348 3308).

Bridge Building at Waikato: Co-Operative Education in Chemistry

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Introduction

University funding and function continue to receive much scrutiny in these times of accountability and contestability [1,2,3,4]. There have been numerous calls from both educationalists and industrialists that university chemistry programmes should be made more relevant, should develop the professional skills needed to equip students better for the real world of work in science, and should bridge the gap between university department and employer. These sentiments, touched upon in the Parry Report [5] thirty years ago, have been echoed frequently in New Zealand [for example, [6,7,8,9,10,11] and overseas [for example, [12,13,14,15,16,17]. New Zealand chemistry departments have responded more than is sometimes realised. Changes have been introduced to give students the option of undertaking vocationally relevant courses as part of their degree programes. Courses in chemical technology, analytical chemistry, industrial and applied chemistry, polymer science, materials science, and science and management are now available. Industrially based project work, site visits, and industrial guest lecturers are features of applied chemistry courses. At Waikato, the co-operative B.Sc [Tecnology] degree in Chemistry introduced "to meet the needs of students who have an interest in an industrial/applied career in chemistry and the demands of employers for graduates with some work experience." [18], has been developed over the last decade to provide the sort of education in chemistry and training in technology and management that is now being widely advocated.

Co-operative education and experiential learning are terms little used in New Zealand's chemical education literature. They are likely to become more common during the 1990's. The idea of "learning on the job" is as old as technology itself. It was first used as a formalised university teaching tool in 1906 when Professor Herman Schneider of the University of Cincinnati designed an engineering programme around regular periods of paid employment in industry. Schneider's School of Engineering went on to become one of the world's most important centres for teaching and research in engineering. In North America and Europe, co-operative courses [or sandwich courses as they are sometimes referred to in the U.K.], are an integral part of higher education at levels ranging from post-primary through to post-graduate. For example, in the USA, approximately 1000 colleges and universities offer co-operative programes to 250,000 students who find placements with 50,000 employers and so earn on average US$7000 pa. towards the cost of their study programes [19].

The purpose of this paper is to describe the co-op programme at Waikato; how it addresses contemporary issues in chemical education, and how it has facilitated the formation of educational partnerships with local and national industries. We offer observations what may be useful to institutions contemplating establishing co-operative programmes, and potential employers of co-op students who may also have industrial reserch projects suitable for co-operative graduate thesis topics.

Co-operative Education

Co-operative education is a special type of university-industry linked study programme. It is a system of education that integrates on-campus learning with periods of off-campus work experience. The paid work experience components, organised with co-operating employers, are related to the student's academic area of study and are a integral part of the study programme. They complement academic study by allowing students to combine theoretical knowledge with practical experience.

The World Council and Assembly on Co-operative Education offers the following definition:

"Co-operative Education includes the following essential features:

a) It is a strategy of applied learning.

b) It involves a structured programme developed and supervised by an educational institution in collaboration with one or more employing organisations.

c) Relevant productive work is a integral part of the student's regular academic programme and an essential component of the final assessment.

d) The programme normally commences and terminates with an academic period.

e) The work experience components involves productive work and comprises a reasonable proportion of the total programme.

f) At whatever level programmes are offered, they maintain excellence."

Programmes for full time degree students who may be required to do occasional vacation work, or for full time employees who may take occasional course work as part of a certificate programme, lack the commitment to an employer-institution partnership and do not conform to this definition.

Co-operative education is well established overseas in universities and other tertiary institutions and is of growing popularity. The direct and indirect benefits to student, employer, institution, and community that account for this growth are now well recognised [19,20,21,22] and are summarised diagrammatically in Figure 1 below:

Figure 1: Advantages of Co-operative Education

For a small and developing department, introduction of a co-operative programme had potential for growth in student numbers at a time of static or declining science enrolments. By offering a programme that was vocationally oriented and unique to Waikato, the Department hoped to inspire more local students to pursue university studies in chemistry and to attract technologically oriented students from a wider area. Incorporation of an employment component at an early stage might go some way towards overcoming the financial constraints of students from socio-economic groups and geographic locations who has been previously represented poorly in university chemistry courses. Because highly specialised technological training could be incorporated into the periods of work experience, it was possible to provide an educational experience far beyond that which the Department could provide from its own resources.

Waikato's B.Sc.[Technology]: "the degree that works!"

The principal features of Waikato's co-operative B.Sc.[Technology] degree which has evolved are summarised below:

B.Sc[Technology] in Chemistry
* Four year degree incorporating academic content of B.Sc.
* Vocational Experience as an integral part of the degree 12 months course related employment sessions to develop professional skills
* Directed academic studies including: Chemistry major Analytical, Applied and Industrial Chemistry Management Studies and/or Economics

(1) Vocational Experience and Professional Skills: "learning by doing!"An essential aspect of the B.Sc[Technology] degree is that a total of 12-months of vocationally relevant work experience is integrated into a programme of formal university instruction. The pattern of integration for the work experience component has varied to maximise employment opportunities. Initially it consisted of two 6-month periods spanning term time of the third year and the summer vacations of the second and third years. More recently we have used the vacation at the end of the second year as a 3-month period and the vacation at the end of the third year and the first semester of the fourth year as a 9-month period. This pattern allows full advantage to be taken of the well established pattern of student vacation employment and, furthermore, the student is able to complete a chemistry major before undertaking the major work experience period.

Each student in an industrial placement has both an industrial and an academic supervisor. Day to day supervsion is the responsibility of the industrial supervisor. The departmental supervisor's role is to ensure that liaison is maintained and that any personal or academic problems are dealt with. The departmental supervisor may also make departmental resources available, or act as a consultant to the student's project if called upon. While the student is in employment a laboratory diary must be kept and at the end of the employment period, the writing of a formal report on the experience gained is required. Of course if any of the student's work has been of a confidential nature, this can be protected.

One of the intended objectives of the work experience component is to allow the student to develop personal and communication skills by having to work and get along with practising professionals and other members of the industrial work force. In addition we expect students to become proficient at technical writing through maintaining the laboratory diary and writing their work experience formal reports. These reports, particularly for the 9-month placement periods can be significant documents. Students are encouraged to identify areas where processes could be improved or where new techniques could be employed. Often ideas for subsequent project work or even thesis topics are developed during the period of work experience. The major part of the report is usually based on project work completed but it can also be concerned with a topic related to the placement that is mutually acceptable to the student and the academic and industrial supervisors. Assessment of student performance is based upon the quality of the laboratory diary, the formal report, site visit reports (coordinated by university staff) and the industrial supervisor's assessment of performance as determined by a standardised questionnaire.

Because employers have stressed the importance of professional skills[9], we no longer leave these to be acquired in a totally ad hoc manner during employment. A formal assessable component, covering topics such as report writing, committee work, oral communication, health and safety, computer familiarity, information retrieval, team-work, presentation of data and problem solving, is introduced into the industry courses. Vocational experience, professional skills, and the Management component together constitute a minimum of 7 of the 28 courses of the degree.

Placing students has been the most difficult part of running the B.Sc[Technology] programme. Unlike countries in which programmes like B.Sc[Technology] are well established, New Zealand has little tradition of co-operative education. The numbers of chemists employed in chemically based industries, are generally small. Much of the chemical research and development is done overseas. The New Zealand economy has been in recession for the last decade and has recently undergone extensive restructuring producing widespread redundancies and an employment environment where staff recruitment is often a minor concern. While the industrial establishment is sympathetic to the general aims of co-operative education we have found that it does not have the resources to make the long-term employment commitments necessary for the efficient organisation of student placements. It might also be noted that successive governments, while claiming to be supportive of initiatives designed to make education more relevant and cost effective, have not been prepared to offer any direct support and have withdrawn from the university students the sort of employment - training subsidies that are available to other sectors. In the USA and Canada, on the other hand, co-operative programmes receive significant government assistance, particularly in the form of start-up grants [20,23].

In spite of early difficulties, sufficient students joined the programme to ensure its survival and to warrant, by 1986, the appointment of an industrial Programme Director with responsibilities that included liason with industry and seeking suitable placements for students. Aspects of the organisation of the programme were centralised by the formation of a Coordinating Committee and standard practises were adopted by all the subjects offering the programme. Out of necessity, and also because we think it beneficial, the student has been involved in taking a more active role in the securement of the placement. Working with each Departmental Coordinator, the Programme Director identifies sympathetic employers. The student is required to prepare a curriculum vitae and apply to the employer for an interview. Tight control is kept over the process to ensure that, while employers can be offered a choice, they do not get overwhelmed with students seeking the same position. Because the Department's credibility is at stake, only students who are successful in their course work are considered for industrial placements. We endeavour to match student interest with job opportunity and where possible direct students to positions that are available in their home districts. This minimises accommodation difficulties and allows companies to support students in their own communities. In 1989 a total of 26 chemistry students were placed by this method at locations ranging from Whangarei to Gisborne. Over the School of Science and Technology, 74 students were placed throughout New Zealand.

(2) Academic Programme: Directed Studies

Another essential aspect of the B.Sc[Technology] is that the academic component of the degree satisfies all the requirements of a conventional B.Sc. Thus graduates from the programme can proceed to higher degrees if they wish. The majority of the the course work is specified upon entry to the programme and includes required courses in Analytical Chemistry, Management or Economics, and Industrial and Applied Chemistry, as well as the courses required to complete the Chemistry major. The Management/Economics component provides a base upon which to develop the further skills that are needed for positions of managerial responsibility in science-based industry.

An important development in the Department's teaching programme has been the introduction of courses in Industrial and Applied Chemistry. Designed to complement the industrial component of B.Sc[Technology], these courses are also popular amongst other undergraduates. For example, at the second year co-op students are required to take an introductory course in Industrial and Applied Chemistry. It covers chemical raw materials and their conversion to useful products [with special emphasis being placed on New Zealand's processing industries]. There is an introduction to simple ideas of process technology including unit operations, mass and heat balance, idealised reactors, industrial safety, and a consideration of industrial effluents, their treatment, and environmental effects. Part of the philosophy of the course is that not only should the content be relevant but the teaching method should help develop the personal and professional skills needed in industry. Thus activities such as group work to prepare a position paper or solve an assigned problem, individually researched case studies on some aspect of chemical technology relevant to New

Zealand, brief oral presentations to the class, and field trips to industrial sites are included. The field trips are a highlight of the course, impressing upon students the range, scale and scope of chemical technology and the chemical processing industries in New Zealand before they enter their first period of work experience.

Bridging the University-Industry Gap and Other Barriers

Measurement of the success or otherwise of an educational programme is usually not a simple undertaking. From a purely numerical point of view, the B.Sc[Technology] can be judged a modest success, particularly in view of the rapid growth of recent years [see Figure 2]. Approximately one fifth of all chemistry students at Waikato are enrolled in the co-op programme. It is disappointing to note that while the programme has been successful in attracting first generation university students from throughout New Zealand and even from overseas it has not yet had an effect on Maori enrolments. The programme has however attracted a significant percentage of women students.

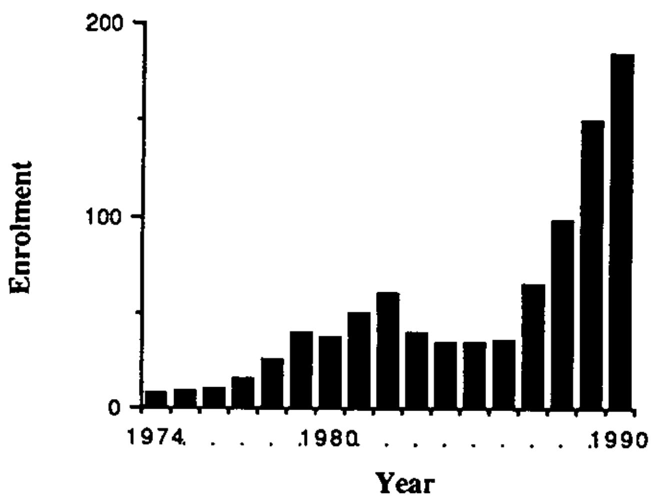

Figure 2: B.Sc.(Technology) Enrolments

Anecdotal evidence from students and employers is sufficient to indicate that programme goals are being met, eg..:

Employers comment: *"I firmly believe that practical industrial experience is an invaluable part of the B.Sc[Technology] course. It provides the student with an early insight into how science and technology are applied to industry. This makes the transition from university to the work-place that much easier."*[24]

Student's comment: *"The Industrial Placement experience helped me develop much needed communication skills, good co-worker relationships and work habits that I would not have learnt in a university environment. It showed me the role that science and technology played in the industry. It also helped me to determine what my real interest and career selection should be. I enjoyed my placement and learnt more than I ever expected to do in three months"*[25]

Case histories of individual graduates indicate that the programe prepares students for career options that might not otherwise have been considered. Work experience placements have led to permanent employment and to date B.Sc[Technology] graduates have had no difficulty finding positions that utilised their skills, and ironically, as graduates, have been sought after by employers.

Personal finances are a increasing problem for students at the tertiary level. The co-op student has the benefit of earnings spread over the period of study and the guarantee of vacation employment. Taking into account bursary payments and assuming similar vacation earnings, a student who completes a B.Sc[Technology] would have total earnings no more than a few hundred dollars less than a student who graduated B.Sc. after three years and worked full time for the fourth year. By the end of the fifth year, and from then on, because of the higher salary commanded by a four-year degree with work experience [24], the B.Sc.[Technology] graduate's earnings could be expected to progressively exceed those of the B.Sc. graduate.

The liaison activities, supervision of Technology students during periods of industrial placement, and research projects that have been identified and developed during these placements, have done much to strengthen the relationships between the Department and local and national organisatons that employ chemists. Interest of students and employers in expanding work placement projects or problems into thesis topics has led to the establishment of a new post-gradaute degree, the M.Sc.[Technology][25]. Research contracts for post-graduate research have resulted. In addition staff consultancy work has increased to such an extent that it has been necessary to establish a Chemical Services Unit to Coordinate this activity and enable the Department to make its skills and facilities available in a professional manner.

Waikato's co-operative B.Sc[Technology] programme has done much to bridge the "gap" between university and industry.

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Co-operative Education at the Graduate level: M.Sc.[Technology] in Chemistry

There are numerous models available for successful co-operative education first degrees. One of these is the B.Sc[Technology] in Chemistry that has been discussed earlier in this journal [1]. Co-operative education at the graduate level is much less common. Waikato's experience has been that although B.Sc. [Technology] graduates are well educated and trained for employment and sought after by employers, more than half of our graduates have returned to study for higher degrees. By the mid 1980's it had become clear that to meet the educational aspirations of the returning co-op graduates in a way that recognised their unique undergraduate experience, and to provide a better means of developing co-operative research projects on industrial problems or opportunities, a new post-graduate degree was required. Ideally this would incorporate the following features:

(1) It would be sequential to B.Sc.[Technology] but B.Sc. graduates with suitable records and some work experience should not be excluded.

(2) The academic content of the new degree must be equivalent to that of a conventional honours degree and must allow a graduate to proceed to a doctorate.

(3) A mechanism must be provided for the adequate supervision and assessment of research topics that might be located off campus and be in areas outside the specific areas of expertise of academic staff members.

(4) There should be a component of advanced Technology and Management built upon the undergraduate work experience and management courses.

The New Degree

The structure of the six paper co-operative degree designed to meet these requirements is summarised below:

- three papers chosen from traditional chemistry honors level papers
- one paper in industrial Science and Management
- a thesis investigation of a real industrial or applied problem or topic, originating from industry or involving the industrial application of university-based research.

The special characteristics of the new degree derive from the selection of students with appropriate undergraduate and industrial experience, the special nature of the thesis topic and the inclusion of the Industrial Science and Management course. Each of these features is considered briefly below.

(1) Selection of Students

While it was envisaged that the majority of those enroling for the degree would be co-op students., it was recognised that appropriately qualified graduates, including those with technical qualifications, already employed in industry and wishing to gain a higher qualification that included work related research, could also be suitable candidates once the necessary prerequisites had been met. Appropriate degree regulations have been drawn up allowing for the possibility that much of the degree be taken by the distance learning mode.

(2) Industrial Science and Management

This course is designed to give students an overview of the application of scientific, management and technological skills, knowledge, and resources to industrial problem solving and management issues. It thus involves a considerably broader approach than subject-specific course material. However depth in the students subject area is provided for by a special individualised case study. The course is divided into two equal components: a lecture/seminar programme and a case study.

The lecture/seminar programme is offered with the support of guest lecturers from industry. It explicitly recognises the interdisciplinary nature of industrial science and focuses on issues of importance not usually mentioned in traditional honours programmes in science. For example, there are sessions on industrial quality assurance, patents and intellectual property, technology transfer, industrial relations, science communication, negotiation, and the role of research and development. Speakers provide resource material such as reading lists and/or important documentation before the session to allow students with quite different specialist backgrounds to participate equally. As in the undergraduate programme, considerable emphasis is placed on the development of interpersonal skills as part of the learning process. Interactive presentations with role-playing and experiential learning exercises have been found to be particularly effective at this level. Students are given the opportunity of demonstrating their mastery of the material through the writing of the two executive-type documents that are used for assessment purposes.

The case study component is intended to allow the student to develop the sort of analytical skills that are essential for the design of industrial research and development or technology transfer programmes. It usually involves an individually-designed investigation of an aspect of industrial or applied science relevant to the students thesis investigation. For example the case study could be in the form of a research proposal for the thesis topic, developed by the student collaboration with the University and Industry supervisors, and which would form the basis of the student's thesis research. Alternatively it could involve an in-depth investigation of the industrial implications of the student's thesis research which would include a proposal for the commercial application of the research results. In either case the student would be required to formulate an industrial problem in scientific terms, use the technical literature to seek solutions, decide what further research needs to be done and estimate the costs, resources and time required.

(3) Thesis Component

An important requirement of the M.Sc.[Technology] thesis project is that it is industrially based or designed with industrial inputs to met a perceived industrial need or opportunity. Industrial research is not new to university science departments. Industrial research is not new to university science departments. Industrial research contracts have become an increasingly important form of funding for doctoral research programmes. At the masters level, particularly if located off campus, such collaboration is less common.

This sort of research requires careful planning and formal structures are necessary to ensure that the predictable problems and constraints associated with student involvement in commercially driven research do not lead to misunderstandings and disillusionment if project goals are not achieved fully. Time scales and expectations of the university and the company are usually different and even defining the project goals can be time consuming. To a large extent we have overcome such difficulties by involving the Industrial Liaison Unit as soon as a likely project area has been identified. A project panel involving the university supervisor(s), industrial representatives and the student (plus outside experts if necessary) is set up and potential difficulties of the sort already mentioned and others such as confidetiality, owndership of intellectual information, publication rights, resource implications, budget, assessment, etc are discussed until all parties are satisfied and an exchange of letters can take place. This panel meets regularly during the two year programme to consider the student's progress reports and to monitor the direction of the project. While there is not necessarily a research contract, and the company is not formally asked to contribute funds to the University or the student (or vice-versa)!), the company is required to provide evidence of a commitment to the project. This may take the form of paid industrial experience for a B.Sc.[Technology] student for work related to the project, direct supervision and consultancy services, access to plant and materials, access to confidential information, and funding of those parts of the project that cannot be met by university resources (consultants' fees, special equipment, journals reference books, computer literature searches, and travel).

Summing Up

The M.Sc.[Technology] represents a logical extension to the graduate level of Waikato's undergraduate co-operative B.Sc.[Technology] programme. Its initial reception by both students and employers has been gratifyingly positive. After just three years, 23 students have enrolled in the programme across the School. There has been no shortage of suitable industrial research topics and industrial guest lecturers have been more than willing to offer presentations in support of the programme's Industrial Science and Management course. Taken together, the B.Sc.[Technology] and M.Sc.[Technology] programes provide a mechanism by which real research and problem solving opportunities can be identified and executed as part of the Department's teaching and research obligations. As a consequence, the Department has been well placed to take advantage of such initives as the Emerging Technologies Programe which is ideally suited to the funding of students engaged in technological research. With ominous signs everywhere that full government funding of unversity research belongs to an era that has passed, the bridges that have been built across the university-industry interface through co-operative education should lead to mutually beneficial teaching and research partnerships in the 1990's.

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[1] Langdon, A.G., and Kirk, C.M. Bridge building at Waikato : Co-operative Education comes of age, Chem. in N.Z., This issue.

BOOK REVIEWS

STUDIES OF HIGH TEMPERATURE SUPERCONDUCTORS VOLUME 4

Edited by Anant Narlikar, Nova Science Publishers, New York, PP 402, 1990

ISBN O-941743-57-8

Since the pioneering discovery of high temperature superconductors in 1976 by Bednorz and Muller there has been a proliferation of published papers, articles and books on this subject. The literature is massive and it is becoming difficult to keep abreast of this field. The present series "Studies of High Temperature Superconductors" is an attempt to bring to professional investigators up-to-date and in-depth accounts of major technical advances in this area. This is a review on Volume 4 in this series.

The book contains fourteen chapters and each is written by a different author(s); all being recognised authorities. Their expertise covers the discipline of condensed matter physics and chemistry, as well as engineering disciplines like ceramics. The articles presented cover a wide spectrum of unusual facets associated with the broad spectrum of studies in this area.

Even though the origin of high Tc has remained disputed, novel theories and mechanisms of superconductivity feature in the present series. In Chapter I, Lobbe presents arguments to support the BCS weak-coupling theory, while in Chapter 8, Schmeltzer further develops the RVB approach of Anderson, and in Chapter 12, Nakamura describes superconductivity by a new theory called the multi-valence resonance condensate.

The quest for new superconductors is taken up by Rao in Chapter 2 with the identification of two new series of superconductors.

Bismuth based cuprates are discussed by Takano (Chapter 3), Mujazawa et al. (Chapter (9) and Nakamura and Ogawa (Chapter 5). The latter authors discuss a fabrication procedure to obtain controlled numbers of Cu-O-layers. Phase diagram determinations and crystal growth of the 1,2,3 superconductors is given by Nevriva in Chapter 14.

The remainder of the chapters are technique oriented, e.g. high resolution polarized XPS by Marcelli (Chapter 13), Mossbauer spectroscopy by Boolchand and McDaniel (Chapter 7) and ion beam techniques by Keinonen et al. (Chapter 10)

The book contains 402 pages, with the chapters not grouped into any particular subject order. It is reasonably error free, and to facilitate speedy publication the camera-ready pattern has been followed. This volume (as well as earlier members in this series) is specifically designed for professional specialists and graduate students in physics, chemistry and material science, and this aim is achieved with volume 4. Others who want a more general introduction to this subject should look elsewhere.

E.W. Ainscough

CONDITIONERS, EMOLLIENTS and LUBRICANTS

Michael and Irene Ash. Edward Arnold, (a division of Hodder & Stoughton) 1990, Pp. 389. ISBN 07131 36 74 X.

Price Unknown. Available in N.Z. in 1991.

This book is No. 4 in a series "What Every Chemical Technologist Wants To Know..." but it does not inform users of conditioners, emollients or lubricants on the nature of these materials, how they work in formulations or react on the human body. It is a dictionary of the properties, brand names and suppliers of SOME raw materials chosen from the thousands that are available.

It appears to have been complied from manufacturer's bulletins, by converting their information to the format used in the book — viz. some 30 headings comprising Synonyms, Trade names, Form, Colour, S.G. etc and then getting a computer to write the book, with almost no editing. there are even entries under "Uses" which have no connection to cosmetics.

The poor editing shows, for example, under one entry for the "Form" of one material: "Liquid" "Oily Liquid" :Clear Oily Liquid" and "Clear Low Viscosity Oil". More space-wasting material appears under "Ionic Nature" for the well-known quaternary cetyl trimethyl amnonium chloride, where, after "Cationic" there are 19 brand names, all of which have already appeared in the "Trade Names" entry. There are also six more trade names — perhaps these brands are unique in not being cationic?

Many products give the density in lb./U.S. Gallon as well as specific gravity. Mineral oil is a classic, where 31 S.Gs. of oils from six suppliers are followed by 31 densities, most conforming roughly to 8.33 times the S.G.

The "Uses" paragraphs become suspect when isopropyl myristate, a widely-used emollient in creams and lotions, is listed as being used only in bath products. There are other equally poor entries.

Most laboratories will have a copy of the "Rubber Bible" - the C.R.C. Handbook of Chemistry and Physics, now costing nearly $200, and possibly the Merck Index, (about $150), and any serious cosmetic chemist of supply manager will have a copy of the C.T.F.A Cosmetic Ingredient Dictionary, even at a price greater than either of the others. The last-named, in its 610 A4 pages, has far more entries than the book under review, with structural formulas, suppliers' names, brands, and excellent cross-indexes. In a specific field, there is also extensive literature from most reputable suppliers, so for a cosmetic chemist in this country, the purchase of "Conditioners, Emollients and Lubricants" seems pointless. Others such as teachers, students or consultants would learn more from other sources.

C.L.H. Stonyer

CARBON DIOXIDE AS A WORLD "GREENHOUSE" GAS - A NEW APPROACH?

PART I

A.A. Evans,
Hazards Analysis Ltd., P.O. Box 29-037, Wellington

The above topic was approximately half the subject matter of a paper presented at the annual Institute of Chemistry Conference (Health and Environment Session), Wellington, New Zealand in August, 1990. The same concepts that were illustrated then are presented here but with more detail.

Introduction

Without exception, we are all contributors to the "Greenhouse" effect both directly and indirectly, hence the above topic should be one of general interest. In this paper it is assumed, without discussion, that the "Greenhouse" effect and the resultant climate change is both real and detrimental to the world's environment. Such a view is, for instance, supported by a paper by Schneider (1) but is, for instance, opposed in another paper by Schneider (2).

This topic should also be of general interest to chemists because currently it is a matter of public debate. It is more than this, it is a matter of New Zealand Govemmental policy - "The aim: 20% reduction of 1990 carbon dioxide emissions by 2005 as an interim objective of Government (3a)" In the policy there are further targets being considered - "The Secretary for the Environment, on behalf of the NZCCP, will report by 31 October 1991 on:- what actions could be undertaken to meet the following targets and what the implications of these would be:* Carbon Dioxide from human-related activities:

30% reduction in emissions by year 2005
40% reduction in emissions by the year 2005
60% reduction in emissions by the year 2020
* Methane from human-related activities:
15% reduction by the year 2020(3b)"

In fact it is much more than this, a strategy of 20% reduction by the year 2005 is likely to be an international policy.

Carbon Storage Areas and Carbon Fluxes

Houghton & Woodwell (5) have constructed a table giving estimated values for the world's major carbon reservoirs (see Table 1). From table 1 note that the atmosphere currently contains less than 2% of the world's carbon whereas over 80% of the world's carbon is found in the sea. It is expected that the relative size of these values would surprise most readers.

Houghton & Woodwell(5) also gave values for current net flows between these carbon reservoirs (see figure 1). Deforestation causes the "vegetation/soils reservoir" to give up 2 billion tonnes of carbon (net) annually. Combustion processes cause the :fossil fuel reservoir" to give up 5 billion tonnes of carbon (net)/annum. The net gain by the "air reservoir" is 3 billion tonnes/annum while the net gain by the "sea reservoir" is 4 billion tonnes each year., Note the difference in kind between deforestation and the burning of fossil fuels in that the former is reversible by reforestation, whereas, with current feasible technology, the latter is not.

Table 1 The Current World's Major Carbon Reservoirs (values in billion tonnes)

(1) Atmosphere	735 (1.7%)
(2) World Vegetation and Soils (560 + 1500)	2060 (4.8%)
(3) Sea	3600 (82.2%)
(4) Fossil Fuel Reservoirs	greater than 5000 (11.4%)

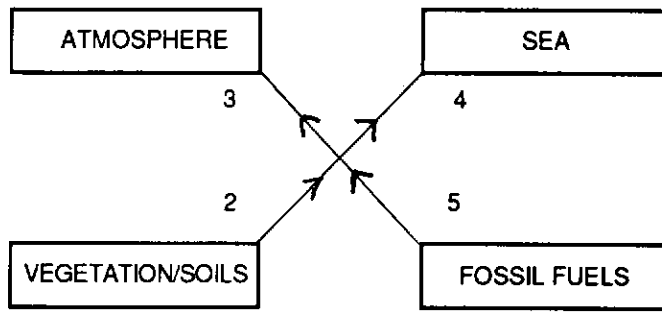

Figure 1 Carbon Reservoir Net Fluxes - Current Value (in billion tonnes/year)

Scenario 1 - Constant Proportional Flow Scenario

If the net rate of carbon transfer between reservoirs continued to persist at their current levels, then in about 1000 years, the current known fossil fuel reserves (lowest estimate) would then be exhausted. At the end of that time, hypothetically, the situation would be that given in Table 2 where the fossil fuel reservoir is empty and there is amost no vegetation. This "constant proportional flow" scenario also indicates that the concentration of carbon dioxide in the atmosphere will become five-times its current level.

Table 2 The World's Major Carbon Reservoirs in 1000 Years Time if Current Rate of Flux Continues (billion tonnes) - Scenario 1

(1) Atmosphere	3735	(8.53%)
(2) World Vegetation and Soils (15 + 45)	60	(0.14%)
(3) Sea	4000	(91.33%)

The following quote shows that the "constant proportional flow" scenario is a model which is being proposed for the carbon dioxide flow - "Not all the carbon dioxide which is produced stays in the atmosphere. Natural ecosystems, particularly the oceans, are able to absorb approximately 50 percent of the excess carbon dioxide which is produced by human activities. It is the other 50 percent which remains in the atmosphere that is causing concern (6)"

Scenario 2 - Equilibrium Scenario

In dilute solutions, the equilibrium relationship between the gas and liquid concentrations is depicted by Henry's law. This law gives a straight line relationship between the concentrations (assuming Dalton's law) i.e. doubling the concentration of carbon dioxide in the air would double the concentration of carbon dioxide in the sea (equilibrium). The equilibrium scenario proposes that Henry's law be applied to the average concentrations.

Before the industrial revolution (i.e. in 1850) the amount of carbon in the atmosphere was probably only around 600 billion tonnes (5). Assuming carbon dioxide equilibrium between sea and air existed in 1850, and assuming that the averaged redistribution since that time is in the same proportion as those given in Figure 1 (i.e. difference values of 135:90:180:225 in ration 3:2:4:5), gives the values shown in Table 3. However if a different redistribution pattern was used it would not markedly alter the atmosphere/sea carbon ratio because the amount of carbon in the sea is so large e.g. if there was the same atmosphere and fossil fuel increments but a zero increment in vegetation/soils then the atmosphere/sea carbon ratio would be 600/35,910 = 0.01671 instead of 600/35,820 = 0.0167

Table 3 Estimated World's Major Carbon reservoirs in 1850 (billion tonnes)

(1) Atmosphere	600	(1.4%)
(2) World Vegetation and Soils (560 + 1500)	2150	(4.9%)
(3) Sea	35820	(81.8%)
(4) Fossil Fuel Reservoirs	greater than 5225	(11.9%)

Consider again 1000 years from today at the current rate of carbon transfer, assuming Henry's law, and that equilibrium has then been established between the sea and atmospheric carbon dioxide concentration levels. This gives the values shown in Table 4. Under the "equilibrium" scenario there should be no great concern because the long term effect, once equilibrium is achieved (0.01675:1), gives a value which is below the current air carbon dioxide level.

It should be noted that the salts in the sea have a buffering effect on the carbon dioxide concentration, so the situation in the sea is more complex than simply a Henry's law relationship. There are also capacitative effects within the sea and atmosphere. However although the situation is more complex than presented here, it is reasonable to believe that the carbon dioxide level would drop markedly if the large man-made carbon dioxide contribution was discontinued i.e. the carbon dioxide would continue to be absorbed by the sea after the large man-made contribution ceased until the level in the atmosphere fell to the equilibrium value (estimated currently to be from 735 (see Table 1) to (0.01675 x 36,000 =) 603 billion tonnes of carbon)

Table 4 The World's Major Carbon Reservoirs in 1000 Years Time with Current Rate of Flux (billion tonnes) - Scenario 2

(1) Atmosphere	720	(1.64%)
(2) World Vegetation and Soils (15 + 45)	60	(4.9%)
(3) Sea	43015	(98.22%)

Scenario 3 - Potential Difference Scenario

In this scenario, the man made additional carbon dioxide flow from the atmosphere to the sea depends on the potential difference that exists between them. The potential difference may be expressed in terms of partial pressures, mole fractions, concentrations or even quantities. A standard equation for mass transfer is

$$N_{(y)} = K_{(g)} (y-y^*) \quad \text{(Equation 1)}$$

where $K_{(g)}$ is the overall gas-phase mass-transfer coefficient,
$N_{(y)}$ is the air-sea mass transfer rate,
y is the concentration in the gas phase, and y^* is the vapour concentration which would be in equilibrium with the liquid concentration.

Equation 1 is similar to the standard equation used to determine the flow of electricity, i.e.

$$I = (V_1 - V_2)/R \quad \text{(Equation 2)}$$

where I is the current,
R is the resistance, an
V is the voltage (subscripts 1 and 2 indicating a difference), hence the mass-transfer coefficient, $K_{(g)}$, in equation 1 is like the reciprocal of a resistance or, in other words, a conductance. It is reasonable to assume that the resistance to mass transfer of the carbon dioxide (i.e. $1/K_{(g)}$ does not change significantly with changes in flow rate of the man-made carbon dioxide going from the atmosphere to the sea. Therefore the ratio, flow/(potential difference), should be constant (i.e. should not change with time) in the "potential difference" scenario.

Consider Figure 1 again. The 4 billion tonne flux which is flowing to the "sea reservoir" is the quantity which should be used in the releation above. 3 billion tonnes of carbon/year are also going into the atmosphere in order to raise the carbon dioxide level and thereby increase the potential difference between the air and the sea. Almost 50% of the carbon flux is remaining in the atmosphere because of its large capacitive effect, as will be demonstrated. The flow behaviour can be described very simply by equation 3,

$$N_{(t)} = N_{(y)} + N_{(c)} \quad \text{(Equation 3)}$$

where $N_{(t)}$ is the sum of the mass transfer rates from the "fossil fuels fuels reservoir" and the "vegetation/soils reservoir", and $N_{(c)}$ is net mass rate transfer into the air.

The current equilibrium value for "CO_2" carbon would be around 603 billion tonnes (see above). Hence the potential difference would be 735 - 603 = 132 billion tonnes of "CO_2" carbon at the current rate of 4 billion of carbon/year. Therefore, for a rate of 7 billion tonnes of carbon/year, the atmospheric concentration should be (7/4) x 132 = 603 = 834 million tonnes of carbon plus an increment to account for a small annual increase of the carbon content in the sea.

In order to increase the carbon content in the air from 735 to 834 billion tonnes of carbon with a rate of 3 billion tonnes/year would take 33 years. But, because the concentration of carbon dioxide in the atmosphere and hence potential difference would be increasing, a larger proportion of the man-made carbon dioxide would be flowing into the sea. Therefore, there would be exponential-type behaviour, with the time required to nearly reach the "steady-state" condition being about 100 to 200 years. Thus the large capacitive effect of the atmosphere has been demonstrated.

Once again consider the next 1000 years, while assuming the current rate of carbon transfer is continued through that period. On the basis of the "potential difference" scenario, the values of that time would be those given in Table 5. As indicated, the carbon dioxide level should be 29% greater than the current level. Provided future discoveries do not greatly increase the "fossil fuel reservoir" above the original value (see Table 1), thereafter the air carbon dioxide concentration would decrease exponentially (over say 100 to 200 years) until it reached the level indicated by Table 4 (720 billion tonnes).

Table 5 The World's most Major Carbon Reservoirs in 1000 Years Time with Current Rate of Flux (billion tonnes) - Scenario 3

(1) Atmosphere	948	(2.16%)
(2) World Vegetation and Soils (15 + 45)	60	(0.14%)
(3) Sea	42787	(97.70%)

Discussion

The "potential difference" scenario is considered to be the correct model for describing carbon dioxide transfer between the different carbon reservoirs. The "equilibrium" scenario is not correct because it would take a long period for equilibrium to be reached once man-made flow of carbon dioxide into the atmosphere was stopped. The "potential difference" scenario and the "equilibrium" scenario give the same result when the "potential difference" is zero.

The "constant proportional flow" scenario is considered to be in error because it ignores the carbon dioxide capitative effect in the atmosphere. The proportion of man-made carbon dioxide remaining in the atmosphere has only kept constant in recent years because the amount of man-man carbon dioxide being emitted is increasing each year. This increase effectively increases the atmosphere's capacity to retain carbon dioxide because increased flow gives a higher "potential difference" for the "steady-state" condition. Recent papers appear to be adopting the "constant proportional flow" scenario (1),(8),(9),(10). Note that Schneider (1) presents a graphical representation of a constant emission rate and gives a constant increase in the carbon dioxide level with time which would be the characteristic of the "constant proportional flow" scenario.

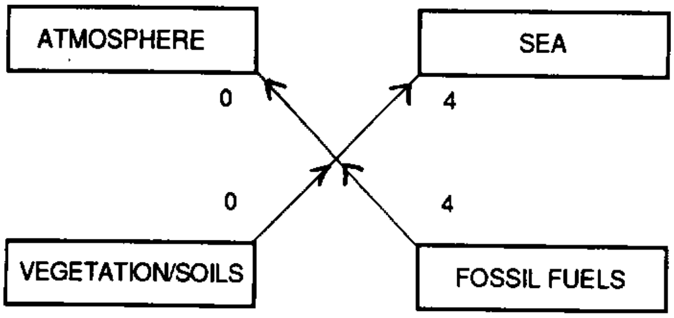

Figure 2 Carbon Reservoir Net Fluxes - Reduced Values (in billion tonnes/year)

If the current rate of man-made carbon dioxide emissions (7 billion tonnes of carbon annually) were held constant then the amount of carbon in the atmosphere should eventually increase above 834 billion tonnes of carbon. However, if the current burning of fossil fuels was reduced to 80% of its current value and net deforestation was no longer continued, then the carbon emission rate should fall to around 4 billion tonnes/annum. At this rate there should be no increase of carbon dioxide in the atmosphere and hence the carbopn dioxide concentration should remain near its present level. This might be termed the "steady-state" scenario.

Scenarios 2 & 3 show that the carbon dioxide pollution problem is more one of where the carbon dioxide is going rather than the actual amount. If our carbon dioxide emissions went directly to the sea then our carbon dioxide "greenhouse" effect problem could possibly be solved (see Figure 3a). This would remove the need to pass carbon dioxide into the atmosphere. Figure 3b shows an even better option. As long as replacement reforestation occurs, the combustion of wood could be used to provide more of the world's energy requirements with most of the resulting carbon dioxide bring absorbed into the sea. Carbon dioxide which is not absorbed by the sea can be recaptured by tree growth or, if absorption by the sea is very efficient, then the operation could be used to remove carbon dioxide from the air which has been generated in areas remote from the seaside. If electric cars were fully developed then both wood and oil could be burnt to provide electricity and much of the carbon dioxide removed from the combustion gas by absorption in sea water. it would be a matter of cost and, at any carbon dioxide gas entry point, the important possibility of local ecological damage from the high carbonic acid concentration and a consequential calcium deficiency.It should be noted that the figures given in this paper are only indicative values for illustrative purposes. For instance Houghton and Woodwell (5) give more accurate values of 5.5 and 1.8 billion tonnes/annum instead of 5 and 2 billion tonnes/annum for fossil fuel combustion and forest clearing. Also the carbon content of the atmosphere would be closer to 610 than to 600 billion tonnes.

Conclusions

(1) Man-made carbon dioxide emissions cannot simply be divided into a portion retained by the atmosphere and another portion absorbed into the sea.

(2) A new "potential difference" scenario demonstrated in this paper should be a satisfactory method of describing the carbon dioxide flow between carbon reservoirs.

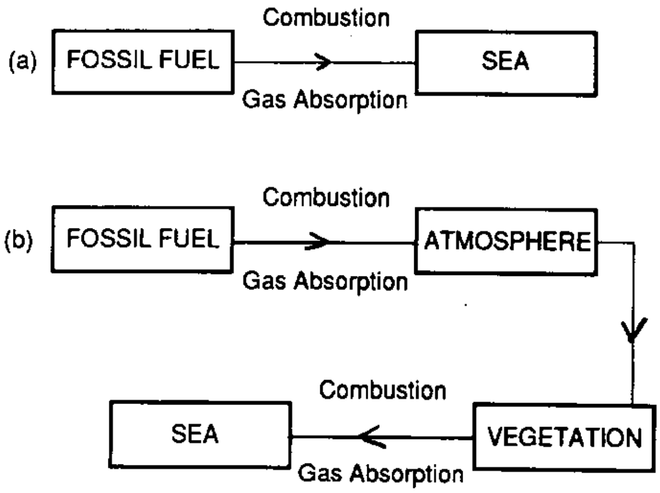

Figure 3 The Possibilty of Carbon Dioxide Being Directly Absorbed by the Sea

(3) If the amount of carbon dioxide emitted by man was held constant at its current value, then the concentration of carbon dioxide in the atmosphere would eventually level out to a value which is about 15% above its present value.

(4) Considerable time (say 100 to 200 years) would be required before the "steady-state" value was reached. The "steady-state" value would increase with time due to the increasing carbon dioxide in the sea.

(5) If net deforestation was discontinued and the current fossil fuel usage reduced to 80% of its current value then the carbon dioxide level would remain near its current value. Hence such a world policy could indeed prevent any further significant increase in the "greenhouse effect" due to man-made carbon dioxide emissions.

(6) If man-made carbon dioxide emissions were reduced to near zero there would be a considerable fall in the atmospheric carbon dioxide concentration (perhaps as much as 20%). Once again this decrease would be exponential and occur over a long time period.

(7) The absorption of man-made carbon dioxide by the sea might be short-circuited with appropriate technology and thereby avoid any atmospheric build-up of that "greenhouse gas", carbon dioxide.

(8) WHAT A GREAT AND MIGHTY CARBON RESERVOIR ARE OUR OCEANS!

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Chemistry in New Zealand 1990/91 Year Book

YEARBOOK

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6 **ALLENS UNITED WASTE DISPOSALS LTD** **C**
30 Neales Rd
East Tamaki
PO Box 58-032
Greenmount
AUCKLAND
Ph (09) 274-5572 Fax (09) 274-1065
40 Milton Rd, TAURANGA, Ph (075) 718-618
Specialists in the disposal of chemical wastes.

7 **ALLIED CORPORATION (N.Z.) Ltd** **D**
Ph (09) 464-850 Fax (09) 464-849
This entry has been carried over from the 1989 yearbook

8 **ALLTECH ASSOCIATES INC** **A**
PO Box 100352
NSMC
AUCKLAND 10
Ph (09) 444-3230
Supplier of chromatographic instruments, equipment, materials and reagents.

9 **ALPHA BIOLOGICALS** **C**
6 Fencible Drive
PO Box 38-213
Howick
AUCKLAND
Ph & Fax (09) 534-4424
Microbiological quality control laboratory. Telarc registered for testing foods, cosmetics, waters, sewage and effluents.
This entry has been carried over from the 1989 yearbook

10 **ALPHATECH SYSTEMS LTD** **A,E,F**
35 Scarborough Tce
PO Box 37-583
Parnell
AUCKLAND
Ph (09) 770-392 Fax (09) 398-514
63 Mills Rd, Brooklyn, WELLINGTON, Ph (04) 893-905
Importers and distributors of a wide range of scientific equipment and consumables for use in analytical chemistry, biochemistry, molecular biology, physics, medical physics and biotechnology. A full back up service is provided.

11 **ANALYTICAL RESEARCH LABORATORIES** **C**
PO Box 989
Napier
Ph (06) 835-6807 Fax (06) 835-0785
Independent analytical laboratory and consulting services.

12 **ANALYTICAL SERVICES LIMITED** **C**
85 Queen St
CAMBRIDGE
Ph (071) 274-409
Telarc registered laboratory and member of the NZ Association of Consulting Laboratories specializing in the analysis of minerals and nutrients in soils, plant tissues, feedstuffs and waters.

13 **ANALYTICAL SOLUTIONS LTD** **C**
PO Box 87-212
AUCKLAND 5
Ph (09) 523-1400
A scientific consultancy offering advice and development assistance for clients using or considering instrumental methods of analysis.

14 **APPLIED BIOSYSTEMS (AUSTRALIA) P/L** **A**
26 Harker St
Burwood
Victoria 3125
AUSTRALIA
Ph (00-61-3) 808-7777 Fax (00-61-3) 887-1469
Supplier of systems and tools for biotechnology research and related applications. Manufacturer and distributor of a wide range of automated instruments, chromatography columns and components and associated chemicals.

15 **APPLIED INSTRUMENTS Ltd** **E**
PO Box 62-010
Sylvia Park
AUCKLAND
Ph 592-633 Fax 592-630
Importers and distributors of industrial instrumentation.
This entry has been carried over from the 1989 yearbook

16 AQUA TREATMENT Ltd **C**
32 Monokia St
ROTORUA
Ph (073) 470-407 Fax (073) 478-911
Analysis of water, effluents, boiler deposits, environmental chemists and consultants.
This entry has been carried over from the 1989 yearbook

17 W ARTHUR FISHER **A,B,C,E,F**
525 Great South Rd
PO Box 12-747
Penrose
AUCKLAND
Ph (09) 592-629
27 Te Puni St, PO Box 38-774, LOWER HUTT, Ph (04) 689-629
144 Hazeldean Rd, PO Box 4158, CHRISTCHURCH, Ph (03) 667-692
Suppliers and consultants in the field of laboratory instruments equipment, process control instrument and processing equipment.

18 AUCKLAND VALVE & FITTING CO. Ltd **B**
26 Ryan Place
Manukau City
PO Box 97-687
Sth Auckland Mail Centre
AUCKLAND
Ph (09) 278-6164 Fax (09) 277-9069
Christchurch Valve & Fitting Co., Ph (04) 381-830
New Plymouth, Ph (067) 79-535
Specialists in valves and fittings and the installation of laboratory gas systems.
This entry has been carried over from the 1989 yearbook

19 AUSTIN CHALK CO **D**
PO Box 146
KAIAPOI
Ph (0327) 6119
Non metallic mineral, chemicals and surface coatings made to order.

20 AVERY NEW ZEALAND LTD **A**
21-23 Pretoria St
PO Box 44-155 VIC
LOWER HUTT
Ph (04) 698-588 Fax (04) 698-822

7C First Avenue, WHANGAREI,	Ph (089) 84-872
17-19 Teed St, Newmarket, AUCKLAND,	Ph (09) 502-072
64 Commerce St, HAMILTON,	Ph (071) 75-459
2 Newton Trade Centre, Newton Rd, MT MAUNGANUI SOUTH,	Ph (075) 52-318
322 Aberdeen Rd, GISBORNE,	Ph (079) 74-479
27 Carlyle St, NAPIER,	Ph (070) 54-602
194 Courtney St, NEW PLYMOUTH,	Ph (067) 83-907
57 Ingestre St, WANGANUI,	Ph (064) 56-064
3/1005 Treamaine Ave, PALMERSTON NORTH,	Ph (063) 88-680
80 Kingsley St, CHRISTCHURCH,	Ph (03) 65-119
62 Sturdee St, DUNEDIN,	Ph (03) 53-227
42 Gloucester St, NELSON,	Ph (054) 87-798
1 Bank St, TIMARU,	Ph (056) 89-488
39 Gala St, INVERCARGILL,	Ph (021) 84-737
Shops 11 & 12 Raiwaga Shopping Centre, Suva, FIJI,	Ph (00-679) 383-737

Manufacturers importers and suppliers of electronic and mechanical weighing and counting machines, including analytical and top-pan balances.
This entry carried over from the 1989 yearbook

21 BASF N.Z Ltd **D**
PO Box 407
AUCKLAND
Ph (09) 644-371 Fax 666-901
Importers and manufacturers representatives.
This entry has been carried over from the 1989 yearbook

22 BAYER DIAGNOSTIC AUSTRALIA PTY Ltd **B,D**
NEW ZEALAND BRANCH
PO Box 59-174
Mangere Bridge
AUCKLAND
Ph (09) 646-000 Fax (09) 646-005
Manufacturer and distributor of Ames Miles and Technicon products.

23 BAYER N.Z. Ltd **D**
CPO Box 2825
AUCKLAND
Ph (09) 480-1540 Fax (09) 480-1541
Marine Parade, PO Box 38-405, Petone, WELLINGTON, Ph (04) 688-176 Fax (04) 688-181
105 Rutherford St, CHRISTCHURCH, Ph (03) 843-136
203 Nelson St, HASTINGS, Ph (070) 60-259
Subsidiary of Bayer AG Leverkusen.

24 BDH CHEMICALS NEW ZEALAND Ltd **A,D**
PO Box 1246
PALMERSTON NORTH
Ph (063) 82-038 and 0800-657-792
Importer and supplier of chemicals, reagents, diagnostic products and laboratory materials.

25 R.A. BELL INSTRUMENTS Ltd **A,B**
PO Box 12-279
WELLINGTON
Ph (04) 764-516
Repair, maintenance and construction of all types of laboratory equipment and instruments.

26 BETA CHEMICALS (N.Z.) Ltd **D**
9 Lorien Place
PO Box 58-034
East Tamaki
AUCKLAND
Ph (09) 274-4574 Fax (09) 274-5365
Wellington Branch, Ph (04) 683-936
Christchurch Branch, Ph (03) 666-882
Manufactureres of adhesives, sealants, plastisols, screen printing inks specialised paints and solvents.
This entry has been carried over from the 1989 yearbook

27 BETZ LABORATORIES PTY LTD **C,D**
69-77 Williamson Rd
Ingleburn
NSW 2565
AUSTRALIA
RD 3, Drury, AUCKLAND, Ph (09) 294-8276
PO Box 13-029, Hillcrest, HAMILTON, Ph (071) 68-904
PO Box 296, KAWERAU, Ph (076) 36-537
Suppliers of specialty chemicals and engineering services programs for water, energy and process systems.

28 BLAXALL AND STEVEN Ltd **A**
PO Box 25-095
CHRISTCHURCH
Ph (03) 662-828
Importers and distributors of optical instruments.

29 BROWN AND DUREAU NZ Ltd **D**
1-5 Wiremu St
Balmoral
AUCKLAND
Ph (09) 608-438
451-453 St Asaph St, CHRISTCHURCH, Ph (03) 664-336
12 Fifeshire Ave, WELLINGTON, Ph (04) 850-398
Importers and suppliers of chemicals, industrial products, plastics and wine.

30 G. BUCHAN WATER TREATMENT **C**
92 Ellice Rd
Glenfield
PO Box 65-040
Mairangi Bay
AUCKLAND
Ph (09) 444-8209 Fax (09) 444-6903
Involved in all aspects of chemical metering and control for water treatment and other industrial applications. Also involved in sewage processing with extended aeration.
This entry has been carried over from the 1989 yearbook

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31 CANTERBURY FROZEN MEAT Co Ltd **C**
PO Box 283
CHRISTCHURCH
Ph (09) 796-900
Belfast Laboratory, PO Box 2, Belfast, CHRISTCHURCH 5, Ph (03) 238-696
Specialists in processing of meat and meat byproducts offering a service in testing of food, meat, meat byproducts and water and environmental testing.

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32 CARINA CHEMICAL LABORATORIES Ltd **C,D**
PO Box 30-366
Lower Hutt
WELLINGTON
Ph (04) 662-753
Consultants specializing in the research and development of new processes and chemical methods from initial laboratory trials through scale up to commercialization. Also supplier of fine chemicals.

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33 CASTROL N.Z. Ltd **D**
PO Box 11-047
WELLINGTON
Ph (04) 843-978 Fax (04) 842-044
Port Rd, Seaview, LOWER HUTT, Ph (04) 683-049
Cnr Hamer and Jellico Sts, Freemans Bay, AUCKLAND, Ph (09) 796-460
504 Cranford St, Papanui, CHRISTCHURCH, Ph (03) 526-099
Manufactureres and marketers of lubricants and allied products.
This entry has been carried over from the 1989 yearbook

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34 CATOLEUM NEW ZEALAND Ltd **D**
44 Cryers Rd
East Tamaki
AUCKLAND
Ph (09) 274-5032
Suppliers of chemicals service and technology in the area of water treatment and specialty process chemicals for a wide range of industries.

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35 CAWTHRON INSTITUTE **C**
Private Bag
NELSON
Ph (054) 82-319 Fax (054) 69-464
Auckland Office, Ph (09) 535-9024
Independent research institute offering services in: environmental consulting, chemical and microbiological testing and waste utilization.

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36 CERAMIC ENGINEERING Ltd **B,E**
71 The Mall
Onehunga
AUCKLAND
Ph (09) 665-251
Manufacturers of ceramics, refractories and other high temperature components for the foundry, aluminium and steel industries.

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37 CHEMCHEK NZ LABORATORY **A,B,D,E**
8A Aintree Ave
PO Box 43-047
Mangere
AUCKLAND
Ph (09) 256-0188
Suppliers of water and wastewater test reagents and equipment and water purifiers.

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38 CHEMCOLOUR INDUSTRIES (N.Z.) Ltd **D**
Poland Rd
Glenfield
PO Box 100-145
NSMC
AUCKLAND
Ph (09) 444-4650 Fax (09) 443-1047
Manufacturers and importers of a range of surfactants, pigment ***dispersions, dyestuffs, dispersants, processing aids, enzymes, vitamins, fatty alcohols and fatty acids.***

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39 CHEMTEST LABORATORIES **A,C**
PO Box 63-097
Papatoetoe
AUCKLAND
Ph & Fax (09) 274-5336 & (09) 274-8873
Servicing of water treatment equipment especially ion exchange. Supplier of chemical injection pumps. Analytical services for water, plant tissues and soils.

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40 CHEMICAL CLEANING Ltd **D**
Totara St
MT MAUNGANUI SOUTH
Ph (075) 53-157 Fax (075) 57-076
201-203 Fraser St, TIMARU, Ph (056) 45-026
Suppliers of commodity chemicals, proprietary detergents, fungicides, bottle washing compounds, aluminium etchants, bleaches and sequestering agents.
This entry has been carried over from the 1989 yearbook

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41 CHEMICAL SERVICE LABORATORIES (1985) Ltd **C**
3 Hardy St
PO Box 13-033
Johnsonville
WELLINGTON
Ph (04) 787-039 Fax (04) 787-402
Analytical and consulting chemists, bacteriolIologists.
This entry has been carried over from the 1989 yearbook

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42 CHEMICAL SPECIALTIES Ltd
166 Princes St
Onehunga
AUCKLAND
Ph (09) 668-618
Chemical compounders manufacturing filling compounds, hand cleaners and polyester and epoxy coatings.

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43 CHEMIPLAS NZ Ltd **A,B,D,E**
PO Box 37-408
AUCKLAND
Ph (09) 793-466 Fax (09) 392-715
Terrace House, 4 Oxford Tce, PO Box 1616, CHRISTCHURCH, Ph (03) 661-255, Fax (03) 54-201
1 Margaret St, LOWER HUTT, PO Box 31-165, WELLINGTON, Ph (04) 693-888, Fax (04) 661-536
Supplier of industrial raw materials, laboratory equipment and instruments for laboratories and process control.

44 CIBA-GEIGY NEW ZEALAND LIMITED **D**
47-51 Patiki Rd
Avondale
AUCKLAND
Ph (09) 883-149
1/2 Horlor St, Naenae, WELLINGTON, Ph (04) 674-778
Manufacturers and distributors of agricultural chemicals, dyestuffs, pharmaceuticals, plastics, additives, pigments and other industrial chemicals.

45 COLGATE PALMOLIVE Ltd **D**
Nevis St
Petone
WELLINGTON
Ph (04) 686-018
Manufacturers of soap, toothpaste and detergents.

46 COMMERCIAL MINERALS Ltd **D**
58 Ellice Rd
Glenfield
PO Box 2679
AUCKLAND
Ph (09) 444-4521 Telex Commin 21025
6 Gasson St, PO Box 1802, CHRISTCHURCH 2,
Ph (03) 69-395, Telex WABCHCH 4673
Importers of chemicals, industrial minerals, dyestuffs, pigments, textile auxiliaries, fat liquors and manufacturers of textile and leather auxiliaries.
This entry has been carried over from the 1989 yearbook

47 CONTAMINATION CONTROL Ltd **A,F**
PO Box 14-621
AUCKLAND 6
Ph (09) 570-135
Specialists in water treatment from small scale point of use systems to town water supplies. Manufacturers of UV products.

48 CPL PLASTICS **B**
13 Patiki Rd
Avondale
AUCKLAND
Ph (09) 886-054 Fax (09) 884-520
Suppliers of fume, laminar flow and saltspray cabinets, extraction systems and plastic waste piping.

49 DAVID E COOPER **C**
Consulting Environmental Chemist
PO Box 62
MANGAWHAI, NORTHLAND
Ph (0846) 68-596
Consulting environmental chemistry on water, wastewater and treatment. Air pollution and control backed up by laboratory work.
This entry has been carried over from the 1989 yearbook

50 P.J. DAWSON LABORATORIES **C**
PO Box 13-518
AUCKLAND
Ph (09) 643-637
P.J. Dawson Laboratories, Ph (071) 380-251
Specialists in the trace analysis of environmental organics in particular pesticides and mycotoxins.

51 DIVERSEY N.Z.Ltd **D**
PO Box 23-172
Papatoetoe
AUCKLAND
Ph (09) 278-2119
Specialty chemical manufacturers.
This entry has been carried over from the 1989 yearbook

52 DOW CORNING NEW ZEALAND **D**
Administration House
Unit G (Level 7)
44 Anzac Ave
CPO Box 3775
AUCKLAND
Ph (09) 733-870 Fax (09) 733-877
Manufacturer and marketer of silicone based products.

53 DSIR CHEMISTRY **C**
Private Bag
Petone
WELLINGTON
Ph (04) 666-919 Fax (04) 694-500
Mt Albert Research Centre, CPO Box 2224, AUCKLAND, Ph (09) 893-660, 17 Kelly St,
Mt Eden, AUCKLAND, Ph (09) 601-747
Geothermal Res. Centre,
Private Bag, TAUPO, Ph (074) 48-211
Ilam Research Centre, PO Box 29-181,
CHRISTCHURCH, Ph (03) 516-019
New Zealands largest and most comprehensive chemical facility.

54 DSIR LAND RESOURCES **C**
Private Bag
Eastern Hutt Rd
LOWER HUTT
Ph (04) 673-119
Private Bag, PALMERSTON NORTH, Ph (063) 67-154
Private Bag, CHRISTCHURCH, Ph (03) 252-511
Private Bag, DUNEDIN, Ph (03) 477-4050
Private Bag, HAVELOCK NORTH, Ph (070) 778-196
c/- Ruakura Agricultural Research
Centre, Private Bag, HAMILTON, Ph (071) 385-376
DSIR Land Resources is New Zealand Largest provider of expert scientific information and advice on the land and its biota with 230 scientific and support staff with extensive experience in New Zealand, the South Pacific, Asia and Antarctica.

55 DSIR MATERIALS PERFORMANCE GROUP
DSIR Industrial Development,
AUCKLAND, Ph (09) 303-4116
DSIR Industrial Development,
WELLINGTON, Ph (04) 690-788
DSIR Industrial Development,
CHRISTCHURCH, Ph (03) 358-9189
DSIR Chemistry Ph (04) 666-919
DSIR Materials Performance Group is a multi-disciplinary collection of technical adviser and scientists who can provide a comprehensive range of services and advice on materials research, performance monitoring and failure investigations.

56 **DU PONT (N.Z.) Ltd** **A,E**
PO Box 76-256
Manukau City
AUCKLAND
Ph (09) 277-8080 Fax (09) 278-0204
Importers
This entry has been carried over from the 1989 yearbook

57 **EBBETT AUTOMATION Ltd** **E**
70-74 Victoria St
Petone
WELLINGTON
Ph (04) 686-377 Fax (04) 682-374
Manufacturers and suppliers of instrumentation and control systems, power inverters, computer power supplies and voltage regulators.

58 **ELECTRICAL MEASUREMENT & CONTROL Ltd** E **B,C**
171 Target Rd
AUCKLAND 10
PO Box 31-145, Milford
AUCKLAND 9
Ph (09) 444-9229 Fax (09) 444-1145
Importers and maufacturers of industrial instruments, controllers and electronic weighing equipment.
This entry has been carried over from the 1989 yearbook

59 **EMAIL INDUSTRIES** **B,C**
6 Monahan Rd
Mt Wellington
AUCKLAND
Ph (09) 574-037
42 Cable St, WELLINGTON, Ph (04) 859-578
6 Lincoln Lane, CHRISTCHURCH, Ph (03) 69-892
An Australian company with many Australian divisions represented in New Zealand.
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60 **ENVIROLAB SERVICES Ltd** **C**
8 Leek St
PO Box 9437
Newmarket
AUCKLAND
Ph (09) 524-4721
Consultants and providers of analytical services related to all aspects of environmental engineering.

61 **EQUUS INDUSTRIES Ltd** **D**
4 North St
PO Box 601
BLENHEIM
Ph (057) 80-214 Fax (057) 80-214
Manufacturer of protective coatings for building and engineering industries. Products specially designed on request.

62 **FARMAC ENTERPRISES LTD** **D**
228 Neilson St
Onehunga
AUCKLAND 6
Ph (09) 668-186
Manufacturer and distributor of concentrated volumetric or ready to use laboratory reagent solutions aluminium soldering flux, buffer and swimming pool test kits etc.

63 **FERTILIZER AND LIME RESEARCH CENTRE** **C**
Massey University, Private Bag
PALMERSTON NORTH
Ph (063) 69-099 Ext 7736
Consultants specializing in the fertilizer industry, waste disposal and land rehabilitation. Also analysis of soils plants water and fertilizers.

64 **FLINDERS COOK (TECHNICAL SERVICES) LTD** **C**
3 Fenton St
PO Box 437, AUCKLAND
Ph (09) 303-3425, 303-3465
PO Box 2346, WELLINGTON, Ph (04) 858-422
Public analytical and consulting chemical laboratory with special expertise in bulk liquid quality and quantity control.

65 **FOUR SHIPS SCIENTIFIC** **A**
56 Ngahere St
Stokes Valley
PO Box 37-067
WELLINGTON
Fourteen years experience in sales and service of Kratos mass spectrometers and surface analysis equipment.
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66 **H.B.FULLER COMPANY (NZ) Ltd** **D**
64 Tidal Rd
PO Box 43-164, Mangere
AUCKLAND
Ph (09) 275-6062 Fax (09) 275-6002
Wellington Branch, Ph (04) 679-390
Christchurch Branch, Ph (03) 492-236
Manufacturer and distributor of a wide range of adhesives, sealants and specialty coatings.

67 **FURST-LAB** **B,C**
13 Ropa Lane
PO Box 15-017
Miramar
WELLINGTON
Ph (04) 888-607 Fax (04) 888-607
Specialists in laboratory fitments.

68 **GAMLEN CHEMICAL COMPANY NZ Ltd** **C,D,F**
34 Leonard Rd
Mt Wellington
PO Box 11-049
Ellerslie
AUCKLAND
42 Railway Ave, LOWER HUTT, (04) 694-501
Manufacturers and suppliers of water treatment chemicals and consultant in the field of water treatment and analysis (including Legionella and Pneumodimica).

69 **GCNZ WOODWARD-CLYDE** **C**
22 Heather St
Parnell
PO Box 37-547
AUCKLAND
Ph (09) 399-477 Fax 399-702
29 Glenelg Spur, CHRISTCHURCH 2, Ph (03) 332-3519
Consulting engineers, geologists and environmental scientists specializing in wastewater treatment, waste minimisation, water resources, occupational health and air pollution, EIA risk assessment and environmental audits.

70 **GEOCHEMISTRY RESEARCH Ltd** **C**
27 Voltaire St
Karori
WELLINGTON
Ph (04) 764-078
Chemical and geochemical consulting with special expertise in minerals and industrial chemistry, mineral exploration, mineral characterization, analysis, reactions, industrial utilization and processing. Petroleum exploration geochemistry.
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71 **GOUGH TECHNOLOGY Ltd** **B**
PO Box 22-073
CHRISTCHURCH
Ph (03) 798-740 Fax (03) 796-776
PO Box 68-150, , AUCKLAND — Ph (09) 763-174, Fax (09) 784-592
PO Box 38-421, Petone, WELLINGTON, — Ph (04) 686-675, Fax (04) 684-376
PO Box 1193, DUNEDIN, — Ph (03) 477-5823
Marketers of a range of test equipment
This entry has been carried over from the 1989 yearbook

72 **W.R. GRACE (NZ) Ltd** **D**
Private Bag
Porirua
WELLINGTON
Ph (04) 376-069
Olive Rd, Penrose, AUCKLAND, Ph (09) 591-324
Lancaster Lane, CHRISTCHURCH, Ph (03) 661-883
Suppliers of chemicals to the chemical industry.

73 **W. GRAYSONS AND ASSOCIATES Ltd** **C**
100 Hugo Johnson Drive
PO Box 12-545
Penrose
AUCKLAND
Ph (09) 590-329 Fax (09) 599-044
Inorganic Laboratory, 575 Great South Road, Penrose, AUCKLAND, Ph (09) 592 669
Macraes Laboratory, Macraes Flat, Palmerston, DUNEDIN Ph (034) 770-240
General technical consultants dealing with mine process control, timber, water, failure, microbiological and pathogen, food and pharmaceutical analysis, environmental surveys, product and Q/A system development and product Q/C. Telarc registered laboratory for asbestos, trace metal, timber, microbiological and pathogen, nitrate/nitrite and vitamin analyses, tube calibrations, thermostating and container approval for hazardous substances to UN code.

74 **HAMILTON ANALYTICAL LABORATORY** **C**
PO Box 4136
HAMILTON EAST
Ph (071) 395-143 Fax (071) 393-590
This entry has been carried over from the 1989 yearbook

75 **HAMILTON MEDICAL LABORATORIES** **C**
PO Box 52
HAMILTON
Ph (071) 82-599 - Fax (071) 80-594
This entry has been carried over from the 1989 yearbook

76 **HARCROS CHEMICALS (NZ) Ltd** **A,B,D,E,F**
119 Carbine Road
Mt Wellington
AUCKLAND
Ph (09) 276-4019 Fax (09) 276-7231
111 Molesworth St, WELLINGTON, Ph (04) 739-569
467 Selwyn St, CHRISTCHURCH, Ph (03) 667-547
Suppliers of laboratory instruments and equipment, laboratory and industrial chemicals and process and process control equipment.

77 **A.C. HATRICK (NZ) Ltd** **D**
22 York St
Parnell
AUCKLAND
Ph (09) 303-2695
Avondale Plant and Laboratories, Ph (09) 887-007
Tawa Plant and Sales Office, Ph (04) 327-199
Bell Block Plant, Ph (067) 71-783
Manufacturer and suppliers of a wide variety of synthetic resins.

78 **HAZARDS ANALYSIS Ltd** **C**
8 Silverstream Rd
Crofton Downs
WELLINGTON
Ph (04) 791-388
Analysis of hazards involving flammable vapours and dusts and also toxic chemicals. Services include analysis of causes of accidents and recommendations for preventative procedures, chemical plant safety audits, half day safety training programmes.
This entry has been carried over from the 1989 yearbook

79 **R.J. HILL LABORATORIES** **C**
25 Te Aroha St
PO Box 4048
HAMILTON
Ph (071) 552-266
Telarc registered laboratory specializing in analysis of soil, water and plant material.

80 **HOLT LLOYD Ltd** **D**
35 Leonard Rd
Mt Wellington
PO Box 11-049
Ellerslie
AUCKLAND 5
Manufacturer of car care products and polyester fillers and contract packer of aerosols and small packs and tubes.

81 **B.R. HOMERSHAM Ltd** **A,C,E**
PO Box 280
CHRISTCHURCH
Ph (03) 358-8309
PO Box 12-258, Penrose, AUCKLAND, Ph (09) 641-984
Suppliers of laboratory and process control instruments and consultants on process control systems.

82 **ICI INSTRUMENTS** **A**
246 Kyhber Pass
Grafton
PO Box 68-330
Newton
AUCKLAND
Ph (09) 735-765
Manufacturers and suppliers of analytical instruments with full back up services.

83 **INDEPENDENT SERVICE LABORATORIES (ISL)** **C**
25 McPherson St
Richmond
Private Bag
NELSON
Victoria St, PO Box 135, WAIHI, Ph (08163) 8969
Industrial chemists, mining and exploration consultants and analysts (specialists in geochemistry). Experienced in method development for companies not having their own laboratory facilities.
This entry has been carried over from the 1989 yearbook

84 **INSTRUMATICS (CONTROLS AND SYSTEMS) Ltd** **E**
PO Box 22-671
Otahuhu
AUCKLAND
Ph (09) 276-7096
Specialists in micro-processor based process control and energy management systems offering a service from system design through importation installation commissioning and technical support.

85 **JOHN MORRIS SCIENTIFIC Ltd** **A,B,E**
PO Box 6348
Wellesley St
AUCKLAND
Ph (09) 444-5836 Fax (09) 444-0974
352 Manchester St, CHRISTCHURCH, Ph (03) 653-825, Fax (03) 666-975
7 Hinau St, Eastbourne, WELLINGTON, Ph (04) 627- 525, Fax (04) 627-212
Suppliers of laboratory instruments and fittings and process control equipment.

86 **JOHN YOLLAND AND ASSOCIATES Ltd** **C**
PO Box 51-411
Pakuranga
AUCKLAND
Ph (09) 569-807
Consulting services specializing in product testing of building materials and systems, solid fuel heaters, air temperature, flow and pollution and industrial hygiene.

87 **LAB SUPPLY PIERCE (NZ) LTD** **A,B,D**
PO Box 34-234
Birkenhead
AUCKLAND
Ph (09) 419-2551
PO Box 20-035, Bishopdale, CHRISTCHURCH, Ph (03) 358-7410
Suppliers of scientific instruments and equipment and laboratory fittings and chemicals.

88 **LIFE TECHNOLOGIES Ltd** **A,D**
18-24 Botha Rd
Penrose
PO Box 12-502
AUCKLAND
7 Brixton St, CHRISTCHURCH, Ph (03) 494-215
Manufacturer and supplier of consumables and equipment specific to clinical and research laboratory use.

89 **MacEWANS MACHINERY Ltd** **F**
706 Great South Rd
Penrose
PO Box 12-845
AUCKLAND
Ph (09) 590-185 (579-0185 after 5th April 1991)
Fax (09) 591-317 (579-1315 after 5th April 1991)
Suppliers of specialized technical process equipment and systems to the food, beverage chemical and water treatment industries.

90 **W.D. McGREGOR Ltd** **B**
188 Stoddard Rd
Mt Roskill
AUCKLAND
Ph (09) 694-119
Manufacturers and suppliers of furnaces.

91 **MAF QUALITY MANAGEMENT** **C**
Lynfield Food Services Centre
PO Box 41
AUCKLAND
Analytical laboratory services.

92 **MAF CHEMICAL SERVICES** **C**
WALLACEVILLE ANIMAL RESEARCH CENTRE
PO Box 40-063, UPPER HUTT
Ph (04) 286-089 Fax (04) 280-493
Consulting laboratory undertaking a wide range of residue analyses on both animal and plant materials.

93 **MED-CHEM Ltd** **D**
5th Floor
Augustus House
15 Augustus Tce
Parnell
AUCKLAND
Ph (09) 774-932
Importers and distributors of food grade and technical grade chemicals.

94 **MEDIC CORPORATION Ltd** **A,B,D,E,F**
Private Bag
LOWER HUTT
Ph (09) 693-539
535 Parnell Rd, AUCKLAND, Ph (09) 303-2979
18-20 Lake Rd, HAMILTON, Ph 472-729
14 Yulcan Place, Marylands,
CHRISTCHURCH, Ph (03) 338-1936
141 Frederick St, DUNEDIN, Ph 740-722
Suppliers of all requirements for the health care industry and process filtration specialists.

---

95 **MEDTEC PRODUCTS** **A,B**
1/125 Naenae Rd
Naenae
WELLINGTON
Ph (04) 670-011
Unit B, 129 Onewa Rd, Northcote, Ph (09) 480-6763,
AUCKLAND, Fax (09) 480-6386
323 Cranford St, Edgeware,
CHRISTCHURCH, Ph (03) 355-8105
Suppliers of medical and analytical instruments and laboratory consumables.

---

96 **METALLURGICAL AND INDUS TRIAL CONSULTANTS** **C**
72-82 Taranaki St
PO Box 2346
WELLINGTON
Ph (04) 858-422 Fax (04) 852-961
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97 **METALLURGICAL SERVICES Ltd** **C**
PO Box 44
Drury
SOUTH AUCKLAND
Ph (09) 294-8437
Consultants specializing in metallurgical analysis and heat treatment services.

---

98 **MINTECH NZ Ltd** **D**
121 Carbine Rd
PO Box 62-718
Mt Wellington
AUCKLAND
Ph 0800-804-461
Suppliers of chemicals and minerals to the chemical industry.

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99 **MOBIL OIL NZ LTD** **D**
62 The Terrace
WELLINGTON
Ph (04) 722-078
Mobil Bulk Warehouse and Terminal, Seaview,
WELLINGTON, Ph (04) 683-089
Suppliers of petroleum products, solvents and chemicals.

---

100 **MOOYMAN & HORNBY LABORATORIES** **C**
PO Box 21-188
CHRISTCHURCH
Ph (03) 792-644
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101 **MOSS INDUSTRIES Ltd** **C**
PO Box 19-000
Avondale
AUCKLAND 7
Ph (09) 817-8698
Consulting chemists in the forensic, industrial, manufacturing and development fields. Computer consultants offering technical advice, hardware repairs and software modifications.

---

102 **NATIONAL AGLAB** **A**
188 Collingwood St
HAMILTON
Ph (071) 80-599
Analytical laboratory specializing in plant tissue, soil nutrients, and surface waters for domestic and agricultural users.
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103 **NDA LABWARE** **A,D**
PO Box 11-095
Ellerslie
AUCKLAND
Ph (09) 525-1031 Fax (09) 525-1033
PO Box 210, PALMERSTON NORTH, Ph (063) 63-951
PO Box 31-044, LOWER HUTT, Ph (04) 697-099
PO Box 9033, CHRISTCHURCH, Ph (03) 669-712
Suppliers of laboratory equipment and chemicals to the food and meat industries.

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104 **NEW ZEALAND HYDROPONICS Ltd** **A,C,D**
PO Box 949
TAURANGA
Ph (075) 780-849
Suppliers of hydroponic materials and equipment.

---

105 **NUCLEAR SCIENCES GROUP**
Division of Physical.Sciences, DSIR
Public Trust Bldg
Lambton Quay
WELLINGTON
Ph (04) 666-919
Specialists in the construction of instruments based on nuclear techniques (Density gauging, fat /moisture content), remote sensing of corrosion, remote monitoring and tracing of residence times and flow paths for solids liquids and gases.

---

106 **NUPLEX INDUSTRIES Ltd** **D**
PO Box 12-841
Penrose
AUCKLAND
Ph (09) 592-029 Fax (09) 510-542
25-29 Broderick Rd, PO Box 3833, Johnsonville,
WELLINGTON Ph (04) 785-681, Fax (04) 783-177
14 Iverston Tce, CHRISTCHURCH,
Ph (03) 666-802, Fax (03) 790-279
Manufacturers of emulsion polymers, alkyd resins, polyester resins and coatings.

---

107 **NZIG Ltd** **B,D,F**
133-137 The Terrace
WELLINGTON
PO Box 3337, WELLINGTON
Ph (04) 725-725 Fax (04) 730-833
Penrose, AUCKLAND, Ph (09) 598-166, Fax 594-976
LOWER HUTT, Ph (04) 684-249, Fax (04) 687-249
CHRISTCHURCH, Ph (03) 487-199, Fax (04) 430-463
DUNEDIN, Ph (03) 488-2065
HAMILTON, Ph (071) 493-963,
Suppliers of gases and gas mixtures for a wide range of uses from instrument calibration to inert blanketing and purging. NZIG also offer process control equipment, troubleshooting and innovative design and development services.

108 NZ PHARMACEUTICALS Ltd

PO Box 1869
PALMERSTON NORTH
Ph (063) 258-676

Processors of natural raw materials into pharmaceutical raw materials and fine chemicals intermediates.

109 NZ SAFETY LIMITED — B

Private Bag
AUCKLAND 1
Ph (09) 592-880

Branches in Avondale, East Tamaki, Penrose, Glenfield, Whangarei, Hamilton, Rotorua, Hastings, Gisborne, Napier, New Plymouth, Petone, Nelson, Christchurch, Dunedin, Invercargill.

Suppliers of personal protection, firefighting equipment, hygiene and first aid supplies.

110 PACIFIC ANALYTICAL Ltd — C

407 Grey St
PO Box 4266
HAMILTON EAST
Ph (071) 68-766

Consultancy involved with technical/scientific personnel placement computer/EDP consultancy (real time systems for laboratories), general laboratory consultancy. Offering staff training /evaluation, technical report preparation, computer consumables.

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111 PACIFIC RAW MATERIALS Ltd — CD

PO Box 22-064
AUCKLAND
Ph (09) 759-789

Importer and supplier of chemical and fertilizer raw materials.

112 PEARSON BIOLOGICALS — C

Tower Building
Cnr Montreal and Salisbury Sts
PO Box 25-091, CHRISTCHURCH
Ph (03) 650-624 Fax (03) 650-690

Telarc registered laboratory offering comprehensive microbiological testing and consultancy for the food, cosmetic and water supply (for drinking and industrial use). Services include testing for Listeria and Legionella.

113 PHARM CHEM RESEARCH LABORATORIES — C,D

PO Box 5313
DUNEDIN
Ph (03) 4 777-967

Consultants in the fields of analysis, physical measurement, chemical synthesis research and literature searches.

114 PHILIPS SCIENTIFIC AND INDUSTRIAL PTY Ltd — A,E

2 Wagener Place
Mt Albert
AUCKLAND
Ph (09) 894-160

125 Wexford Rd, Miramar, WELLINGTON, Ph (04) 889-788
224 Lichfield St, CHRISTCHURCH, Ph (03) 792-030

Suppliers of scientific and industrial equipment. Services include pre sales testing, installation, operator training, software upgrades, preventative maintenance and service agreements.

115 PLASFAB INSTALLATIONS 1977 Ltd — B

24 Hill St
Onehunga
AUCKLAND
Ph (09) 666-689, 666-340

Manufacturers plastic fume and laminar flow cabinets.

116 POLYCHEM MARKETING LIMITED — D

PO Box 6435
AUCKLAND
Ph (09) 520-5868

PO Box 9141, WELLINGTON, Ph (04) 856-609
PO Box 13-383, CHRISTCHURCH, Ph (03) 660-652

117 PROCESSED CHEMICALS INDUSTRIES Ltd — C,D,E,F

PO Box 88
Silverdale
NORTH AUCKLAND
Ph (0942) 48-179

Equipment and consumables for water purification. Analysis for water soil and plant materials.

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118 PWT NEW ZEALAND Ltd — C,D,E,F

11 Spring St
Onehunga
AUCKLAND
Ph (09) 641-079 Fax (09) 640-782

Wellington Branch, Ph (04) 723-3070
Christchurch Branch, Ph (03) 343-3515
Napier Branch, Ph (06) 843-5869
Rotorua Branch, Ph (073) 487-433
Palmerston North Branch, Ph (063) 63-192

Specialists in engineering, control and chemical aspects of water treatment and process control.

119 QUIK-STIK INTERNATIONAL Ltd — B

PO Box 76-221
Manukau City
AUCKLAND
Ph (09) 278-0939 Fax (09) 278-9082

20 Hutt Rd, Petone, WELLINGTON,
PO Box 44-094, Ph (04) 695-194
373 Brisbane St, Sydenham,
CHRISTCHURCH, Ph (03) 664-729

Producers of pressure sensitive labels for identification and safety. Processable by hand, typewriter or EDP units.

120 RADIOMETER PACIFIC — A,B

Unit A
10-20 Sylvia Park Rd
Penrose
AUCKLAND
Ph (09) 573-1110 Fax (09) 573-1106

Radiometer pacific is a subsidiary of Radiometer Copenhagen importing and distributing scientific and medical instruments and equipment with a full back up service.

121 RANKINE & HILL Ltd ENVIRONMENTAL SERVICE — C

6 Crowhurst
PO Box 9762
NEWMARKET
Ph (09) 520-6019

Environmental and biological consulting services and chemical and microbiological analysis.

122 RHONE-POULENC NEW ZEALAND Ltd — D

PO Box 35-060
Naenae
LOWER HUTT
Ph (04) 693-091

Rhone-Poulenc focuses its activities in three main areas: applied life sciences; specialty chemicals, performance products and new materials and chemical intermediates which supply integrated industrial networks.

123 **ROBERT BRYCE & CO LTD** **D**
PO Box 30-145
LOWER HUTT
Ph (04) 683-559
Auckland, Ph (09) 656-169
Christchurch, Ph (03) 687-530
Suppliers of chemical raw materials for industrial production.

124 **ROCKLABS Ltd** **B**
PO Box 18-142
AUCKLAND 6
Ph (09) 570-4698
Manufacturers, suppliers and exporters of sample preparation equipment.

125 **RORY SHANAHAN LABORATORIES Ltd** **C**
55 Halsey Drive
Mt Roskill
AUCKLAND 4
Ph (09) 673-149
Consulting and analytical services to defence council, private investigators and industry.

126 **SALMOND SMITH BIOLAB (BIOLAB SCIENTIFIC)** **A,B,D**
30 Woodside Ave
Private Bag
Northcote
AUCKLAND
Ph (09) 418-3039
410 Hutt Rd, PO Box 31-044, LOWER HUTT, Ph (04) 697-099
68 Orbell St, PO Box 1813, CHRISTCHURCH, Ph (03) 663-663
Suppliers of diagnostic equipment, scientific glassware, plasticware chemicals and consumables.

127 **SCIENTIFIC ANALYTICAL Ltd** **C**
22 Vogel St
PO Box 1355
DUNEDIN
Ph (03) 477-2204
General consultant and analyst for manufacturing and processing industries and agriculture related industries. Specialists in soil and plant analysis.
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128 **SCIENTIFIC AND GENERAL CONSULTANTS** **C**
PO Box 13-219
Onehunga
AUCKLAND
Ph (09) 642-593
Independent consulting and analytical services to industry specializing in food analysis, personal care products, industrial commodities and processes.

129 **SCIENTIFIC SERVICE LABORATORIES LTD** **C,D**
PO Box 3030
Onekawa
NAPIER
Ph (070) 439-218
Manufacturers and packers of corrosive products such as soldering fluids, chemical pickles, etchants, hydrochloric and sulphuric acids. Consultants in the design and installation of small scale chemical plants and industrial scale glassware and disposal of acid effluents.

130 **SCIENTIFIC SUPPLIES Ltd** **B,D**

131 **SCI-MED DIVISION OF TECHNOLOGY CORPORATION Ltd** **A,B,C,E**
156 Frederick St
PO Box 321
DUNEDIN
Ph (03) 477-5537 Fax (03) 477-0757
Auckland Branch, Ph (09) 793-993,
PO Box 68-585, Fax (09) 793-477
Wellington Branch, Ph (04) 682-519,
PO Box 38-314, Fax (04) 682-292
Christchurch Branch, Ph (03) 812-333,
PO Box 32-116, Fax (03) 812-335
Distributors of a wide range of scientific and medical instrumentation and accessories. Customers are supported with service in each main centre to provide solutions to their scientific problems.

132 **SCOTT ELECTRONICS** **F**
2 Gossamer Drive
Pakuranga
AUCKLAND
Suppliers of water purifiers.

133 **SHELL CHEMICALS NEW ZEALAND Ltd** **D**
PO Box 2091
WELLINGTON
Ph (04) 720-080
Shell Petro-chemicals, PO Box 1084,
AUCKLAND, Ph (09) 778-880
Shell Agriculture, PO Box 2091,
WELLINGTON, Ph (04) 720-080
Importers and distributors of agricultural and petro-chemicals.

134 **SORENSON LABORATORIES Ltd** **C**
PO Box 43-122
Mangere
AUCKLAND
Ph (09) 275-1459
Microbiological testing.

135 **SULKEM CO LTD** **D**
40 Anzac Ave
PO Box 2294
CPO
AUCKLAND
Ph (09) 390-769
Suppliers of all types of chemicals and raw materials.

136 **SWIFT NEW ZEALAND** **D**
222 Station Rd
Penrose
PO Box 2301
AUCKLAND
Ph (09) 591-039 Fax (09) 597-047
2nd Floor David Forman House,
134 Queens Drive LOWER HUTT,
PO Box 2328, WELLINGTON, Ph (04) 665-361,
Fax (04) 665-843
Amuri Courts, Durham St, Ph (03) 662-851,
PO Box 1611, CHRISTCHURCH, Fax (03) 651-797
Importers of chemicals, chemical raw materials filtration materials.

137 **TASMEX LABORATORIES Ltd** **C**
92 Alpha St
CAMBRIDGE
Ph & Fax (071) 650-624
Microbiological and chemical analysis.
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138 **TELARC NEW ZEALAND** **C**
19 Mauranui Ave
Remuera
AUCKLAND 5
Ph (09) 523-1045
77 Durham St, CHRISTCHURCH, Ph (03) 797-358
Telarc promotes identifies and formally recognizes quality in the supply of New Zealands goods and services and offers educational services for the training of laboratory staff.

---

139 **THERMOPLASTIC ENGINEERING Ltd** **B,C,T**
151 Park Rd
Miramar
WELLINGTON
Ph (04) 882-092 Fax (04) 887-523
Specialists in the design fabrication and installation of fume cupboards, fume extraction fans ducting and fume extraction systems bench tops draining racks and other rigid laboratory fittings in PVC and polypropylene.

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140 **TOWER BIOLOGICALS Ltd** **C**
PO Box 25-091
CHRISTCHURCH
Ph (03) 50-624
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141 **UNION CARBIDE (NEW ZEALAND) LIMITED** **D**
Until APRIL 1991
Unit 11
Ellice Court
95 Ellice Rd
Glenfield
Ph (09) 444-8046
From April 1991
cnr Bush Rd and Piermark Drive
North Harbour Industrial Estate
Albany
AUCKLAND 10
Ph to be advised.
Importer and distributor of chemicals for industry.

---

142 **UNIVERSITY OF CANTERBURY** **C**
GEOLOGY DEPARTMENT
Private Bag
CHRISTCHURCH
Ph (03) 667-001
X-ray fluorescence and diffraction for the analysis and identification of plant material and mineral samples.

---

143 **UPJOHN PHARMACEUTICALS** **D**
3 Fisher Cres
Mt Wellington
AUCKLAND
Ph (09) 270- 0328
Importers and distributors of human and veterinary pharmaceuticals and pharmaceutical fine chemicals.

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144 **VELA AGAROSE LTD** **D**
PO Box 2900
WELLINGTON
Ph (04) 662-753
Manufacturer of agarose.

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145 **WASH SYSTEMS Ltd** **B**
9 Corban Ave
PO Box 21-342
Henderson
AUCKLAND
Ph (09) 837-2372 Fax (09) 837-0880
Manufacturers and distributors of commercial and industrial wash machines.

---

146 **WASTE MANAGEMENT NZ Ltd** **D**
25 Diversey Lane
Wiri
PO Box 76-108
MANUKAU CITY
Ph (09) 278-3644, 278-2433
Supplier of specialist and general services for the removal, treatment and disposal of hazardous liquid wastes.

---

147 **WATSON VICTOR Ltd** **A,B,E**
4 Adelaide Rd
PO Box 1180
WELLINGTON
Ph (04) 857-699
616-618 Great South Rd, PO Box 1216,
Ellerslie, AUCKLAND, Ph (09) 593-039
Unit 14, 75 Peterborough St,
PO Box 706, CHRISTCHURCH, Ph (03) 669-282
Cnr Clyde and Albany Sts, PO Box 921,
DUNEDIN, Ph (03) 477-7291
Watson Victor Ltd supply a wide range of products in the field of laboratory instruments, equipment and consumables and process control equipment. Their products are supported by a full back up service.

---

148 **W.B. WEBLEY - APPLIED RESEARCH AND CONSULTING SERVICES** **C**
PO Box 687
NELSON
Ph and Fax (054) 82-442
Specialist in industrial and environmental consulting.

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149 **WILTON INSTRUMENTS** **A,E**
410 Hutt Rd
PO Box 31-044
LOWER HUTT
Ph (04) 697-099 Fax (04) 697-240
Woodside Ave, Private Bag, Ph (09) 418-3039,
Northcote, AUCKLAND, Fax (09) 418-0729
68 Orbell St, Ph (03) 663-663,
CHRISTCHURCH, Fax (03) 697-240
Suppliers of scientific laboratory appliances and instruments and industrial process control equipment.

---

150 **XL CONSULTANTS** **C**
1/164 Beach Rd
Campbells Bay
AUCKLAND 10
Ph (09) 410-7710
Consultants in formulation and manufacturing techniques of industrial, veterinary and household products.

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151 **HOECHST N.Z. Ltd** **D**
21-39 Jellicoe Rd.
Panmure
AUCKLAND
Ph (09) 527-8068
94 Bell Rd South, Gracefield, WELLINGTON, Ph (04) 698-212
Jipcho Rd, Sockburn, CHRISTCHURCH, Ph (03) 348-0375
Importers of chemicals, plastics, fibre dyes, pigments, resins and pharmaceuticals.

SECTION A LABORATORY INSTRUMENTS

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Analytical

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New Zealand Association of Consulting Laboratories

Company and Address	Contact	Telephone & Fax

Company and Address	Contact	Telephone	Fax
Alpha Biologicals Ltd PO Box 38 213, Howick AUCKLAND	Geoffry Hill	(09) 534 4424	(09) 534 4424
Analytical Research Laboratories PO Box 989, NAPIER	Peter Lorentz	(06) 836 6807	(06) 835 0785
Analytical Services Ltd Private Bag, CAMBRIDGE	John Turner	(071) 274 409	(071) 274 495
Rankine & Hill Environmental Servies 32 Monokia Street, ROTORUA	Nick Miller	(073) 470 407	(073) 478 911
Allan Aspell & Associates Ltd Constellation Drive, Mairangi Bay AUCKLAND 1	Allan Aspell	(09) 279 2962	
Cawthron Institute PO Box 175, NELSON	Graham Robertson	(054) 82 319	(054) 69 464
Chemical Service Laboratories Ltd PO Box 13-033, Johnsonville WELLINGTON	Murray Friar	(04) 787 039	(04) 787 402
P J Dawson Laboratories PO Box 178, HAMILTON	Peter Dawson	(071) 80 251	(071) 82 313
Dr Elizabeth Ebbett PO Box 437, AUCKLAND	Elizabeth Ebbett	(09) 303 3465	(09) 303 3465
Flinders Cook Technical Services PO Box 437, AUCKLAND	Peter Bailey	(09) 303 3465	(09) 303 3425
W Grayson & Associates Ltd PO Box 12-545, Penrose AUCKLAND	Bill Grayson	(09) 590 320	(09) 599 044
Hamilton Analytical Laboratory PO Box 4136, HAMILTON EAST	Mike Lowe	(071) 395 143	(071) 393 590
Dr Gloria Hettige PO Box 30-366, LOWER HUTT	Gloria Hettige	(04) 662 753	(04) 698 514
R J Hill Laboratories PO Box 4048, HAMILTON EAST	Roger Hill	(071) 552-266	(071) 552-266
Chem Test Laboratories PO Box 63 097, Papatoetoe South AUCKLAND	John Thompson	(09) 274 8873	
Metallurgical & Industrial Consultants PO Box 2346, WELLINGTON	Derek Wilkinson	(04) 868 422	
Mooyman & Hornby Laboratories PO Box 6178, CHRISTCHURCH	Colin Knudsen	(03) 792 644	
NZ Hydroponics Ltd PO Box 949, TAURANGA	Margaret Arnold	(075) 780 849	(075) 780 847
Hamilton Medical Laboratories PO Box 52, HAMILTON	Brian Lineham	(071) 80 599	(071) 80 594
Scientific & General Consultants PO Box 13-219, Onehunga AUCKLAND	Dennis Karl	(09) 642 593	(09) 646 728
SGS New Zealand Ltd PO Box 13-518, Onehunga AUCKLAND 6	Karl Smith	(09) 643 637	(09) 666 054
Shanahan Scientific Services PO Box 49 048, Mt Roskill South AUCKLAND 4	Rory Shanahan	(09) 673 149	
Sorenson Laboratories Ltd PO Box 43 122, Mangere AUCKLAND	Torben Sorenson	(09) 275 1459	
Envirolab Services Ltd PO Box 9437, Newmarket AUCKLAND	Robert Fullerton	(09) 524 4721	(09) 524 6502
Tasmex Laboratories 92 Alpha Street, CAMBRIDGE	John Smale	(071) 273 061	
Pearson Biologicals Ltd PO Box 25091, CHRISTCHURCH	David Robertson	(03) 650 624	(03) 650 920
Zentech PO Box 1777, DUNEDIN	Thomas Henderson	(03) 477 9669	(03) 477 9605
Executive Secretary NZACL, PO Box 268 WAIKANAE	John Liddle	(058) 36 255	(058) 37 936

SECTION C CONSULTANTS GEOGRAPHICAL LISTING

1 AUCKLAND AND NORTH AUCKLAND

2 ABELS Ltd
Manufacturers of and consultants in chemical testing of fats and oils. Equipment includes UV - Vis spectrophotometers, Capillary GC and pulsed NMR

5 ALLAN ASPELL & ASSOCIATES Ltd
Analytical chemists and scientific consultants specializing in environmental chemistry, microbiology, analysis of foods, pharmaceuticals and industrial material and specialist investigations. Equipment includes AAS (flame, graphite furnace and hydride generation); GC with FID, NPD, ECD and purge trap apparatus; mass selective detector (MSD); scanning UV-Vis; scanning fluorimeter; IR spectrophotometer; furnace and incubators; ion selective electrodes; Karl Fischer apparatus

6 ALLENS UNITED WASTE DISPOSALS LTD
Specialists in the disposal of chemical wastes.

9 ALPHA BIOLOGICALS
Microbiological quality control laboratory. Telarc registered for testing foods, cosmetics, waters, sewage and effluents. Microbiological quality including sterility of veterinary preparations. Plant hygiene evaluation. Instrumentation includes Laminar flow cabinet, microscopes, incubators,
Seward Stomacher, Freeze drier and membrane filtration apparatus.
This entry has been carried over from the 1989 yearbook

13 ANALYTICAL SOLUTIONS LTD
A scientific consultancy offering advice and development assistance for clients using or considering instrumental methods of analysis. Services include: instruction of staff in the application of specific new technologies and techniques; Development of sample pre-treatment and separation
strategies; Needs analysis and independent advice in specifying and configuring instrumentation prior to purchase. Equipment available includes capillary and packed column GC, HPLC, AAS, UV-Vis, (FT)-IR.

17 W ARTHUR FISHER
Suppliers and consultants in the field of laboratory instruments equipment, process control instrument and processing equipment.

27 BETZ LABORATORIES PTY LTD
Suppliers of specialty chemicals and engineering services programs for water, energy and process systems.

30 G. BUCHAN WATER TREATMENT
Involved in all aspects of chemical metering and control for water treatment and other industrial applications. Also involved in sewage processing with extended aeration.
This entry has been carried over from the 1989 yearbook

35 CAWTHRON INSTITUTE
Independent research institute offering services in: environmental consulting, chemical and microbiological testing and waste utilization. Equipment available includes: HPLC with UV, IR, Fluorescence detectors; GC with FID, ECD; Spectrophotometers AA, IR, UV-Vis and liquid scintillation counter.

39 CHEMTEST LABORATORIES
Servicing of water treatment equipment especially ion exchange. Supplier of chemical injection pumps. Analytical services for water, plant tissues and soils.

49 DAVID E COOPER
Consulting environmental chemistry on water, wastewater and treatment. Air pollution and control backed up by laboratory work.
This entry has been carried over from the 1989 yearbook

50 P.J. DAWSON LABORATORIES
Specialists in the trace analysis of environmental organics in particular pesticides and mycotoxins. Equipment includes: HPLC, GC with FID, TCD, N/P, ECD and UV Vis spectrophotometer.

53 DSIR CHEMISTRY
New Zealands largest and most comprehensive chemical facility. Able to analyse almost anything. Most analytical techniques are available - AAS, GC-MS, HPLC, NMR, ICP.

55 DSIR MATERIALS PERFORMANCE GROUP
DSIR Materials Performance Group is a multi-disciplinary collection of technical advisers and scientists who can provide a comprehensive range of services and advice on materials research, performance monitoring and failure investigations. Almost all industrial materials can be analysed from metals to rubbers to concrete to lubricants. Most performance testing equipment is available including Scanning electron microscope, X-ray powder diffraction and thin layer activation.

60 ENVIROLAB SERVICES Ltd
Consultants and providers of analytical services related to all aspects of environmental engineering.

64 FLINDERS COOK (TECHNICAL SERVICES) LTD
Public analytical and consulting chemical laboratory with special expertise in bulk liquid quality and quantity control. Analysis of Petrochemicals, solvents, paints, plastics, pharmaceuticals, triglycerides, waste waters, monomers, oils etc. Equipment includes FTIR, AAS, GC, HPLC, Flash point UV-Vis spectrophotometers.

68 GAMLEN CHEMICAL COMPANY NZ Ltd
Manufacturers and suppliers of water treatment chemicals and consultant in the field of water treatment and analysis (including Legionella and Pneumodimica).

69 GCNZ WOODWARD-CLYDE
Consulting engineers, geologists and environmental scientists specializing in wastewater treatment, waste minimisation, water resources, occupational health and air pollution, EIA risk assessment and environmental audits. Equipment includes Portable organic vapour monitor, portable GC, occupational health monitoring equipment, GFO-Technical and soil
monitoring and sampling equipment.

73 W. GRAYSONS AND ASSOCIATES Ltd
General technical consultants dealing with mine process control, timber, water, failure, microbiological and pathogen, food and pharmaceutical analysis, environmental surveys, product and Q/A system development and product Q/C. Telarc registered laboratory for asbestos, trace metal,
timber, microbiological and pathogen, nitrate/nitrite and vitamin analyses, tube calibrations, thermostating and container approval for hazardous substances to UN code. A wide range of modern equipment is available.

81 B.R. HOMERSHAM Ltd
Suppliers of laboratory and process control instruments and consultants on process control systems.

86 JOHN YOLLAND AND ASSOCIATES Ltd
Consulting services specializing in product testing of building materials and systems, solid fuel heaters, air temperature, flow and pollution and industrial hygiene. Calibration of manometers to 6kPa.

91 MAF QUALITY MANAGEMENT
Analytical laboratory services. Equipment available includes GC, MS, HPLC.

97 METALLURGICAL SERVICES Ltd
Consultants specializing in metallurgical analysis and heat treatment services. Advisory service on forging and casting. Optical emission spectrometer available.

101 MOSS INDUSTRIES Ltd
Consulting chemists in the forensic, industrial, manufacturing and development fields. Computer consultants offering technical advice, hardware repairs and software modifications.

118 PWT NEW ZEALAND Ltd
Specialists in engineering, control and chemical aspects of water treatment and process control. Consultant services available on all forms of water treatment for various purposes.

121 RANKINE & HILL Ltd ENVIRONMENTAL SERVICES
Environmental and biological consulting services and chemical and microbiological analysis. Including detection of Gardia and Legionella. Equipment available includes UV-Vis spectrophotometer, AAS and epifluorescence microscope.

125 RORY SHANAHAN LABORATORIES Ltd
Consulting and analytical services to defence council, private investigators and industry. Analyses include Blood alcohol, alcoholic beverages, accelerants and other hydrocarbons, identification of hairs and textile fibres, microscopy. Services include scientific testimony, scientific expert evaluations, forensic investigations including arson, general physical evidence. Equipment includes GC with FID and integrator, visible spectrophotometer, stereobinocular microscope, UV and IR photography.

128 SCIENTIFIC AND GENERAL CONSULTANTS
Independent consulting and analytical services to industry specializing in food analysis, personal care products, industrial commodi-

High Performance Liquid Chromatography

A suite of compact, user friendly and modular instruments to simplify your most complex liquid chromatography needs.

- ICI LC1100 Dual Piston Pump
- ICI LC1200 Variable Wavelength UV-Vis Detector
- ICI LC1260 Electrochemical Detector
- ICI LC1430 Gradient Controller
- ICI LC1431 System Organiser Module
- ICI LC1432 System Organiser Module
- ICI LC1500 Dual Piston Pump
- ICI LC1600 Advanced Auto-Sampler
- ICI TC1900 HPLC Oven
- ICI DP800 Chromatography Data Processing System
- ICI DP700 Chromatography Data Processing System
- ICI DP600 Dual Pen Chart Recorder
- Dani range of GC instruments and accessories.

Spectroscopy

Incorporating the latest features and accessories, the ICI/GBC spectroscopy range provides a cost-effective solution to a host of analytical applications.

- ICI/GBC 911 UV Visible Spectrophotometer
- ICI/GBC 904/906 Atomic Absorption Spectrophotometers
- ICI/GBC HG3000 Automatic Hydride Generation
- ICI/GBC System 3000 Graphite Furnace Atomic Absorption Spectrophotometer.

Materials Testing Equipment

An advanced range of instruments providing essential data for the definition, quality control and processing of high technology materials.

- ICI Instruments Impact Testers
- Lloyd Tensile Testers
- Bohlin Rheometers
- A new range of Melt Rheometers
- Setaram Thermal Analysers: DSC, Calorimeter, DTA, TGA, TMA, Dilatometer

ICI Instruments

INTERNATIONAL

ICI is an internationally respected chemical company servicing 150 countries and generating sales of more than US$18 billion annually. It's businesses are involved in the pharmaceutical, biotechnology, agricultural, materials, organic chemical, and environmental industries.

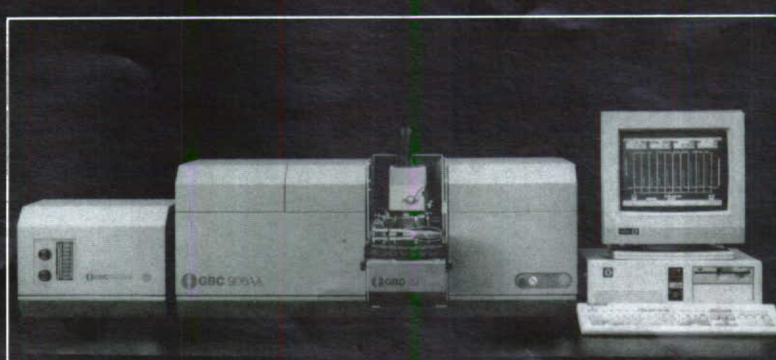
AUSTRALIA & NEW ZEALAND

ICI Instruments (Australia) is a division created to design, manufacture and market quality instrumentation internationally. Backed by the resources of ICI, (one of the world's largest users of analytical instrumentation), ICI Instruments is in a strong position to understand and appreciate your analytical requirements.

ICI Instruments has a fully integrated research and development team, specialised manufacturing facilities and a marketing operation based in Melbourne, Australia. The company's principle philosophy is based on 'inherent reliability, quality of manufacture and superiority of service'. With this philosophy, ICI Instruments has achieved a rapid rise to international success with an office now based in New Zealand.

With a broad product range, extensive experience and an international network, ICI Instruments guarantees satisfaction and expert professional support throughout a wide range of demanding applications.

ICI HPLC Automated Gradient System



ICI/GBC 906 Atomic Absorption Spectrophotometer

For further information:
David Payne, ICI Instruments
246 Khyber Pass Road, Grafton,
Auckland Phone: (09) 735 765

CONSULTANTS CONTINUED

ties and processes. Equipment includes UV- Vis spectrophotometer, AAS, GC, HPLC, Karl Fischer.

134 SORENSON LABORATORIES Ltd
Microbiological testing. Product development and feasibility studies in the food area.

138 TELARC NEW ZEALAND
Telarc promotes identifies and formally recognizes quality in the supply of New Zealands goods and services and offers educational services for the training of laboratory staff.

150 XL CONSULTANTS
Consultants in formulation and manufacturing techniques of industrial, veterinary and household products.

2 Waikato and Bay of Plenty

6 ALLENS UNITED WASTE DISPOSALS LTD
See listing in the Auckland, North Auckland section for details.

12 ANALYTICAL SERVICES LIMITED
Telarc registered laboratory and member of the NZ Association of Consulting Laboratories specializing in the analysis of minerals and nutrients in soils, plant tissues, feedstuffs and waters.

16 AQUA TREATMENT Ltd
Analysis of water, effluents, boiler deposits, environmental chemists and consultants.
This entry has been carried over from the 1989 yearbook

50 P.J. DAWSON LABORATORIES
See listing in the Auckland, North Auckland section for details.

54 DSIR LAND RESOURCES DSIR
Land Resources is New Zealand Largest provider of expert scientific information and advice on the land and its biota with 230 scientific and support staff with extensive experience in New Zealand, the South Pacific, Asia and Antarctica. Expert information and advice on vegetation, wildlife, soils and land use. Environmental advice. Land suitability and hazard analysis. Waste disposal and irrigation. Land rehabilitation. Plant identification. Analytical services. Geographical information and maps. Radiotracing. Equipment available includes X-ray diffraction and fluorescence, AAS, Autoanalysers, IR, DTA, Mossbauer, TEM, Carbon analysers, Ion chromatography, GC and Beta counters.

74 HAMILTON ANALYTICAL LABORATORY
This entry has been carried over from the 1989 yearbook

75 HAMILTON MEDICAL LABORATORIES
This entry has been carried over from the 1989 yearbook

79 R.J. HILL LABORATORIES
Telarc registered laboratory specializing in analysis of soil, water and plant material for advice in environmental agricultural and industrial matters. Equipment available includes AAS with hydride generation and graphite furnace, UV-Vis spectrophotometer.

83 INDEPENDENT SERVICE LABORATORIES (ISL)
Industrial chemists, mining and exploration consultants and analysts (specialists in geochemistry). Experienced in method development for companies not having their own laboratory facilities.
This entry has been carried over from the 1989 yearbook

102 NATIONAL AGLAB
Analytical laboratory specializing in plant tissue, soil nutrients, and surface waters for domestic and agricultural users.
This entry has been carried over from the 1989 yearbook

104 NEW ZEALAND HYDROPONICS Ltd
Suppliers and consultants in the field of hydroponic materials and equipment and systems. Analysis of waters, soils, nutrients and plant materials. AAS available.

110 PACIFIC ANALYTICAL Ltd
Consultancy involved with technical/scientific personnel placement computer/EDP consultancy (real time systems for laboratories), general laboratory consultancy. Offering staff training /evaluation, technical report preparation, computer consumables.
This entry has been carried over from the 1989 yearbook

137 TASMEX LABORATORIES Ltd
Microbiological and chemical analysis.
This entry has been carried over from the 1989 yearbook

3 Wellington, Hawkes Bay, Manawatu and Taranaki.

11 ANALYTICAL RESEARCH LABORATORIES
Independent analytical laboratory and consulting services. Analysis of soils, plant materials, agricultural and industrial products and food for major and trace elements, acids, sugars, additives, herbicides, insecticides, fungicides and general analytical services. Equipment available includes HPLC, AAS, UV-Vis, GC, Auto analyser.

17 W ARTHUR FISHER
See listing in the Auckland, North Auckland section for details.

32 CARINA CHEMICAL LABORATORIES Ltd
Consultants specializing in the research and development of new processes and chemical methods from initial laboratory trials through scale up to commercialization. Also supplier of fine chemicals. Equipment available includes GC, UV-Vis IR.

41 CHEMICAL SERVICE LABORATORIES (1985) Ltd
Analytical and consulting chemists, bacteriologists.
This entry has been carried over from the 1989 yearbook

53 DSIR CHEMISTRY
See listing in the Auckland, North Auckland section for details.

54 DSIR LAND RESOURCES
See the Hamilton region entry for more details

55 DSIR MATERIALS PERFORMANCE GROUP
See listing in the Auckland, North Auckland section for details.

63 FERTILIZER AND LIME RESEARCH CENTRE
Consultants specializing in the fertilizer industry, waste disposal and land rehabilitation. Also analysis of soils plants water and fertilizers. A comprehensive range of chemical and physical analyses on soils fertilizers; also advice on fertilizers requirements. Equipment available include automated colorimetric analysers, AAS, X-Ray diffraction, SEM and TEM and scintillation counters.

64 FLINDERS COOK (TECHNICAL SERVICES) LTD
See listing in the Auckland, North Auckland section for details.

67 FURST-LAB
Specialists in laboratory fitments and consultants in laboratory design.

68 GAMLEN CHEMICAL COMPANY NZ Ltd
See listing in the Auckland, North Auckland section for details.

70 GEOCHEMISTRY RESEARCH Ltd
Chemical and geochemical consulting with special expertise in minerals and industrial chemistry, mineral exploration, mineral characterization, analysis, reactions, industrial utilization and processing. Petroleum exploration geochemistry.
This entry has been carried over from the 1989 yearbook

73 W. GRAYSONS AND ASSOCIATES Ltd
See listing in the Auckland, North Auckland section for details.

78 HAZARDS ANALYSIS Ltd
Analysis of hazards involving flammable vapours and dusts and also toxic chemicals. Services include analysis of causes of accidents and recommendations for preventative procedures, chemical plant safety audits, half day safety training programmes.
This entry has been carried over from the 1989 yearbook

81 B.R. HOMERSHAM Ltd
See listing in the Auckland, North Auckland section for details.

92 MAF CHEMICAL SERVICES
Consulting laboratory undertaking a wide range of residue analyses on both animal and plant materials. Specializes in analysis of veterinary drugs, pesticides, herbicides environmental contaminants, vitamins, nutrients, trace and macro elements and food analysis. Equipment available
includes AAS, HPLC with UV and fluorescence detectors, GC with MS, N/P and ECD, UV-Vis spectrophotometers and Autoanalysers.

96 METALLURGICAL AND INDUSTRIAL CONSULTANTS
Specialists in failure analysis, metallographic testing, heat treatment, mechanical and non-destructive testing.
This entry has been carried over from the 1989 yearbook

CONSULTANTS CONTINUED

105 NUCLEAR SCIENCES GROUP
Specialists in the construction of instruments based on nuclear techniques (Density gauging, fat / moisture content), remote sensing of corrosion, remote monitoring and tracing of residence times and flow paths for solids liquids and gases. Process investigations using radiotracers.

118 PWT NEW ZEALAND Ltd

4 Nelson, Blenheim, Marlborough

35 CAWTHRON INSTITUTE
See the listing in the Auckland, North Auckland section for details.

83 INDEPENDENT SERVICE LABORATORIES (ISL)
See the listing in the Hamilton, Bay of Plenty section for details.

148 W.B. WEBLEY - APPLIED RESEARCH AND CONSULTING SERVICES
Consultancy services in the fields of chemistry, computing and technical management. Advice on and implementation of environmental monitoring systems and effluent treatment systems. applied research services for product and process development.

5 Christchurch and Canterbury

17 W ARTHUR FISHER
See the listing in the Auckland, North Auckland section for details

31 CANTERBURY FROZEN MEAT Co Ltd
Specialists in processing of meat and meat byproducts offering a service in testing of food, meat, meat byproducts and water and environmental testing. Proximate analysis of Food and food products, microbiological analyses of food, water and environmental samples and chemical analysis of water and effluents. Equipment available includes UV-Vis spectrophotometers, AAS and Automated Kjeldahl.

53 DSIR CHEMISTRY
See the listing in the Auckland, North Auckland section for details

54 DSIR LAND RESOURCES
See the listing in the Hamilton, Waikato, Bay of Plenty section for details

55 DSIR MATERIALS PERFORMANCE GROUP
See the listing in the Auckland, North Auckland section for details

69 GCNZ WOODWARD-CLYDE
See the listing in the Auckland, North Auckland section for details

81 B.R. HOMERSHAM Ltd
See the listing in the Auckland, North Auckland section for details

100 MOOYMAN & HORNBY LABORATORIES
Water soil and plant analysis. Equipment available includes AAS, UV-Vis, Flame Photometer. This entry has been carried over from the 1989 yearbook

112 PEARSON BIOLOGICALS
Telarc registered laboratory offering comprehensive microbiological testing and consultancy for the food, cosmetic and water supply (for drinking and industrial use). Services include testing for Listeria and Legionella.

118 PWT NEW ZEALAND Ltd
See the listing in the Auckland, North Auckland section for details

138 TELARC NEW ZEALAND
See the listing in the Auckland, North Auckland section for details

140 TOWER BIOLOGICALS Ltd
This entry has been carried over from the 1989 yearbook

142 UNIVERSITY OF CANTERBURY
X-ray fluorescence and diffraction for the analysis and identification of plant material and mineral samples.

6 Dunedin, Otago

54 DSIR LAND RESOURCES
See the listing in the Auckland, North Auck
land section for details

73 W. GRAYSONS AND ASSOCIATES Ltd
See the listing in the Auckland, North Auckland section for details

113 PHARM CHEM RESEARCH LABORATORIES
Consultants in the fields of analysis, physical measurement chemical synthesis research and literature searches. Research and development projects feasibility studies and forensic studies undertaken.

127 SCIENTIFIC ANALYTICAL Ltd
General consultant and analyst for manufacturing and processing industries and agriculture related industries. Analyses of soil, herbage, water, trace elements, food and processed foodstuffs, household and industrial products, manufactured goods. Equipment includes AAS with hydride generation and graphite furnace, UV-Vis spectrophotometer Karl Fischer and Kjeldahl.
This entry has been carried over from the 1989 yearbook
See listing in the Auckland, North Auckland section for details.

129 SCIENTIFIC SERVICE LABORATORIES LTD
Manufacturers and packers of corrosive products such as soldering fluids, chemical pickles, etchants, hydrochloric and sulphuric acids. Consultants in the design and installation of small scale chemical plants and industrial scale glassware and disposal of acid effluents.

139 THERMOPLASTIC ENGINEERING Ltd
Specialists in the design fabrication and installation of fume cupboards, fume extraction fans, ducting and fume extraction systems bench tops, draining racks and other rigid laboratory fittings in PVC and polypropylene.

Metrohm

STABILITY OF EDIBLE OILS & FATS

The new 679 Rancimat determines automatically the oxidative stability of 6 fat or oil samples in parallel. The expanded temperature range (50-200° C) and the use of calibrated electrodes increase the application possibilities. It is also now possible to determine the thermal stability of PVC according to DIN 55 381. By separating the control and wet sections, the instrument can be operated conveniently from the laboratory bench, while actual measurement is performed in a fume.

New Karl Fischer Titrator 701 KF Titrino

Metrohm have just released the newest and most sophisticated KF titrator on the market.

Its features include:

- automatic titer determination
- automatic blank determination
- automatic drift compensation
- non volatile memory
- bidirectional RS 232 interface
- integrated stirrer and pump
- new exchange unit with ceramic stopcock

The 701 KF Titrino is now available at a price to suit all budgets.

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